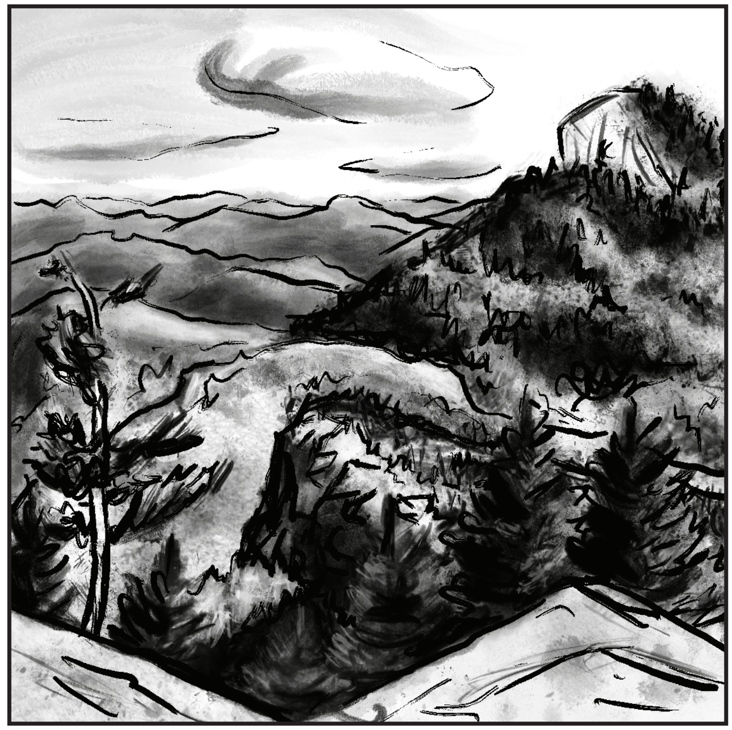
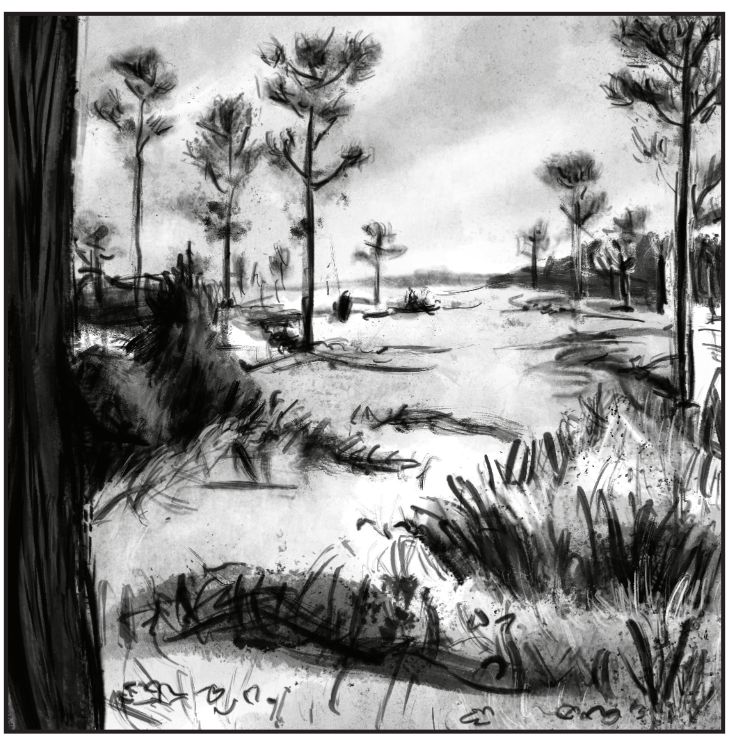
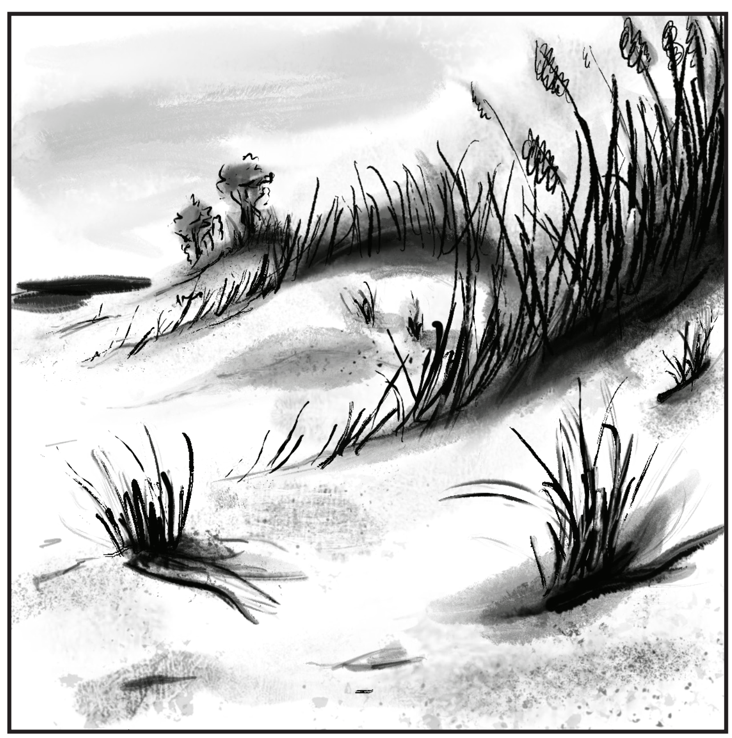



CLASSIFICATION OF THE NATURAL COMMUNITIES OF NORTH CAROLINA

Fourth Approximation

By Michael Schafale

CLASSIFICATION OF THE NATURAL COMMUNITIES OF NORTH CAROLINA
FOURTH APPROXIMATION

Michael P. Schafale
Ecologist
North Carolina Natural Heritage Program

North Carolina Natural Heritage Program
N.C. Department of Natural and Cultural Resources
Raleigh, NC

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INTRODUCTION

This document presents a revised framework for the classification of natural communities in North Carolina. Natural communities are central to the work of the Natural Heritage Program. Tracking occurrences of good examples of them comprises a substantial portion of the program's inventory and database work. Natural communities are also primary drivers of land conservation decisions by the North Carolina Land and Water Fund, by state land conservation agencies, and by some private organizations. Classification of natural communities is also useful for a wide variety of other purposes, including guiding research, organizing ecological information, characterizing sites, and defining habitat for particular species.

Natural communities are important components of biodiversity, with the different kinds representing different combinations of species interactions and of ecosystem processes. They also represent a crucial means of conserving species diversity, as they offer a means of providing representation for many of the poorly-known and untracked species that occur in them. The vast majority of species are not tracked and most in the invertebrate and microbial realms have not even been assessed for their rarity; many are not even known.

Increasingly important as the climate changes, natural communities also represent the variety of physical environments as they affect the biota. Physical site stratifications may be done by slicing important environmental gradients into units in many ways, but the sites representing the diversity of natural communities as they exist today indicate the combinations of factors and their thresholds that are also most likely to drive new communities of the future.

DEFINITION OF NATURAL COMMUNITIES

A natural community is defined as:

> "a distinct and reoccurring assemblage of populations of plants, animals, bacteria, and fungi naturally associated with each other and their physical environment."

This definition implies an attempt to account for a wide variety of ecological components, so that the units will represent differences in local-scale ecosystem function and structure, as well as differences in species composition. It implies that we seek to define units that are the result of the processes of nature, that differ in ways that are enduring and significant rather than transient or minor, and that would be found again in other places with similar environments.

Natural community classification considers a wide range of ecological characteristics, including vegetation composition and physiognomy, assemblages of animals or other organisms, topography, substrate, hydrology, soil characteristics, other enduring site characteristics, and prevailing natural disturbance regimes. It thus differs conceptually from classifications that are based solely on vegetation, such as the National Vegetation Classification. In practice, however, this large number of factors is tightly correlated, and the natural community units usually correspond well to units defined by the vegetation that exists in the most natural, least altered examples that can be found.

NEED FOR A NEW APPROXIMATION

The 3rd Approximation was published in 1990. Much new information, experience, and understanding have accumulated since that time. Indeed, the study of natural communities in North Carolina has expanded as never before. Natural Heritage Program inventories have found hundreds of new, good examples of natural communities. Numerous graduate studies and published scientific papers offer new insights. The Carolina Vegetation Survey (CVS) has systematically amassed the largest set of vegetation plot data ever collected in the state. The National Vegetation Classification (NVC) has developed, offering different perspectives on the crucial vegetation component of natural communities in North Carolina as well as giving information on communities in other states. We now know of the importance of distinctions that were not recognized in 1990, we know of kinds of communities that we didn't know existed then, and we have a better understanding of the nature of most of our communities.

One particular challenge has been a trend toward increased splitting of community units. The NVC has much more finely divided units than the 3rd Approximation. The demand for these more detailed units, along with a desire to tie the North Carolina classification into the NVC as much as possible, has been a major driver in the way the 4th Approximation has developed.

Much remains to be learned about all of our natural communities and how they are related to each other. This edition of the classification, as previous ones, is called an approximation. This is meant to remind the user that, while it is the best synthesis of knowledge the author can offer at this time, and can be useful, our understanding will continue to evolve.

DEVELOPMENT OF THE 4TH APPROXIMATION

Work on the 4th Approximation began in the late 1990s. Early drafts of the classification were made available for field testing and review. These informed later development and the final form. After the primary classification was worked out, the 4th Approximation Guide was completed in 2012. At that time, the Natural Heritage Program began using the classification as its primary means of naming and tracking examples of natural communities and using them to rate site significance. A commitment was made to provide a more detailed descriptive book for the communities defined. This document is that detailed book.

The use of the classification through the ten years needed to complete this book has provided additional testing and experience with the communities as they are defined. New research, new development of the NVC, and new analysis of CVS data have led to new understandings of the communities. Some new communities have been discovered. The draft descriptions have been provided to botanists and ecologists and been available for peer review. For all these reasons, the classification and the community units described here have evolved since 2012. A few units have been dropped, a few added, the boundaries of a few changed, the relationship to the NVC has been revised for some.

STRUCTURE OF THE CLASSIFICATION

The 4th Approximation is structured largely the same as the previous editions. This includes limited upper-level hierarchy, with the finer units, the primary focus, being called types, subtypes, and variants. Subtypes are the units tracked by the Natural Heritage Program, in the way that varieties and subspecies are tracked as the elements of biodiversity at the "species" level. Subtypes are the scale the Natural Heritage Program considers appropriate to use as separate targets for biodiversity representation. Subtypes are a similar ecological scale to the associations of the NVC, the primary level viewed as biodiversity conservation targets when that classification was developed.

Variants are less formal, finer-scale divisions of subtypes, used to name recognizable differences that are either too poorly known or considered too fine-scale to use as conservation targets. Variants may also be the testing ground for new subtypes. Most of the subtypes newly recognized in the 4th Approximation were treated as variants in the 3rd Approximation. The experience gained from using them contributed to their adoption as subtypes.

Types are useful if a slightly coarser classification is desired, and they provide a way of tying classification back to the 3rd Approximation units. Most type-level units are unchanged between the 3rd and 4th Approximations.

The community types are nested in biological themes. The 32 themes were defined in 1993 to provide a meaningful coarser ecological classification for purposes where that was needed. Since they were published in the 1993 Natural Heritage Program Protection Plan, they have seen widespread use, including in the State Parks System Plans and the Wildlife Action Plan. Small changes have been made in them here to fit the 4th Approximation. The themes are different from the informal ecological groups that were used in earlier approximations and in the earliest drafts of the 4th Approximation. Using the ecological themes should increase the versatility of the 4th Approximation, offering meaningful classification entities at three levels over a great range in breadth. As with the previous grouping, the themes are a grouping rather than a top down hierarchy. Some community types could reasonably be placed in two different themes.

A single additional top level of hierarchy consists of the wetland systems of Terrestrial, Palustrine, and Estuarine. This roughly follows Cowardin et al. (1979). In that document, Riverine and Lacustrine categories were considered deepwater areas only, and vegetated communities associated with rivers and lakes are classified as Palustrine. Some deviation from Cowardin et al. (1979) occurs in the floodplains and wet savannas, where some communities that are not generally treated as jurisdictional wetlands are included as Palustrine because their ecological processes and affinities are nevertheless driven by water and their closest affinities are with communities that are jurisdictional wetlands.

CLASSIFICATION METHODS

CLASSIFICATION APPROACH

The 4th Approximation, as in previous approximations, uses an integrative approach which considers all of the ecological characteristics that are known, and attempts to group them in ways that they are naturally correlated. It attempts to find units that will go beyond simply describing one kind of data and will allow predictions of patterns in ecological process and in unstudied biota such as invertebrates. It is thus not a pure vegetation classification nor a pure ecological land classification; it attempts to capture aspects of both. It classifies the environment, but from the point of view of the biota. It classifies vegetation but based on how it responds to the environment. It does not explicitly classify animal communities but it attempts to describe habitat in ways that would affect assemblages of animals, especially of smaller and less wide-ranging animals.

The greatest emphasis is upon vegetation and upon readily observable aspects of the physical environment such as topography, elevation, and wetness. This is justified because plants are good indicators of the most important environmental influences, and they integrate the effects of those influences over time. It is also necessary, because plants are most easily observable, and we have much more information on them than on any other component. However, vegetation is interpreted in light of what it tells us about the environment and how that may be important for animals and other organisms. Differences in vegetation that indicate short-term fluctuations or human alteration are downplayed; those that indicate prevailing natural disturbance regimes, soil fertility, moisture levels, and other enduring environmental factors are emphasized. Conversely, aspects of the environment that can be seen to affect the flora are emphasized. Aspects of the environment considered likely to affect other biota without affecting vegetation may be used, but only if confidence in their importance is high.

Potential 4th Approximation types and subtypes were evaluated for suitability by a set of criteria:

- The unit represents a difference in enduring natural character and is not just a short-lived part of a natural cycle. Communities that are parts of longer term, naturally shifting mosaics are recognized if they will persist for a number of years or if they will not likely return to the original state, while predictable and short-lived shifts are not recognized as different types. Thus, beaver ponds are recognized in the classification, while the drastic differences in vegetation stature that follow fire in pocosins but which fade in just a few years are considered part of natural temporal variation within the same community.
- The unit's distinctness is a result of natural environment and natural processes and is not an artifact of a different history of human alteration. All existing community occurrences have at least some human alteration, which we seek to understand. However, we use the least altered existing examples, along with our knowledge of how things are altered, to base classification on underlying natural characteristics.
- The differences between the unit and related units matter for biodiversity conservation. They are great enough that we would not consider the units interchangeable for conservation purposes but would seek to protect examples of both. They represent an appropriate balance between broad brush ecosystems and a view of every site as irreconcilably unique.
- The occurrences of the unit are at the appropriate spatial scale to be conservation planning targets – ¼ acre to hundreds or potentially thousands of acres, depending on the physical structure and contrast with adjacent areas. Micro-ecosystems such as the mosses on fallen logs in forests or on individual boulders may have strong contrast but are too small to be practical conservation targets. (Being conservation planning targets does not mean that we seek to conserve them without their landscape context, just that we must think about them specifically to make sure they are conserved.)
- The unit is well enough understood that we would recommend conservation action on it. It is well enough understood that other people can be told how to recognize it and to distinguish it from related units.

Two additional major considerations in developing the 4th Approximation were to minimize disruption to users of the 3rd Approximation, and to provide as much commonality with the National Vegetation Classification (NVC) as possible. Recognizing most of the new units at the subtype level, while keeping most community types unchanged, means that most users familiar with the 3rd Approximation should easily be able to transfer that knowledge. All NVC associations attributed to North Carolina were considered for creation of equivalent 4th Approximation types or subtypes. However, no such units were adopted without meeting the above tests. This led to substantial one-to-one correspondence with the NVC but not complete agreement. Where units were particularly uncertain, comments indicate that they are accepted provisionally. Others with less confidence are treated as variants.

The 3rd Approximation names were changed only where there was a significant change in the concept of the type or where new understandings or past confusion made a compelling case for a I different name. Most community type names remain the same, and for many of the changes, the connection to the old name should be apparent. A table of new names for which the 3rd Approximation equivalent name is not obvious is included at the end of this introduction.

DATA SOURCES FOR CLASSIFICATION – QUALITATIVE AND QUANTITATIVE DATA

The classification approach used here integrates several sources of quantitative and qualitative information. Earlier approximations used what quantitative data and analysis were available, in the form of published literature, as well as dissertations and unpublished theses. Most of these were analyses of a range of vegetation in a single site or small region. A few were focused on a narrower set of communities across their range or at least across a broader area. Much more quantitative information is now available than was present in 1990. More studies of these two kinds have been conducted. However, the Carolina Vegetation Survey (CVS) represents a major new and distinct source of community data. Through "pulse" events involving hundreds of volunteers over 26 years, and additionally pooling data from many other studies with compatible sampling methodology, CVS has compiled a vast database of plant community plot data from North Carolina and nearby states (Peet et al. 1998; Peet et al. 2012). The CVS data are far from being fully analyzed, but analyses done on target groups of communities, by students and by the CVS principal investigators, have provided tremendous clarification for some communities. Additionally, the CVS database has been used heavily by the author in describing the 4th Approximation vegetation and clarifying differences among them.

Qualitative information used includes descriptive reports on individual sites, along with some qualitative syntheses of community patterns, most of it unpublished. This type of information too has vastly expanded, perhaps by an order of magnitude since 1990. Much of this material comes from the Natural Heritage Program's county inventory effort, protection work, and other surveys, but a network of supporters has also contributed material to the program. This work has also provided incomparable feedback on the 3rd Approximation and new ideas for improvements to classification. Well-argued proposals by Richard LeBlond, Bruce Sorrie, Harry LeGrand, Ed Schwartzman, and others have become the basis for many new community units in the 4th Approximation. The author's own growing experience with communities and with applying the classification in the field are now a much larger contributor than they were in earlier approximations. Ongoing collaboration with the other members of the CVS has also been a major contributor to new classification ideas.

The NVC stands as one of the largest new sources for the 4th Approximation, albeit of a different kind that spans both qualitative and quantitative input. Projects done by NatureServe on National

Park, National Forest, and other sites provide new plot data and analysis that have informed the NVC. Additional input from other states to the NVC provide insights and perspectives for the 4th Approximation. The NVC and the North Carolina classification grew up in conversation with each other, with 3rd Approximation units, including variants, being adopted into the NVC, all North Carolina associations in the NVC being considered for the 4th Approximation, and the NVC being modified in response to input based on field testing of draft 4th Approximation units.

Specific published sources and formal unpublished sources such as theses are specifically cited in the community descriptions. Unpublished site descriptions and reports, individually cited in earlier approximations, have become too numerous to cite individually here. Where there once were several, now there are dozens, sometimes more than 100. While the individual contribution of each such source is thus generally diminished, the role of them collectively, and of their contributors in the Natural Heritage Program and in the ecological and botanical community, is enormous and is gratefully acknowledged.

VALUE OF QUALITATIVE AND QUANTITATIVE DATA

The use of qualitative as well as quantitative data has been continued in the 4thIv Approximation because there are complementary strengths in each. Quantitative data are considered the standard for scientific work. If sufficient appropriate measurements are collected accurately, they provide a level of objectivity, precision, and rigor that cannot be achieved any other way. The weaknesses come partly in the ways that these ideals are not met. Despite the largest plot dataset ever assembled in our region, it is clear that some communities are not sufficiently represented. In Lee et al. (2000), a standard of five plots per association was met for 59% of the associations in the region. Experience of the author and others suggest that even five plots are not sufficient to answer many questions about community differences. The plots that exist have not generally been randomly or objectively located. More directed plot placement has been necessary, because random or systematic location would have resulted in even poorer representation of the rarer communities, but it carries with it a likely share of bias in addition to statistical noise. Plots are additionally limited to lands on which sampling is allowed and which can readily be reached at the specific time of sampling events, in some cases a geographically limited, biased, or otherwise inadequate sample. Finally, there is bias inherent in what vegetation has remained relatively unaltered.

Additional limitations come up in analyzing and using the data. Ideal methods for analyzing large sets of plot data are still being worked out. Unsupervised classification of vegetation plots often yields results that reflect geographic variation, degree of alteration, or other factors that are not useful for a classification that is related to the environment or is likely to represent unknown species. Or it may produce clusters that resemble existing classification units but are different in ways that are not necessarily improvements. In addition, at present, though some careful analyses of plot data have yielded useful new classifications, most of the CVS data have not been analyzed. They can be used for quantitative characterization of communities, but this characterization is based on assignment of plots to communities by decidedly nonquantitative individual judgement.

Qualitative data, in the form of site descriptions and whole-site species lists, are less precise, more variable, and, in the author's experience, can sometimes be hard to replicate. However, they offer several advantages to offset these weaknesses. There are many more sites and much more area represented by them, allowing a broader geographic and ecological scope. They represent the communities for which quantitative data are inadequate or absent. They better characterize a whole site or whole stand of a community. They can better represent the rarer or more sparsely distributed species that are often missed in plots. They often have information on characteristics not captured by standard plot data, such as spatial or gradient relationships among communities, additional environmental factors, variation in vegetation, and relationship of vegetation to site history. One form of intermediate data analysis has also been used. Species lists for sites are often divided by communities. This represents a kind of data that can be analyzed in a rough quantitative way, by determining frequency of species among sites. This kind of analysis was frequently used in preparing the 4th Approximation, to inform community descriptions and to investigate distinctions among communities where plot data were not adequate for the purpose.

The 4th Approximation classification therefore represents a synthesis of quantitative and qualitative study. It aims to cover all natural communities that seem sufficiently distinct to recognize, regardless of the state of data. The circumscription of the subtypes is done with the best combination of data available. For some groups, such as longleaf pine communities, Piedmont floodplains, seeps, and high elevation rock outcrops, this is a comprehensive quantitative analysis, interpreted to accept the units that seem to represent natural vegetation variation that is related to enduring or repeating environmental influences. For other groups, such as Coastal Plain floodplains, pocosins, and many oak forests, the classification uses a qualitative combination of several less comprehensive quantitative analyses along with many site descriptions and the author's experience. For others, such as the boulderfield communities, low elevation rock outcrops, and glades, it is primarily based on site reports.

RELATIONSHIP TO THE NATIONAL VEGETATION CLASSIFICATION

Much effort has been made to have the 4th Approximation and the NVC correspond at the level of the subtype and association respectively. This has been substantially achieved, with a one-to-one correspondence between comparable units in a large majority of cases. Many NVC associations are based on 3rd Approximation or draft 4th Approximation communities and correspond exactly, while other 4th Approximation subtypes were adopted from the NVC. Feedback to the NVC has resulted in some associations being changed to more closely match the 4th Approximation, or to clarify that associations do not occur in North Carolina.

For the minority of subtypes that do not correspond to associations, there are several reasons. Some are differences in breadth of concepts. Many of these cases are noted in the descriptions, but some may not have been recognized. In some cases, the concept of NVC associations is not clear, making it unclear how close the fit to the association is. In some cases, the author did not believe the association met the criteria for ecological distinctness, enduring natural character, and conservation significance listed above. In other cases, it was inadequately clear if it met the criteria. The NVC has several conceptual differences from the 4th Approximation. It is conceived as solely a classification of existing vegetation. It includes a goal of including anthropogenic and semi-natural vegetation as well as natural. Given these differences, substantial correspondence is perhaps remarkable. However, the conversation between the two classifications, the involvement of many of the same ecologists, and the interest in natural features and conservation of all has led to convergence.

COMMUNITY NOMENCLATURE

4th Approximation communities are named with the intent of providing convenient, memorable titles by which to refer to them, while minimizing confusion. No single form of names, such as all environmental names or all plant-based names, is used. Instead, the correlated characteristics that are easiest or most concise to name are used. They are named from the viewpoint of North Carolina. Though, with the addition of some regional modifiers, many could be used in a broader context.

Some descriptors used in names must be interpreted in light of the common usage and range of variation in factors within North Carolina or within the range of similar community types. Thus, northern subtypes are those that occur in the northern part of North Carolina, and typic subtypes are those that are most common or most central to the community concept within North Carolina. Savannas are wet to mesic communities and not dry communities as they are in some other regions. Terms such as “marl” and “bog” are used as they are commonly used among North Carolina ecologists but occasionally may not fit the more widely used geological or hydrological definitions. Other terms are relative to local conditions. Thus, “xeric” refers to the driest conditions in North Carolina, even though desert regions elsewhere are drier. Similarly, “basic” is used as it is used by most North Carolina ecologists, as a convenient word for a correlated set of characteristics that includes a higher soil pH (but not necessarily truly alkaline), higher content of “base” cations (compared to other upland sites but not to alluvial soils), and presence of a distinctive set of species that tend to occur on such soils and not elsewhere. It should be remembered, however, that all names are merely “handles” and are not definitions. The names here are an attempt at a compromise between precisely indicating the concept they represent and being short and memorable enough to be used. Much explanation of community concepts and distinguishing features has been given to allow the user to learn the ideas behind the names, and dichotomous keys are provided to aid in practical identification. The user should not assume that the characteristics in the name are either necessary or sufficient to recognize the type but should realize that the relationship between names and characteristics may vary. Thus, High Elevation Red Oak Forests will not naturally lack red oaks, but Dry Oak-Hickory Forests may occasionally have no hickories and Chestnut Oak Forest may occasionally be dominated by scarlet oak.

BREADTH OF UNITS

From the author’s childhood with life divided into plant and animal kingdoms, we now find a range from five to nine kingdoms recognized. From the four classical elements of earth, air, water, and fire, we have gone to 118 elements. “There are two kinds of people in the world….” Nature, and human nature, has a way of turning out to be more complex than we think. “It is by the endless subdivisions based upon the most inconclusive differences, that some departments of natural history become so repellingly intricate” wrote Herman Melville in *Moby Dick*, in reference to whether there were two kinds of right whales. He said it in a chapter entitled “Cetology”, in which he had previously declared that whales are fish, and then spent much of the space describing how they differ from “other fish.” Deciding on an appropriate breadth for the classification units – “lumpiness” or “splittiness,” is one of the most difficult aspects of classification of any set of natural features. A position must be taken along the scale from “every place is unique” to “you’ve seen one, you’ve seen them all.”

In the case of natural communities, as with many things, there is no single objective measure of breadth of a category. One can look at how many examples there are in each category, but there is no expected number and no reason to expect numbers to be equal. We expect some categories to be more common than others. One can look at the statistical properties of groups of vegetation plots and get hints, but only if you have a lot of plot data, have classified them well, and know them to represent the range of variation that exists on the ground. Even in the rare cases where this standard can be met, it is clear that it isn't the full answer. Not all vegetational variation represents enduring natural ecological character. Some is the result of alteration we don't want to enshrine in the classification, some is statistical noise. In practice, appropriate breadth of community units tends to be decided implicitly, by feedback from peers on individual units, opinions on whether they feel too broad or too narrow, whether they can be distinguished readily enough, and people's intuitive sense of whether the breadth in one part of the classification is comparable to that in another.

While the 4th Approximation keeps most of the basic structure as the 3rd, there is a substantial difference in breadth of the units. The 3rd Approximation had very few community types that were divided into subtypes. In the 4th Approximation, most community types have at least two subtypes, and many have several. Thus, it is much more finely divided. The 4th Approximation contains 343 units at the level of primary focus, where the 3rd Approximation had 112. While some of the new communities, such as several kinds of forested boulderfields, were simply not known to exist in 1990, most of them represent subdivisions of the community types already known. There is no denying that the 4th Approximation is more finely divided, though it should be noted that perhaps half of the new subtypes had been recognized as variants in the 3rd Approximation; having stood the test of time, they are given greater recognition now.

There are several arguments for this greater division. Most compelling is that it appears to serve biodiversity conservation better. It is much more difficult to conserve things that are not known to be distinct. Some of the diversity that is lumped together may get protected by accident, but in general the rarer entities are likely to be missed. The Natural Heritage Program recognized the weakness of the coarser units for setting conservation goals, rating site significance, and explaining the rationale for protecting particular sites. It had already begun to separately track many of the variants in the 3rd Approximation and use them for these purposes. Demand from other users led in this direction as well. The desirability of matching the NVC as closely as possible was an additional major factor that impelled finer divisions, and the level of the division in the NVC represents in itself a demand among many ecologists for a finer scale.

There is an additional, somewhat paradoxical argument for finer division, which is usability and convenience. Finely divided classifications are more complex and may seem "repellingly intricate," but if the reality behind them is complex, hiding that complexity is not always a benefit. Units which are too heterogenous come at a price. It is harder to describe them, harder for a user to grasp what they mean, harder to match one's own knowledge with that of others, and harder to determine if a generalization about them applies to a given example. If it takes many pages to explain how whales differ from "other fish," it might be time to call them something other than fish.

In the end, the benefits and costs of coarseness and fineness must be balanced as seems reasonable. The 4th Approximation attempts to do this, while attempting to fit reasonably well with widespread usage. The author recognizes that in this, more than perhaps in most aspects, some users are disappointed by the lack of recognition for some distinctions they see, while others find some distinctions to be too much effort to make. It is hoped that those who wish for finer division will be able to use the variants, and that they will keep marshalling arguments for the distinctiveness of what they see. It is hoped that those who find the level of detail overwhelming will be able to use the community type level to serve their purposes. In addition, users of the 3rd Approximation should be able to access the 4th relatively easily. Most of the new distinctions recognized in the 4th Approximation are at the subtype level, and most of the community types are unchanged or little changed from the 3rd Approximation.

CONTENT OF DESCRIPTIONS

Species nomenclature

Vascular plant names in this document follow Weakley (2022) to the extent possible. Nonvascular plant, lichen, and animal names, used less frequently in this document, follow the Natural Heritage Program's rare plant and animal lists for rare species and the checklists on the 2020 North Carolina Biodiversity Project web site. Infraspecific taxa are named where there are multiple choices occurring in North Carolina or where it is particularly relevant, but they are sometimes omitted where they provide little additional information to a user familiar with North Carolina's flora or fauna.

Much change has occurred in the systematics and nomenclature of both plants and animals in the last several decades, including much since writing of the 4th Approximation began. Changes in nomenclature are challenging when compiling information from older published and unpublished literature, as well as when using plot data collected over a period of years. Particularly challenging are cases where taxa have been split. Such splits have necessarily been handled on a case-by-case basis. Where possible, an attempt has been made to choose the finer concept and to use the new name most likely to be present in a given community, or to give both if both are likely. However, when this is not obvious and the new name is ambiguous, the name is used as it was initially applied, or in some cases, both names are listed. Thus, by way of example, mentions of *Pteridium aquilinum* are treated as *Pteridium latiusculum* or *Pteridium pseudocaudatum* according to the regions where each predominates; *Viburnum nudum* is used for what might now be either the newly recognized species *Viburnum nitidum* or the newly narrower concept of *Viburnum nudum*; *Persea palustris* is used for older mentions of *Persea borbonia* for most communities, except both *Persea palustris* and *Persea borbonia* are named in the one community where both occur in North Carolina. Where new names are expected to be published but are not yet included in Weakley (2022), as in a new name for our *Carex pennsylvanica*, the older name is used. Finally, some names may be incorrect by current standards simply because the author did not become aware of the change in time to include it, and many more will be incorrect by future standards as taxonomic revision continues. Species names used in the NVC, which is based on a different nomenclatural standard, remain as they appear in NVC; they may therefore differ from names used elsewhere in the descriptions.

Where well-known plant names have been changed fairly recently, the older names are sometimes given in parentheses. This treatment is not systematic but is given to help the reader where it occurs. All choices to use parenthetical names are based on the author's idea of what names may not yet be widely known.

Subtype and Theme Descriptions

Detailed descriptions are given for each subtype and for each theme. No specific description is given for types, but they are characterized to some degree in both subtype and theme descriptions. Theme descriptions contain material that is common to all or most of the communities in the theme. This is particularly true for dynamics and for comments on classification history, which often are shared. The relative division of the content is different among different themes. The reader is advised to check both the subtype and theme description to learn all this document contains about a given community.

Descriptions are based primarily on the most intact examples that are known. More altered examples will fit the description to varying degrees and may be recognizable with reasonable interpretation of what has been changed. Pervasive alterations that have been present in all or most examples for a long time are generally incorporated into the descriptions of vegetation and other factors. Thus, mountain forests are described without *Castanea dentata*, but Canada Hemlock Forests continue to note the recent dominance of *Tsuga canadensis*. Vegetation is generally described as it exists after decades of fire suppression for most communities, but for longleaf pine communities, where prescribed burning has occurred in many examples for several decades, examples with regular fire but with past fire suppression are generally what is described.

Keys

Dichotomous keys are given for all community subtypes, organized by themes. The key leads organize and summarize information in the distinguishing features sections of the descriptions but are necessarily sometimes more abbreviated. As in all descriptive material, the keys are based on relatively unaltered occurrences. More heavily altered examples may be identifiable in some cases but not in others.

SPECIFIC COMPONENTS OF COMMUNITY DESCRIPTIONS

Concept: This is intended to give a brief statement of the idea the community represents. It was included in the 4th Approximation guide but has been substantially revised. In general, the concept is stated hierarchically, describing it first for the type, then for the subtype.

Distinguishing Features: The distinguishing features discussion is focused on the factors that help the user tell the subtype from the most similar communities. Again, generally the type is distinguished first, followed by indications of how to tell the subtype from other subtypes.

The reader should pay particular attention to cases where two or more characteristics are needed simultaneously to reach a classification. Care should also be taken with the wording for species. They may be dominant or abundant, or they may be indicators whose presence as anything more than stray individuals is sufficient. Where suites of species are named, only a few may be present, and any given species may be present only in a minority of examples, but several are generally needed to have confidence in the classification. To keep the section from getting too long, the lists of suites of species are necessarily less than exhaustive. Where the suite is characterized (e.g., species indicative of basic conditions), the user may know of other species in the suite that would also work to indicate the community. The vegetation descriptions give more detail about the abundance of species and name more species. The length of the distinguishing features section varies widely, and it can have very different proportions of material for recognizing the type or the subtype. The distinction of some communities can be explained in a few words, while others, especially those distinguished by differences in suites of species, may necessarily involve long lists.

Distinguishing features are generally based on communities in relatively natural condition. As communities become more altered, they become harder to tell apart. Ruderal or generalist species tend to become more dominant, and distinguishing species, which often are conservative, become scarer. The ability to identify heavily altered communities improves with experience, but at some level of alteration it becomes impossible.

Crosswalks: Closest equivalent crosswalks are given systematically for National Vegetation Classification (NVC) associations, NVC groups, and NatureServe ecological systems, and occasionally for other classifications. At the time of publication, NatureServe has indicated an intent to make groups the primary coarser-level focus of their ecology efforts. For the groups, the "colloquial" names are given rather than the plant species-based "scientific" names because these appear to be more informative for most purposes. Both groups and ecological systems are broader than single subtypes and associations. They are often comparable to each other in breadth but have a different emphasis in their classification. Both are somewhere between types and themes in breadth. Most associations are very similar to subtypes in breadth, but some may be broader, a few narrower, and a few related in more complex ways. It often is impossible to tell how NVC concepts are applied by other users, so exactness of correspondence is approximate. Occasionally, two associations may be listed as crosswalks, indicating that both concepts are subsumed in the subtype but that the first is considered the standard crosswalk. A number of these have been changed since the publication of the 4th Approximation Guide and even since release of early drafts of this document, as the NVC has continued to evolve. Additional relationships to NVC associations, generally less equal in fit, are noted in the comments section but are not treated as crosswalks. In a few cases where there is a comprehensive document on classification of a set of communities and it uses a different classification system or nomenclature, that too is listed as a crosswalk, but no effort has been made to note all the different names a community has been called in the many more local studies or descriptions.

Sites: The site section notes important aspects of the physical environment such as landform, slope position, aspect, geologic substrate, and elevation. Factors are named where they are particularly relevant but are not systematically named where a given character is the default or most common one. For example, occurrence on mafic rocks is often noted but occurrences on felsic rocks, the large majority of the landscape, is not. Similarly, elevations are noted for higher mountain communities but not for communities in the Piedmont or Coastal Plain.

Soils: Soils are characterized to the extent information is available, either by general characteristics or by soil taxa and series that are mapped. The CVS database includes many plots with soil chemistry and texture data, but these have not been compiled or analyzed well at present.

Hydrology: Water conditions, including degree of wetness, water dynamics, and sometimes sources of water or chemistry of water, are noted. While a simple characterization of water abundance (xeric, dry, or mesic) works for most upland communities, wetlands may be wet in different ways beyond simply how much water is present. Some are flooded irregularly, some as regularly as the tides, some are never flooded but are saturated almost all the time. In some, water moves through, while in others it stands for long periods. These have profound effects on the natural communities.

Vegetation: Vegetation is described in terms of structure and composition of vascular plants. Only occasionally are nonvascular plants noted, where easily distinguished taxa are particularly informative or important or where published literature makes detailed information on them available. Vegetation descriptions have been almost completely rewritten since the 3rd Approximation. They may be derived in any of several ways, with wording generally indicating which was used. Where comprehensive studies have been done, these are cited and the vegetation description is based largely or completely on them. Some incomplete analyses of CVS data are also indicated. If there is no comprehensive analysis but CVS plots for the community are numerous enough and appear accurately attributed to the community, summary statistics from them are used to describe the vegetation in detail. Such summaries are usually based on North Carolina plots only but may have included plots of nearby states where the author believed them to be comparable and likely to give a better description. Some other vegetation descriptions combine such statistics from plot data with more crude statistics of species frequency in site descriptions, where plots alone do not give an adequate picture. Site descriptions require their own form of judgment in interpretation, since some species lists are clearly limited in completeness and therefore may contribute to a false impression of species frequency.

Where data are sufficient, species are characterized by both dominance and frequency/constancy. The term "highly constant" generally denotes occurrence in 75% or more of plots or site species lists. "Frequent" or "fairly frequent" indicates species that occur in 25-75% of plots or site species lists. These categories must be regarded as approximate, since inclusion or exclusion of a few plots or sites can move some values across these arbitrary thresholds. Frequency in whole-site species lists means something different than it does in plots, since the area represented is very different. While highly constant and frequent species may be listed in various orders, such as grouping by genus or grouping by sources if there is more than one, they are often listed in order of frequency in the most important source used. Sparsely distributed or patchily distributed species may be frequent in sites but infrequent in plots. Other species may be infrequent even at the site level, perhaps due to dispersal limitations or to small population sizes that can be randomly lost from individual sites.

Species are characterized as dominant if they produce the majority of vegetation cover or (for trees) basal area in the stratum, individually or collectively, and as codominant if they are abundant but roughly equal in abundance with other species. It is difficult to characterize the interaction of frequency/constancy and dominance. A species may be usually present but less often dominant, or it may occasionally dominate even though it is present in only a minority of plots or sites. Species may dominate patches, or plots, but not dominate a large portion of the whole stand. Plot data summaries generally give average cover in plots where a species is present, but it can be difficult to tell if that cover is uniform or highly variable among plots. The author's experience or more detailed qualitative descriptions often provide better ideas of the relationship between frequency and dominance than do summarized plot data. Additional species that are neither dominant nor moderately frequent may be named where they are deemed to contribute to understanding of the community. Species described as "characteristic" are those that are believed to indicate the distinctive environment of the community when they occur, even though they appear infrequently. Most communities have a large number of species that are low in cover and frequency. Some of these are accidental in occurrence or are present only in transitions to other communities, while others reflect the site conditions in the same way the frequent species do. Much additional work could be done to describe these aspects of communities in more detail.

Plot data, vegetation descriptions, and information included based on the author's personal experience are all based on the least altered examples of each community. However, not only are no examples fully pristine, the degree of alteration in the best examples varies among different communities. Some kinds of alteration are less obvious, and some aspects of the unaltered natural vegetation may not be known. For some there is controversy or disagreement. This has been noted in some descriptions but may have been neglected in others. The more precisely the vegetation is described in terms of dominant or frequent species, the more those are based on the existing state rather than the more natural state that once existed.

Range and Abundance: The global ranks given in this section have been assigned by NatureServe for the crosswalked National Vegetation Classification (NVC) association. Global ranks are an index of imperilment of a species, or in this case a community (NatureServe 2023. Many of these were assigned some years ago and were done "by inspection" rather than based on the more detailed analysis that is the present standard for element ranks. Updated and more thorough analysis for all North Carolina's community global ranks awaits future work and is likely to result in changes. Abundance and geographic region of occurrence in North Carolina are noted, based on Natural Heritage Program occurrence data. Ranges in other states are generally based on NatureServe information for the synonymized NVC associations, except where the author has personal knowledge of the range in other states. These may change as the NVC continues to evolve.

Associations and Patterns: Most communities are characterized as small patch, large patch, or matrix communities, after the typology developed by NatureServe. The generalized concepts have been modified to fit the ecological patterns of North Carolina. Matrix communities do not generally single handedly form the landscape matrix, as occurs in some other regions. Instead, matrix communities are regularly repeating parts of a typical landscape mosaic. They could be expected in almost any large piece of that kind of landscape, generally aggregating to substantial acreage even if individual patches are not that large. Large patch communities are those that are not predictable parts of a typical landscape but that occur in large patches and occupy large acreage where they occur. They may be similar to the matrix communities around them or may contrast strongly. Because patches are large, they can have substantial interior area and support large populations of their component species. Small patch communities are unpredictable on the landscape; they are generally associated with distinctive environments that contrast strongly with the surrounding landscape. They occupy small areas and, though multiple patches may be present, generally they add up to only a few acres. They act as islands of habitat for species that generally have small populations and may either exhibit strong metapopulation dynamics or may support relict populations with little genetic exchange. Despite such isolation and despite small population sizes, or because of them, small patch communities imply long term stability and persistence, since species lost in disturbances or habitat changes would be very slow to recolonize. Small patch communities are inherently subject to strong edge effects from the contrasting adjacent communities, even in natural landscapes.

Variation: If variants have been recognized, they are named and briefly described in this section. Most variants recognized in the 3rd Approximation have become new subtypes, so variants are much fewer. Where no named variants are recognized, variation among examples is characterized in more general ways. Some communities are recognized to be highly variable, and it is likely that variants or even subtypes would be recognized with further study. Others are fairly uniform. Some are newly enough recognized or are rare and poorly studied, so that their variation is not well known.

Dynamics: The recognition of the importance of dynamics in natural communities has grown dramatically since the time the 3rd Approximation was published. Though belief in a truly static, unchanging climax state is probably a "straw man" that was never widespread, the role of natural and altered disturbance regimes, the idea of an interplay between static site characteristics and disturbance, the concept of dynamic equilibrium of patches, and other dynamic aspects of communities has certainly grown since that time. Research has been decidedly unequal, with some themes and specific communities being the focus of widespread study while others appear largely ignored. An attempt has been made to characterize what is known about dynamic aspects such as natural disturbance regimes and their importance, patterns of plant reproduction, stability and conservativeness of vegetation, and how particular environmental factors may be responsible for differentiating communities. Because some of these factors are more general than others, some of this discussion is at the theme level, some at the subtype level.

Comments: Comments are made on various aspects of the community that do not fit into other fields. Many of the comments in the 4th Approximation Guide are now placed in one of the other sections, but many communities still have material worthy of comment.

Rare species: Rare species characteristically associated with a community are listed to encourage users to be alert for their presence. This listing is based on taxa tracked by the Natural Heritage Program in 2023. Watch list species are not included.

The lists were assembled from three sources. For several years, rare species present were recorded along with the occurrence records for communities in the Natural Heritage Program database, and these formed a starting point for the lists. This process largely stopped some years ago, so it is most useful for species that the program has tracked for many years. The bulk of the listings came through input from experts who know the community classification as well as knowing a group of rare species. This input came either in a series of meetings or was contributed individually. The approach was particularly successful for vascular plants, where there are multiple experts. For most animal groups and for non-vascular plants, only one or two people were able to contribute. For some groups of animals, there was no contribution. As a final source for the lists, especially where there was little expert input, the author examined habitat descriptions and locations of known occurrences of the rare species.

The lists of rare species are necessarily imperfect, both in being incomplete and in naming species that may not actually be found in the community, but it is hoped that they will serve as a starting point both for aiding rare species survey and for understanding these crucial relationships. Several sources of bias are present and should be kept in mind. Species that might occur in many communities, such as *Isotria medeoloides* or many highly mobile vertebrates, may not be listed, or may be listed only for a few where they were previously linked to specific occurrences. Some common characterizations of habitat types can be equated to a small number of communities and therefore used for listing, which others are simply too broad. Thus, a species known to occur in spruce-fir forests or rich cove forests can be linked to all of the few communities. But a species of oak forests or Coastal Plain floodplain forests has too many possible communities to list them in all. Rarer communities, those that are less visited, and those that are newly recognized have less chance of particular species having been found in them, or of experts knowing they occur there. Some species, particularly among invertebrates and non-vascular plants, are simply too little known to tell what their habitat is, so they may not be listed anywhere or may be listed for only a fraction of the communities they occur in. Finally, there is an unavoidable bias in that the finite group of experts who contributed know some species and some communities better than others.

There are two final cautions in using the rare species lists. Some species use a given community only within a narrow geographic range in the state. These are listed if the community relationship is specific enough. Some species occur only in a specialized type of microsite in a community. Listing a species in these cases is necessarily a judgment call, one that depends on an assessment of how frequent the microhabitat is within occurrences of the community. Thus, moist rock outcrops near streams are particularly common in Acidic Cove Forests, so their species are listed for those communities. Species associated with dead snags or large old trees, which can occur in many different kinds of forest, are not listed.

Bibliography: Only references cited in the community description are included in the bibliography. Additional references relevant to a given subtype may be cited instead in the theme description. General references that are used for many descriptions are not specifically cited in each. These include reports produced by the Natural Heritage Program, contributed unpublished reports in its files, the CVS database, and the NVC descriptions of associations. Also implicitly used throughout are Weakley (2022), the USDA soil taxonomy, SSURGO soil mapping, and the content of Soil Web. The 3rd Approximation book cited numerous unpublished and internal reports such as Natural Heritage Program county natural area inventories, individual site reports, and contributed class reports. These are not cited in the 4th Approximation simply because they have become too numerous for it to be practical. The number of such documents has increased five- to ten-fold since 1990. The contribution of each report is more diffuse, and most are used as a source of summary data or as contributions to the general knowledge of the author.

FUTURE OF NORTH CAROLINA NATURAL COMMUNITY CLASSIFICATION

The 4th Approximation represents more than 30 years of work since the publication of the 3rd Approximation, but the continued use of the term "approximation" in the title indicates the recognition that this book will not be the last word in community classification. Data analysis by the CVS investigators is likely to lead to new insights. A comprehensive book on vegetation of the Carolinas by CVS is expected in the next few years. Further experience gained by using this classification and the NVC by the Natural Heritage Program and others will yield new insight. It is hoped that new investigation can address the areas of the classification where uncertainty most clearly remains.

Several areas in the 4th Approximation are already recognized as inadequate and in need of further study or revision. Many are mentioned in the various descriptions, and many outstanding classification issues are informally listed in an appendix. Of particular note are the most heterogenous subtypes. Low Elevation Basic Glade (Montane Subtype), Piedmont Alluvial Forest, Coastal Plain Small Stream Swamp, Sandhill Seep, and Maritime Wet Grassland are examples of communities where further work is likely to lead to recognition of new subtypes. The several communities that are accepted as provisional may end up being better described or may end up getting dropped as we come to understand them better. Increasing prescribed burning, especially in the mountains, may lead to better characterization of communities such as those in the Mountain Dry Coniferous Woodlands and the Piedmont and Mountain Glades and Barrens themes. Better understanding of the ecological behavior of species such as *Pinus strobus* may lead to different interpretation of communities where they are important to classification.

Feedback on the communities and evidence of unrecognized communities, as well as information on unknown good examples, is requested, solicited, and encouraged.

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KEY TO THEMES

1. Upland communities; xeric to mesic and not subject to significant flooding or saturation. Generally not on alluvial soils, though rare examples may be on high terraces above current natural flood levels. Volume 1.

2. Forest and woodland communities; trees dominant in an open or closed canopy, generally with 25% or more tree cover where not recently subject to catastrophic natural or anthropogenic disturbance. (Most sites that have had catastrophic disturbance generally show evidence of having been dominated by trees, but some may require knowledge of past conditions that no longer are obvious).

3. Forests dominated or codominated by red spruce (*Picea rubens*), Fraser fir (*Abies fraseri*), or mountain ash (*Sorbus americana*), occurring in the Mountains at high elevations (generally above 5000 feet, most above 5500 feet). (Examples formerly dominated by Fraser fir and examples that experienced logging and severe fire may remain without tree recovery for decades and be difficult to recognize). .... **Spruce–Fir Forests**

3. Forests and woodlands not dominated by these species, though they may occasionally be present in small numbers.

4. Communities dominated or codominated by longleaf pine (*Pinus palustris*) under natural conditions; of the Coastal Plain or eastern Piedmont; canopies naturally open, patchy woodlands or savannas but may become dense with alteration of fire regimes (a few of the Sand Barrens may have only sparse longleaf pine, and instead have turkey oak (*Quercus laevis*) dominant). .... **Dry Longleaf Pine Communities**

4. Communities not as above; longleaf pine naturally absent or extremely scarce.

5. Forests dominated or codominated by live oak (*Quercus virginiana*) or sand laurel oak (*Quercus hemispherica*), along with loblolly pine (*Pinus taeda*). Most also contain wild olive (*Cartrema americana*) or yaupon (*Ilex vomitoria*).

6. Forests occurring on barrier islands, small islands in marshes, or on upland sites within a few miles of the coast. .... **Maritime Upland Forests**

6. Forests occurring farther inland, on upland ridges surrounded by floodplain or wetland communities.. ....**Swamp Island Evergreen Forest in Piedmont and Coastal Plain Oak Forests**

5. Forests or woodlands not dominated or codominated by live oak or sand laurel oak, usually completely lacking the above species.

7. Piedmont and Mountain woodlands of xeric sites or extreme site conditions; communities tending toward open canopies because of shallow soil, montmorillonite (shrink-swell clay) hardpan subsoil, sharply convex topography, or steep slopes with southerly aspect; canopies open to sparse under natural fire regimes, but may become dense with long exclusion of fire.

8. Woodlands or open forests on shallow soils associated with granitic flatrock outcrops, with nearly flat exfoliated rock surfaces .... **Granitic Flatrock Border Woodland in Granitic Flatrocks**

8. Communities not as above.

9. Woodlands of extreme site conditions, including shallow soil over rock, montmorillonite clay subsoil, unstable shale, or the most xeric steep slopes in the Piedmont; canopy, if present, dominated by oaks or conifers. .... **Piedmont and Mountain Glades and Barrens**

9. Less extreme though dry sites in the Mountain region and mountainous areas in the upper Piedmont, dominated or codominated by conifers; often on sharply convex ridges and dry slope aspects at low to medium elevations...**Mountain Dry Coniferous Woodlands**

7. Forests of favorable mesic to dry sites across the state; communities tending toward closed canopies in the absence of fire; more open but with substantial canopy under more natural fire regimes; lacking canopy only in gaps or temporarily after catastrophic disturbance.

10. Forests of the Mountain region; or of mountainous upper Piedmont areas and containing multiple species characteristic of the Mountains and not of the Piedmont (e.g., basswood (*Tilia americana* var. *heterophylla*), sweet birch (*Betula lenta*), yellow birch (*Betula alleghaniensis*), cucumber magnolia (*Magnolia acuminata*), American chestnut (*Castanea dentata*), mountain laurel (*Kalmia latifolia*), flame azalea (*Rhododendron calendulaceum*), buffalo nut (*Pyrularia pubera*), black huckleberry (*Gaylussacia baccata*), bear huckleberry (*Gaylussacia ursina*), Table Mountain pine (*Pinus pungens*), pitch pine (*Pinus rigida*), Carolina hemlock (*Tsuga caroliniana*), Canada hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*)).

11. Mountain and upper Piedmont forests naturally dominated or codominated by conifers.

12. Forests dominated or codominated by hardwoods, with Canada hemlock or white pine codominant or a significant component.

13. Forests codominated by oaks, with white pine codominant or a minor component ....**Mountain Oak Forests**

13. Forests dominated by Canada hemlock or codominated by it with mesophytic hardwoods ....**Mountain Cove Forests**

12. Forests naturally dominated by Carolina hemlock, white pine, or yellow pines, without appreciable Canada hemlock (These must be distinguished from successional forests and plantations of white pine and other conifers) ....**Mountain Dry Coniferous Woodlands**

11. Mountain and upper Piedmont forests naturally dominated by hardwoods, or sometimes codominated by hardwoods and conifers.

14. Forests dominated by oaks (*Quercus* spp.), or rarely hickories (*Carya* spp.), or codominated by oaks with white pine; generally on open slopes or ridges (If mesophytic hardwoods are abundant, communities are on ridges or other exposed topography. Yellow pines may be abundant in transitions to drier communities) ....**Mountain Oak Forests**

14. Forests not dominated by oaks, though red oak (*Quercus rubra*) may codominate and other oaks may be present in smaller amounts.

15. Mesophytic forests of higher elevations; generally above 4000 feet, though varying with latitude and slope aspect; on sheltered or open topography; dominated by yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), or buckeye (*Aesculus flava*), occasionally with Canada hemlock codominant, sometimes with other species abundant; species characteristic of lower elevation (e.g., tulip poplar (*Liriodendron tulipifera*), cucumber magnolia (*Magnolia tripetala*), Fraser

magnolia (*Magnolia fraseri*), flowering dogwood (*Cornus florida*)) generally absent .... **Northern Hardwood Forests**

15. Mesophytic forests of mid to lower elevations, generally below 4000 feet; on sheltered topography such as coves or lower slopes (though slopes may be concave or convex); communities often but not always with higher species richness; species characteristic of high elevations generally absent (e.g., yellow birch (*Betula alleghaniensis*), red spruce (*Picea rubens*), witch hobble (*Viburnum lantanoides*)) .... **Mountain Cove Forests**

10. Forests of the Coastal Plain, central to eastern Piedmont, or of the upper Piedmont but lacking most species characteristic of the Mountain region.

16. Forests dominated by oaks (*Quercus* spp.), or rarely hickories (*Carya* spp.); lacking significant presence of beech (*Fagus grandifolia*); yellow pines are often present and may locally codominate; (tulip poplar (*Liriodendron tulipifera*) is abundant only in successional states; red maple (*Acer rubrum*) may be codominant or dominant if oaks have been removed and not regenerated) . ... **Piedmont and Coastal Plain Oak Forests**

16. Mesophytic forests not dominated by oaks; beech (*Fagus grandifolia*), tulip poplar (*Liriodendron tulipifera*), or other mesophytic species generally dominate, though oaks may codominate with these species; rarely a mix of Coastal Plain wetland and upland hardwoods and conifers with few oaks.

17. Outcrops of limestone in the Coastal Plain, generally without many trees on the rocks but often shaded by an adjacent mesophytic canopy. .... **Coastal Plain Marl Outcrop**

17. Mesophytic forest not as above, rocky or more often with deep soil.

18. Rare forests on calcareous sites (shell middens) near the coast, dominated or codominated by calciphilic species such as sugarberry (*Celtis laevigata*) and Carolina basswood (*Tilia americana* var. *caroliniana*); or rare forests of barrier islands dominated or codominated by deciduous hardwoods such as southern red oak (*Quercus falcata*) and beech (*Fagus grandifolia*) .... **Maritime Upland Forests**

18. Common Piedmont and Coastal Plain mesophytic forests of sheltered slopes and low-lying mesic upland areas.**Piedmont and Coastal Plain Mesic Forests**

2. Shrub, herbaceous, or sparse vegetation; trees, if present, generally having less than 25% cover over the whole community, even in the absence of recent catastrophic natural or anthropogenic disturbance. Community aspect is open, without the impression of a tree canopy, though local patches of trees may exist.

19. Rock outcrop communities; bare or lichen-covered bedrock or talus covers the majority of the area of the community; vegetation is limited in cover and is patchy, confined to soil mats or pockets or to edges; vegetation generally is heterogeneous in structure.

20. Rock outcrop communities of high elevations, generally above 3000-3500 feet; flora indicative of high elevation present (e.g., *Bryodesma (Selaginella) tortipilum*, *Sibbaldiopsis tridentata, Trichophorum caespitosum, Carex brunnescens, Geum radiatum, Liatris helleri, Solidago spithamaea, Houstonia montana, Rhododendron (Menziesia) pilosum, Abies fraseri, Picea rubens*, and *Sorbus americana*) .... **High Elevation Rock Outcrops**

20. Rock outcrop communities of the Piedmont, lower elevation Mountains, and rarely Coastal Plain; high elevation species lacking.

21. Outcrops of limestone in the Coastal Plain; rock bare or moderately vegetated but may be shaded by mesophytic trees rooted in adjacent deeper soil..**Coastal Plain Marl Outcrop**

21. Other rock outcrop communities of the Piedmont, lower elevation Mountains, or rarely Coastal Plain.

22. Outcrops of flat or gently sloping exfoliated granitic rock in the Piedmont (i.e., flatrocks or pavements); vegetation primarily of annual herbs, perennial herbs, shrubs, and trees on thin soil mats over unbroken bedrock; characterized by a distinct flora that include *Diamorpha smallii, Minuartia glabra, Packera tomentosa,* and *Croton willdenowii (= Crotonopsis elliptica*)..**Granitic Flatrocks**

22. Other rock outcrop communities of the Piedmont, lower Mountains, or rarely Coastal Plain; near-vertical cliffs, craggy outcrops on exposed sites, sloping exfoliated granitic rock (granitic domes), or open talus; sparse vegetation of varying structure rooted in crevices or deeper soil pockets in irregularities of the rock surface, or vegetation mats on thin soil mats over unbroken bedrock . ...**Low Elevation Cliffs and Rock Outcrops**

19. Communities not rock outcrop communities as above (though often rocky or with shallow soil); more densely vegetated with herbs or shrubs, or sparsely vegetated but with cover not limited by bare rock; if associated with rock outcrops, having shallow soil and at least herbaceous vegetation over most of the area.

23. Maritime communities; on barrier islands and beach areas; shrubland, herbaceous, or sparse vegetation on sand; non-forested because of chronic sea water overwash, heavy salt spray, or young age of substrate.

24. Maritime communities dominated by shrubs (or shrub-size trees)................................ ....**Maritime Upland Forests**

24. Maritime communities dominated by grasses, trailing vines, or sparse vegetation......... ....**Maritime Grasslands**

23. Non-maritime communities throughout the state; not as above; densely or moderately vegetated.

25. High elevation Mountain communities persistently dominated by dense shrubs, grasses, or sedges...**Grass and Heath Balds**

25. Communities not as above; moderately to densely vegetated; in a variety of environments in all regions.

26. Communities of deep sands of relict dunes in the Coastal Plain (inland from the barrier islands); vegetation sparse due to excessive natural soil drainage (must be distinguished from heavily disturbed sandy sites); longleaf pine (*Pinus palustris*) and turkey oak (*Quercus laevis*) predominant; ground cover sparse, dominated by characteristic sand-tolerating species such as wire plant (*Stipulicida setacea*), spiny spikemoss (*Bryodesma acanthonota = Selaginella arenicola*), and reindeer lichens (*Cladonia* spp.)... ....**Sand Barren in Dry Longleaf Pine Forests**

26. Community not as above; vegetation structure a glade (open variable mix of herb, shrub, tree dominance, with bare rock a minority of the area) or barren (open to sparse tree canopy with moderate to dense herbaceous layer); non-forested because of extreme soil conditions, such as shallow soil over rock, montmorillonite clay subsoil, or unstable shale. ....**Piedmont and Mountain Glades and Barrens**

1. Wetland communities: jurisdictional wetlands, floodplains, and estuarine communities; subject to significant soil saturation, standing water, or flooding by river, stream, estuarine, or ocean waters. Volume 2.

27. Community in a floodplain; influenced by at least occasional river or stream flooding and generally occurring on alluvial soils or organic soils along drainages; may or may not be jurisdictional wetlands; (some themes with ambiguous flood influence but along drainages are keyed in both places).

28. Floodplain in the Piedmont and Mountains, including Fall Zone floodplains constrained by bedrock.

29. Piedmont and Mountain alluvial communities; occurring along stream or river channels; and containing at least some characteristic alluvial species such as sycamore (*Platanus occidentalis*) or river birch (*Betula nigra*); usually containing a large, distinct alluvial, beaver pond, or bar flora, but sometimes consisting substantially of mesophytic species; species of bogs and seeps absent or scarce; hydrology ranges from rarely flooded to frequently flooded to permanently inundated...**Piedmont and Mountain Floodplains**

29. Saturated wetlands; not influenced by river/stream flooding, or vegetation indicating greater influence by long-term saturation than by flooding by water from a river or stream.

30. Bog flora present at least in numerous pockets in the community (if not throughout, the rest of the community generally mesophytic, without alluvial flora); characteristic bog species include peat moss (*Sphagnum* spp.), a number of sedges (*Carex folliculata, collinsii, trisperma, atlantica, echinata, baileyi)*, cranberry (*Vaccinium macrocarpon*), cottongrass (*Eriophorum virginicum*, carnivorous plants (*Sarracenia jonesii, Sarracenia purpurea* var. *montana*, *Drosera rotundifolia*), and a diversity of others .... **Mountain Bogs and Fens**

30. Bog flora substantially absent; communities either: a. rock kept saturated by spray from waterfalls, with vegetation a mix of mesophytic and wetland species and abundant bryophytes, or b. mineral or mucky seeps on edges of floodplains (or in uplands), with vegetation containing seepage species not characteristic of bogs (e.g., spicebush (*Lindera benzoin*), sensitive fern (*Onoclea sensibilis*), netted chain fern (*Steinchisma areolata*), lizard's-tail (*Saururus cernuus*), arrow arum (*Peltandra virginica*)) along with a few species shared with bogs (e.g., cinnamon fern (*Osmundastrum cinnamomeum*), occasionally peat moss (*Sphagnum* spp.)). ....**Low Elevation Seep or Spray Cliff in Upland Seepages and Spray Cliffs**

28. Floodplain in the Coastal Plain, occurring on alluvial or organic soils in valleys unconfined by bedrock.

31. Communities along small drainages, sandhills terrain (mostly in the Sandhills region but occasionally elsewhere in the Coastal Plain), with mucky soils kept saturated by seepage; seldom flooded because of rapid infiltration of even heavy rains into the sandy upland soils; characteristic alluvial or floodplain species not present; fire an important influence; vegetation dominated or codominated by pond pine (*Pinus serotina*), Atlantic white cedar (*Chamaecyparis thyoides*), or vegetation a nearly treeless canebrake (dominated by *Arundinaria tecta*)... **Streamhead Pocosins**

31. Communities along small to large rivers or streams; usually with clear evidence of brief to long-duration flooding; vegetation containing substantial numbers of alluvial species (e.g., sycamore, river birch, sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*)), bottomland oaks (*Quercus laurifolia, lyrata, michauxii, pagoda*), or swamp species (cypress

(*Taxodium* spp.), water tupelo (*Nyssa aquatica*), swamp black gum (*Nyssa biflora*)), or consisting of an open water or marshy impoundment or open bar; if occurring in a seepage-saturated drainage in sandhills terrain, then the canopy dominated by swamp black gum or the community an impoundment.

32. Community subject to tidal flooding, by lunar or wind tides; forest dominated by swamp black gum, cypress, or green ash....**Tidal Swamp in Freshwater Tidal Wetlands**

32. Community not subject to tidal flooding; intermittently to seasonally flooded by river or stream flow, or semipermanently flooded by impounded waters in a floodplain ....**Coastal Plain Floodplains**

27. Non-floodplain wetlands and estuarine communities; not influenced by river or stream flooding, or river flooding less important than tidal flooding or long-term saturation; vegetation not generally containing alluvial species.

33. Estuarine and Tidal communities; subject to daily or frequent flooding by lunar or wind tides, or frequent overwash by salt water.

34. Communities subject to frequent flooding by salt or brackish water; flooded by lunar or wind tides, at least at the highest tides; or frequently flooded in storms (some Maritime Grasslands and Maritime Wetlands are less frequently flooded by salt water overwash); vegetation consisting of salt-tolerant species with structure of marsh, open shrubland, or sparse vegetation ....**Estuarine Communities**

34. Communities subject to regular or frequent tidal flooding only by fresh or oligohaline water (though potentially influenced by salt water in major storms); vegetation containing substantial amounts of species intolerant of brackish or salt water (usually dominated by them); vegetation structure usually dense marsh or swamp woodland or forest ....**Freshwater Tidal Wetlands**

33. Other wetlands; hydrology predominantly driven by ponded rainwater, high water table, sheet flow, or seepage, without significant influence by stream or tidal flooding; both alluvial and salt-tolerant species absent or unimportant.

35. Wetlands on barrier islands, in dune swales or flats not subject to frequent salt water overwash (though some may be overwashed or flooded during severe storms); vegetation ranging from swamp forests to shrubland to marsh to open water ponds .... **Maritime Wetlands**

35. Wetlands not on barrier islands; in a variety of sites.

36. Wetlands in or on the edges of distinct basins that hold standing water seasonally or permanently.

37. Wetlands on edges of large to medium size natural lakes; subject to the hydrology of the lake and potentially subject to lake flooding or wave action; vegetation structure marsh or forest ....**Natural Lake Communities**

37. Wetlands in or on the edges of small ponds or in basins that don't contain permanent standing water; vegetation various.

38. Wetlands in small basins that hold water semipermanently or in small to large basins that hold standing water seasonally.

39. Small depression wetlands of the Piedmont and rarely the Mountains; perched wetlands on upland flats or ridge top saddles; generally on montmorillonite or impermeable clay soils; seasonally flooded at least into the early growing season; vegetation structure forest to open shrubland, characterized by willow oak (*Quercus phellos*), overcup oak (*Quercus lyrata*), buttonbush (*Cephalanthus occidentalis*),

swamp black gum (*Nyssa biflora*), coastal fetterbush (*Eubotrys racemosus*), or highbush blueberry (*Vaccinium fuscatum*) .... **Piedmont and Mountain Upland Pools and Depressions**

39. Small depression wetlands of the Coastal Plain; Carolina bays, limesink depressions, swales in dune fields, rarely relict fluvial features in river terraces now above flood levels; flooded seasonally to semipermanently; vegetation structure forest, shrubland, drawdown meadow, marsh, or open water .... **Coastal Plain Depression Communities**

38. Wetlands in small to large basins that have high water tables or saturated soils but rarely if ever contain standing water.

40. Carolina bays or swales with organic soil surface (Histosols or Spodosols or Inceptisols with an organic surface); vegetation dominated by dense evergreen or Ericaceous shrubs or by pond pine (*Pinus serotina*) .... **Peatland Pocosins**

40. Limesink depressions or relict dune swales that do not appear to flood and which contain wiregrass (*Aristida stricta*).. **Wet Pine Flatwoods (Depression Subtype) in Wet Pine Savannas**

36. Wetlands not in or on the edges of basins, or in basins that never hold standing water that influences the vegetation.

41. Longleaf pine communities; wetlands on mineral soils in the Coastal Plain (or occasionally outer Piedmont); naturally subject to frequent fire; vegetation a savanna or woodland naturally dominated or codominated by longleaf pine (*Pinus palustris*); in natural condition, communities have a dense herbaceous layer dominated by grasses (wiregrass (*Aristida stricta*), dropseed (*Sporobolus pinetorum, Sporobolus teretifolius*), toothache grass (*Ctenium aromaticum*), little bluestem (*Schizachyrium scoparium*), or other species of similar ecology (examples with long fire exclusion may be invaded by shrubs and other trees, but remnants of longleaf pine or characteristic savanna species indicate past more open conditions) .... **Wet Pine Savannas**

41. Other wetlands, of all regions; mineral or organic soils.

42. Other nonalluvial wetlands of Coastal Plain flats; flat areas influenced by seasonal high water table, limited runoff of rainfall, and sheet flow; never containing longleaf pine; natural fire less frequent or absent; forests, woodlands, or shrublands.

43. Wetlands on wet flats adjacent to Estuarine Communities or Freshwater Tidal Wetlands; not subject to regular or frequent tidal flooding but influenced by sea level and occasionally flooded during major storms; forests or woodlands naturally dominated by loblolly pine (*Pinus taeda*), or dominated by pond pine (*Pinus serotina*) but without characteristic pocosin shrubs and containing wax myrtle (*Morella cerifera*) ...... **Estuarine Fringe Pine Forest in Estuarine Communities**

43. Community not on wet flats adjacent to Estuarine or Freshwater Tidal Wetlands. If near an estuary, vegetation not as above; if dominated by *Pinus*, without appreciable *Morella cerifera*.

44. Pocosin; vegetation with a dense shrub layer containing fetterbush (*Lyonia lucida*), gallberry hollies (*Ilex glabra, Ilex coriacea*), titi (*Cyrilla racemiflora*), honeycup (*Zenobia pulverulenta*), leatherleaf (*Chamaedaphne calyculata*), cane (*Arundinaria tecta*), and laurel-leaf greenbriar (*Smilax laurifolia*), with or without an open canopy of pond pine (*Pinus serotina*), loblolly bay (*Gordonia lasianthus*), or other evergreen hardwoods; if the canopy contains any deciduous

hardwoods, these don't include appreciable swamp black gum (*Nyssa biflora*) and include no oaks (*Quercus* spp.) or sweetgum (*Liquidambar styraciflua*); deep to shallow organic deposits in large peatlands, organic-filled swales, and peat-filled Carolina bays; Coastal Plain wetlands with organic soils (Histosols or organic-rich Spodosols); (note somewhat similar vegetation in seepage-fed streamheads under alternative number 43 below... **Peatland Pocosins**

44. Not pocosin; forest of swamp black gum, cypress (*Taxodium distichum, Taxodium ascendens*), wetland oaks, or Atlantic white cedar (*Chamaecyparis thyoides*), sometimes with loblolly pine (*Pinus taeda*); some of the above shrubs of pocosins may be present, but are not extremely dense and are not associated with pond pine; organic or mineral soils (usually finer-textured Ultisols or more mineral-rich Histosols); sometimes with shallow seasonal flooding from rainfall; (in organic soil swamps along wind tidal rivers, lack of tidal flooding and a shift to these communities is indicated by the dominance of more acid-tolerant shrubs that are shared with pocosins) .... **Coastal Plain Nonalluvial Wetland Forests**

42. Seepage or spray wetlands of all regions; influenced primarily or exclusively by water emerging diffusely from the ground (or rarely by spray from waterfalls); saturated permanently or seasonally but rarely or never with standing water; occurring on sloping topography or at the base of a slope (sometimes in floodplains or drainage bottoms).

45. Sandhill streamheads; wetlands along drainages in sandhill areas, mostly in the Sandhills region but occasionally in other sandy Coastal Plain areas; sites saturated by seepage from adjacent sandhills, with limited stream flooding; soils organic-rich mineral soils.

46. Vegetation a swamp forest dominated by swamp black gum (*Nyssa biflora*), alone or with other deciduous hardwoods, sometimes with some pond pine (*Pinus* serotina)................ **Sandhill Streamhead Swamp in Coastal Plain Floodplains**

46. Vegetation a forest of Atlantic white cedar (*Chamaecyparis thyoides*), a shrubland dominated by cane (*Arundinaria tecta*), or a pocosin (similar to lead 45 above but usually also with tulip poplar (*Liriodendron tulipifera*) and poison sumac (*Toxicodendron vernix*) which are never present in the above) .... **Streamhead Pocosins**

45. Other seepage or spray wetlands of all regions.

47. Cliffs and steep slopes kept wet by spray from a waterfall, often along with seepage; vegetation a mix of mesophytic and wetland species and abundant bryophytes........................... **Spray Cliff in Upland Seepages and Spray Cliffs**

47. Wetlands without spray from waterfalls.

48. Wetlands of the Mountains and upper Piedmont with bog flora present at least in numerous pockets in the community); characteristic bog species include peat moss (*Sphagnum* spp.), a number of sedges (*Carex folliculata, collinsii, trisperma, atlantica, echinata, baileyi)*, cranberry (*Vaccinium macrocarpon*), cottongrass (*Eriophorum virginicum*), carnivorous plants (*Sarracenia jonesii, Sarracenia purpurea* var. *montana*, *Drosera rotundifolia*), and a diversity of others; soils generally mucky................................... **Mountain Bogs and Fens**

48. Other seepage wetlands of all regions.

49. Seepages of the Sandhills region and occasionally of similar Coastal Plain sandhill areas; side slopes surrounded by upland communities or between uplands and Streamhead Pocosins or floodplains; vegetation either densely shrubby or herbaceous, sharing species with Streamhead Pocosins and Wet Pine Savannas; naturally subject to frequent fire .... **Sandhill Seep in Wet Pine Savannas**

49. Other seepage wetlands of all regions; vegetation highly variable.......... .... **Upland Seepages and Spray Cliffs**

SPRUCE–FIR FORESTS THEME

Concept: Spruce–Fir Forests are communities of the highest elevations in North Carolina, naturally dominated or codominated by *Picea rubens* or *Abies fraseri*.

Distinguishing Features: Spruce–Fir Forests are distinguished from all other natural communities by the present or former dominance or codominance of *Picea rubens, Abies fraseri*, or occasionally *Sorbus americana*, in upland sites at elevations above 5000 feet. Severely disturbed examples may be dominated by *Rubus canadensis*, residual *Betula alleghaniensis*, or by a variety of shrub species. A few of examples of Mountain Bogs and Fens may be dominated or codominated by *Picea rubens*, but these will have saturated soils and wetland species such as *Sphagnum spp*. at least in substantial portions.

Within the theme, Fraser Fir Forests are distinguished by dominance by *Abies fraseri* at the highest elevations, greater than 67% before balsam woolly adelgid-caused mortality. The Red Spruce–Fraser Fir Forest type has a canopy naturally dominated or codominated by *Picea rubens*, often in combination with *Abies fraseri* or *Betula lenta*.

Sites: Spruce–Fir forests occupy almost all landforms at the highest elevations. Other than seepage-fed wetlands and rock outcrops, they cover the high peaks. The lower elevation for continuous spruce-fir forest mosaics is around 5500 feet, but some subtypes extend in local patches down to 4500 feet or even 4000 feet. A pattern of inverted elevation zones is occasionally observed, where Spruce–Fir Forests occur below other communities such as Northern Hardwood Forests or Mountain Oak Forests in sheltered coves or areas with cold air drainage.

Soils: Spruce-Fir Forests are generally mapped as Inceptisols (Humadepts) of the Burton, Craggey, and Wayah series, but those in the Great Smoky Mountains are more recently mapped as Clingman (Lithic Udifolist). In ecological literature on spruce-fir forests, soils are generally described as organic rich and extremely rocky, often as consisting of nothing but organic matter over rock. However, many sites can be observed to have loamy soil which, though rocky, is fairly deep, and many sites have extremely heterogenous soils. It has been noted in West Virginia that spruce forests generally have Spodosols, in contrast to other kinds of soils under hardwoods there. It is believed that the acidic litter of spruce or hemlock is responsible for creation of the spodic horizon (Nauman et al. 2015). This has been used to identify sites for restoration of spruce forest. Extensive Spodosols have not been identified in North Carolina, but some may be found as one component of a heterogeneous soil mix.

Hydrology: Spruce–Fir Forests are mesic to wet due to high rainfall, long periods bathed in fog, low temperatures, and, often, high water-holding capacity in the organic-rich soil. Several high mountain ranges have had measured average annual rainfall of 70-80 inches, and studies have found a comparable amount of additional water input through dripping of fog moisture. Praskievicz and Sigdel (2023) found smaller but still significant water input and found spruce and fir much more efficient than northern hardwood species at capturing it.

Rime ice is also common in winter. Although not commonly considered wetlands, many sites may at times be saturated for long periods in the growing season.

Vegetation: Communities of this theme are naturally closed forests with small canopy gaps, where not recently disturbed. *Picea rubens* and *Abies fraseri* codominate in most of the elevational range, while *Abies* becomes dominant at the highest elevations. *Picea* may dominate at the lowest elevations, but more often codominates with *Betula alleghaniensis*. *Sorbus americana* may occasionally dominate or codominate locally. Lower strata vary among communities, but most examples contain members of a suite of characteristic species that are seldom found in lower elevation communities. These include *Oxalis montana*, *Dryopteris campyloptera, Clintonia borealis*, *Sambucus racemosa* var. *pubens*, *Vaccinium erythrocarpum*, and a number of bryophytes such as *Hylocomium splendens*. A large suite of rare plant and animal species also occur primarily in Spruce–Fir Forests.

Canopy composition has been drastically altered by the introduction of the balsam woolly adelgid (*Adelges piceae*), which killed all adult firs in the 1960s–1970s. Since that time, some stands have increased in cover of *Picea*, *Sorbus*, and *Betula*, others have also had significant spruce mortality and now are nearly treeless, and in others, surviving *Abies* seedlings have grown into dense stands of young canopy trees. Old growth stands before the adelgid were notable for their large basal areas, and some remain so (Smith and Nichols 1999, 39.6 sq. m/ha.; Rose and Nicholas 2008).

Dynamics: These communities in the natural state are uneven-aged, with abundant large, old trees. Work on population dynamics has found formation of small gaps by the death of one or several trees to be the most common mode of natural disturbance and gap phase regeneration the typical mode of tree reproduction (Busing 1985; White, MacKenzie, and Busing 1985). Natural fire is essentially absent in these communities, and the large blowdowns that are known are generally associated with artificial openings. Observations in the 1980s–2000s suggest that both ice and wind storms are significant factors creating small to medium size gaps, which may be numerous after major storms.

Both spruce and fir produce abundant seedlings that are shade-tolerant and persist beneath the closed canopy until a gap is produced. However, this advanced regeneration can be observed to be extremely variable and patchy. Spruce is among the most shade-tolerant of trees, able to achieve up to 82% of its maximum photosynthesis at light levels found in sun flecks beneath a canopy (Alexander et al. 1995). Rentch et al. (2016), in West Virginia, found understory spruce individuals 20-70 years old. Conversely, high light levels, especially when they appear suddenly, have been observed to harm spruce. Fox (1977) suggested a reciprocal replacement pattern between spruce and fir, with each tending to invade gaps left by the other. However, Busing (1985) found that fir was more likely to capture gaps made by all species. Spruce retained dominance or codominance despite its lower probability of gap capture because of its much greater longevity (300-400 years vs. 70-100 for fir). Yellow birch captured enough gaps to remain a permanent minor part of the community. Logging of spruce-fir forests without slash fires, as happened on Roan Mountain, can lead to nearly pure stands of fir at elevations that would otherwise have mixed canopies.

Spruce-fir forests are especially vulnerable to human-caused disturbances such as logging and associated fire, as was widespread in the early 1900s. When the canopy was removed, the soil organic layer was able to dry and carry fire. Logging slash fires were described as consuming the organic soil itself as well as the seedling bank. The dominant trees, particularly spruce, were often unable to reestablish in cleared and burned areas (Korstian 1937; Saunders 1979; Pyle and Schafale 1985, 1988), and many burned areas have not reestablished full forest cover after more than a century. Though the failure of regeneration was sometimes attributed to the loss of organic soils, a similar failure is apparent on many deep mineral soils. However, Brown (1941) noted that spruce and fir were able to invade Grassy Balds and Heath Balds on Roan Mountain.

All Red Spruce–Fraser Fir Forests that escaped logging have been disturbed in recent years by the balsam woolly adelgid (*Adelges piceae*), an introduced insect pest that spread through the region in the 1960s. The adelgid kills essentially all adult firs but is not able to infest young firs that have smooth bark. The degree of disturbance depends on the amount of *Abies fraseri* initially present. Short term changes resulting from fir death included an increase in *Rubus canadensis* and various shrubs, and a decrease in moss and forest herbs (Boner 1979; DeSelm and Boner 1984). Jenkins (2003) noted a decline in *Oxalis montana* and *Clintonia borealis*, an increase in *Dryopteris campyloptera*, and a drastic increase in *Rubus*. Boner (1979) found that seedlings of fir increased with time since adelgid attack. Witter and Ragenovich (1986) suggested that fir seedlings present at the time of attack would be able to mature and reproduce before succumbing to the adelgid. But they noted that if this fails to occur in most places, *Abies fraseri* will cease to be a significant part of these high elevation southern Appalachian communities, since there is no seed bank in the soil. The author's observations suggest longer term results have been quite variable. Young firs have matured into well-developed canopies in many areas in all mountain ranges where they occur, but substantial areas still have broken canopies or remain treeless *Rubus* thickets. Balsam woolly adelgids are much less abundant than when they were spreading through large populations of susceptible trees, but they reappear in some patches and kill the newly mature trees.

In addition to the effects of the balsam woolly adelgid, there has been widespread concern about declines in growth rates and unhealthy conditions of spruce through the 1980s and 1990s. These phenomena are believed to be similar to more severe declines observed in Europe and in the northeastern United States, hypothesized to be the result of air pollution. Extensive research was regarded as inconclusive on the subject of spruce decline and, although Dull et al. (1988) reported that spruce-fir mortality patterns could be largely explained by balsam woolly adelgid effects, concern remained about potential effects of air pollutants. Mathis et al. (2015) and Kosiba, et al. (2018) have noted that tree growth rates increased dramatically around the same time that Clean Air Act revisions greatly reduced acid deposition, suggesting air pollution was important. Soule (2011) noted a similar pattern, though he noted that increased growth also corresponded with warmer climatic conditions.

It is widely accepted that during the colder climate of the Pleistocene, alpine tundra occurred at the highest elevations, and that spruce-fir forests in general migrated to lower elevations. It has been noted that spruce and fir are absent from several mountain ranges that reach elevations where they occur in other ranges. This is attributed to a period of warmer, drier climate after the glaciation, the Hypsithermal interval (Deevey and Flint 1957), when spruce-fir forests may have been unable to persist at these elevations. The highest elevations in ranges that have spruce and fir are somewhat higher than in the ranges that lack them.

It is often said that spruce and fir have limited dispersal ability, and this is supported by the limited return to areas where they were removed by slash fires, and by their failure to return over thousands of years to ranges that apparently lost them during the Hypsithermal period. However, one range where they are absent, the Craggy Mountains, has a high elevation connection to spruce-fir forests of the Black Mountains, and spruce and fir can be seen spreading in small numbers across this connection at present. In ranges with spruce-fir forest, spruce trees can be seen in lower elevation communities and several miles from their optimal habitat, suggesting at least some longer distance seed dispersal.

Though not apparently noted in literature, it is quite possible that the lower elevation limit of spruce, and perhaps of fir and associated species, is determined not by warmer climate, *per se*, but by the past occurrence of fire. Spruce populations persist at lower elevations in wetlands and in a couple of valley settings, locations that are naturally somewhat protected from fire.

Comments: Ecological interest in spruce-fir forests has been intense and persistent, and there is extensive literature on them extending back to the early 1900s and continuing at present (literature reviewed in Schafale 1987).

The Southern Appalachian spruce-fir forests are sometimes called boreal forests to indicate a relationship to the boreal forests of Canada. They share a number of species with the northern forests, but also contain a number of Southern Appalachian endemic species that set them apart. These include *Abies fraseri* itself.

KEY TO SPRUCE—FIR FORESTS

1. Highest elevation sites, generally above 6200 feet (but may be lower on sites with extreme weather such as Grandfather Mountain). Canopy tending to dominance by *Abies fraseri* (or historically dominated by *Abies*). At present, may have young *Abies* stands; sparse *Abies* along with sparse *Picea, Sorbus americana*, or *Betula alleghaniensis;* or may be dominated by *Rubus canadensis* or other shrubs and have dense snags or fallen logs of a former *Abies* stand. Note that less extreme sites may become dominated by *Abies* if logged and not burned, as at Roan Mountain, but these are better regarded as Red Spruce—Fraser Fir Forests.

2. Forest with a dense shrub layer of evergreen ericaceous shrubs, generally with *Rhododendron catawbiense* dominant. Occurring in small patches on sharp, exposed topography or on shallow soil .... **Fraser Fir Forest (Rhododendron Subtype)**

2. Forest without a dense evergreen shrub layer; ground cover of mosses, ferns, other herbs, or deciduous shrubs, sometimes with little ground cover in dense young stands. Occurring in fairly large patches on deep soils in a variety of topography .... **Fraser Fir Forest (Herb Subtype)**

1. Mid to relatively lower elevation sites, generally 4500-6200 feet but occasionally lower. Canopy dominated by *Picea rubens*, or codominated by *Picea* with *Abies fraseri*, *Sorbus americana*, or *Betula alleghaniensis*.

3. Sites boulderfields, with complete cover of large rocks with open space beneath them. Most vegetation growing on rock surfaces or in organic accumulations on and between rock............. .... **Red Spruce–Fraser Fir Forest (Boulderfield Subtype)**

3. Sites not boulderfields; plants rooted in deep or shallow, relatively continuous soil.

4. Mid elevation sites, generally 5500-6200 feet. Canopy generally dominated by *Picea rubens*, potentially along with *Abies fraseri* or occasionally *Sorbus americana*; *Betula alleghaniensis* is present only in small numbers, not codominant.

5. Forest with a dense shrub layer of evergreen ericaceous shrubs, generally with *Rhododendron catawbiense* or *Rhododendron maximum* dominant. Occurring in small patches on sharp, exposed topography or on shallow soil ………………………………….. ……………………………….. **Red Spruce–Fraser Fir Forest (Rhododendron Subtype)**

5. Forest without a dense evergreen shrub layer; ground cover of mosses, ferns, other herbs, or deciduous shrubs, sometimes with little ground cover in dense young stands. Occurring on deep soils in a variety of topography, often in large patches.. .... **Red Spruce–Fraser Fir Forest (Herb Subtype)**

4. Lower elevation sites, generally below 5500 feet, in mosaics with hardwood forests. Canopy codominated by *Picea rubens* and *Betula alleghaniensis*, or occasionally by *Picea rubens* with *Tsuga canadensis, Quercus rubra*, or without codominants.

6. Forest with a dense shrub layer of evergreen ericaceous shrubs, generally with *Rhododendron catawbiense, Rhododendron maximum,* or *Kalmia latifolia* dominant.

7. Occurring in small patches on sharp, exposed topography or on shallow soil. Shrub layer may include *Kalmia latifolia, Rhododendron catawbiense,* or other species of drier sites.. **Red Spruce–Fraser Fir Forest (Birch Transition Shrub Subtype)**

7. Occurring in small patches in sheltered ravines. *Tsuga canadensis* sometimes codominates. Shrub layer usually *Rhododendron maximum* .... **Red Spruce–Fraser Fir Forest (Low Rhododendron Subtype)**

6. Forest without a dense evergreen shrub layer; ground cover of mosses, ferns, other herbs, or deciduous shrubs, sometimes with little ground cover in dense young stands. Occurring

on deep soils in a variety of topography, often in large patches..
................................**Red Spruce–Fraser Fir Forest (Birch Transition Herb Subtype)**

FRASER FIR FOREST (HERB SUBTYPE)

Concept: Fraser Fir Forests are the highest mountain forests, in which *Abies fraseri* naturally dominates and the few other tree species are distinctly subordinate under natural conditions. Widespread mortality caused by balsam woolly adelgid has left many areas devoid of canopy at present. The Herb Subtype encompasses those examples without a substantial evergreen heath layer, which generally have deciduous shrubs and well-developed herb layers. Forests where *Abies fraseri* formerly dominated and has not regenerated may be regarded as degraded examples of this subtype or may be classified as successional communities. Forests where *Abies fraseri* canopies died and regenerated as very dense stands that have no shrub or herb layer are included in this subtype. A few natural forests dominated by *Sorbus americana* along with *Abies fraseri* are also included here. This community is a higher elevation analogue of Red Spruce–Fraser Fir Forest (Herb Subtype).

Distinguishing Features: Fraser Fir Forest is theoretically distinguished from Red Spruce–Fraser Fir Forest and all other natural communities by having present or recent past natural dominance by *Abies fraseri*, making up 67% or more of the canopy cover. The Herb Subtype is distinguished from the Rhododendron Subtype by dominance of the lower strata by herbs or deciduous shrubs, rather than *Rhododendron* or other evergreen heaths.

Because of widespread destruction of fir canopy by the balsam woolly adelgid, examples are now dominated by young fir trees or by successional vegetation of *Rubus allegheniensis* or other species. The presence of large numbers of dead conifer stems at very high elevation, combined with absence or scarcity of other mature trees, is generally sufficient to distinguish a damaged Fraser Fir Forest from other high elevation community types. Some Red Spruce–Fraser Fir Forests became dominated by *Abies fraseri* after logging in the early part of the century, since Fraser fir more readily establishes in gaps than red spruce. These can be difficult to distinguish without historical data but can be expected to gradually succeed to greater spruce dominance.

Crosswalks: *Abies fraseri / Viburnum lantanoides / Dryopteris campyloptera - Oxalis montana / Hylocomium splendens* Forest (CEGL006049).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: Fraser Fir Forest occurs on ridge tops and slopes at the highest elevations, generally above 6200 feet, though lower in the extreme climate of Grandfather Mountain.

Soils: Most examples are mapped as Burton (Typic Humadept) or Craggey (Lithic Humadept). However, areas in the Great Smoky Mountains are more recently mapped as Clingman (Lithic Udifolist). Discussion among soil scientists suggests that soils in spruce-fir communities are extremely heterogeneous and that Spodosols are also possible.

Hydrology: Sites are upland and nominally well drained, but these are likely the wettest of the spruce-fir forests, occurring where fog is common and rainfall is high. Some soils may be shallow and rocky, but thick litter and moss cover retain moisture.

Vegetation: In undisturbed condition, the Herb Subtype exists as a closed forest, broken by small to medium size gaps. *Abies fraseri* makes up more than 75% of the canopy in natural undisturbed condition. Occasionally *Sorbus americana* codominates. Smaller amounts of *Picea rubens* and generally even less *Betula alleghaniensis* are usually present. Occasional *Prunus pensylvanica* and *Acer spicatum* may be the only other trees. The shrub layer may be moderate in density to nearly absent. Saplings of *Abies* and *Picea* may dominate, or combinations of *Viburnum lantanoides*, *Vaccinium erythrocarpum*, *Vaccinium simulatum*, *Vaccinium corymbosum*, and *Sambucus racemosa* var. *pubens* may predominate. The herb layer is dense in mature stands, though it may be sparse under dense young canopies. Species characteristic of most spruce-fir forests predominate, including *Dryopteris campyloptera*, *Athyrium asplenioides, Oxalis montana, Carex intumescens, Carex brunnescens, Oclemena acuminata, Clintonia borealis, Solidago glomerata*, and *Chelone lyonii*. Other species noted by Crandall (1958) in the Smokies, before widespread fir mortality, include *Monotropa uniflora, Impatiens pallida, Houstonia serpyllifolia*, and *Streptopus roseus*. Mosses often cover the ground, alone or under the herbs. *Hylocomium splendens* is most often dominant, but *Hypnum crista-castrensis*, *Rhytidiadelphus triquetrus*, *Polytrichum* spp., and other species may be abundant. Mature forests also often have dense cover of mosses and liverworts on the trunks of fir trees, whose smooth bark is particularly hospitable for epiphytes.

After universal destruction of the fir canopies by balsam woolly adelgid, canopies in this community are now extremely variable. They may range from sparse to dense, and may consist of very young or maturing *Abies*. They also may be replaced by successional *Rubus canadensis* or shrub stands. Young-mature forests often have little shrub, herb, or moss layer beneath a dense canopy, and the young tree trunks have not yet developed the characteristic epiphytic cover.

Range and Abundance: Ranked G1. This subtype is confined to just a few mountain ranges: the Black Mountains, Smokies, Richland Balsam, and Grandfather Mountain. It is present on Mount LeConte and Clingmans Dome in Tennessee but is otherwise endemic to North Carolina.

Associations and Patterns: The Herb Subtype grades to Fraser Fir Forest (Rhododendron Subtype) on more exposed sites. It grades to Red Spruce–Fraser Fir Forest, especially the Herb Subtype, at lower elevations.

Variation: Watson-Cook (2017) recognized two minor variants as well as the classic version of this community. Both of the variants are in lower mountain ranges in places that were logged; they thus appear to be fir-dominated successional versions of Red Spruce–Fraser Fir Forest rather than places that have all the characteristics of Fraser Fir Forest. Crandall (1958) recognized four site types within the range of variation covered by this subtype: *Oxalis-Hylocomium*, *Oxalis-Dryopteris*, *Viburnum-Vaccinium-Dryopteris*, and *Senecio* (i.e., *Rugelia nudicaulis*). These do not seem to be distinguishable in the broader range of this community. Given the extreme changes all examples have undergone, much greater variation in disturbance response now masks any such variation. Many examples that remain now show none of these undergrowth types. *Rugelia nudicaulis* is confined to the Smoky Mountains and could be used to define a unique variant there, but the occurrence of this species too has been heavily altered by the universal disturbance.

Dynamics: Dynamics are generally similar to those throughout the Spruce–Fir Forests theme. However, the extreme high elevation and exposure of this subtype may subject it to more frequent or extreme disturbance by wind and ice. The dominance of fir without codominant spruce on the highest peaks has been noted in ecological literature for decades (e.g., Whittaker 1956). Some spruce, and even birch, is generally present to the highest elevations, showing that the change in communities does not indicate a true limit of physiological tolerance but only a shift in dominance. Busing (1985) and White et al. (1985) found that fir captured canopy gaps at several times the rate the spruce did. The two coexisted in typical Red Spruce–Fraser Fir Forests because this was balanced by the much shorter life span of fir. This dynamic may be shifted at the highest elevations, with more frequent natural disturbance reducing the advantage of spruce's potential life span.

The anomalous natural occurrence of Fraser Fir Forest at lower elevation on Grandfather Mountain likely is caused by greater wind disturbance in the more extreme weather there. The shift to fir dominance after logging (without slash fires), as at Roan Mountain, also results from the ability of fir to capture gaps. Those logged stands can be expected to shift back to spruce dominance over time.

In northern Appalachian forests of *Abies balsamea*, there is a well-studied phenomenon of "fir waves" — migrating elongate canopy gaps. A progression of tree ages on one side shows how the gap has moved in the direction of prevailing winds. The mechanism is increased harshness of the environment at the downwind edge of a gap, which makes older trees more likely to die. On the upwind side, young trees that established on the more sheltered side of the gap are less susceptible to wind. The result is a set of periodic wave-like gradients in tree age. A similar pattern reportedly could be observed in fir forests in Japan. Shortly before the last fir stands died, a pattern of linear gaps was visible on the flank of Mount Mitchell. It is possible that this phenomenon occurred there as well, but the evidence is now lost. Once the structured age pattern is eliminated, it may not easily reform.

Comments: A successional association, *Rubus canadensis* - (*Rubus idaeus ssp. strigosus*) / *Athyrium filix-femina - Solidago glomerata* Shrubland (CEGL003893), has been defined to cover examples of fir forests where canopy trees have died and not regenerated.

The distinction between Red Spruce–Fraser Fir Forest and Fraser Fir Forest has been blurred by the widespread death of firs and may become lost as the climate becomes warmer. However, it appears worth keeping recognition of these community types for the present. After 50 years since the first widespread death of fir, spruce has not come to dominate the highest peaks.

Rare species:
Vascular plants – *Calamagrostis canadensis var. canadensis, Cystopteris fragilis, Phegopteris connectilis, Poa palustris, Rubus strigosus,* and *Rugelia nudicaulis.*

Nonvascular plants – Bazzania nudicaulis, Hylocomiastrum umbratum, Hypotrachyna sinuosa, Hypotrachyna virginica, Leptodontium excelsum, Leptoscyphus cuneifolius, Lobarina scrobiculata, Plagiochila austinii, Plagiochila exigua, Polytrichastrum alpinum, Sphagnum squarrosum, and *Sphenolobopsis pearsonii.*

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Microtus chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata,* and *Setophaga magnolia*.

Invertebrate animals – *Eilema bicolor, Entephria separata, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Hydriomena exculpata, Korscheltellus gracilis, Microhexura montivaga, Pallifera hemphilli, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata.*

FRASER FIR FOREST (RHODODENDRON SUBTYPE)

Concept: Fraser Fir Forests are the highest mountain forests, in which *Abies fraseri* naturally dominates and the few other tree species are distinctly subordinate under natural conditions. Widespread mortality caused by balsam woolly adelgid has left many areas devoid of canopy at present. The Rhododendron Subtype covers those examples with canopies dominated by *Abies fraseri* and with a substantial evergreen heath layer, usually *Rhododendron catawbiense*. These are generally associated with more exposed topography, such as sharp ridge tops, and areas with shallow soil near rock outcrops.

Distinguishing Features: Fraser Fir Forest is theoretically distinguished from Red Spruce–Fraser Fir Forest and all other natural communities by having present or recent past natural dominance by *Abies fraseri*, making up 67 percent or more of the canopy cover. The Rhododendron Subtype is distinguished from the Herb Subtype by having a well-developed shrub layer dominated by *Rhododendron* or other evergreen heaths in places with exposed topography. Exposed very high elevation sites with large numbers of dead trees and dominance by *Rhododendron* can be assumed to be degraded examples of this subtype.

Crosswalks: *Abies fraseri / (Rhododendron catawbiense, Rhododendron carolinianum*) Forest (CEGL006308).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: Fraser Fir Forest occurs on ridge tops and slopes at the highest elevations, generally above 6200 feet, though lower in the extreme climate of Grandfather Mountain. The Rhododendron Subtype occurs on sharp ridge tops, south-facing slopes, and areas with shallow soils near rock outcrops.

Soils: This subtype occurs in association with rock outcrops and in other areas that appear to have shallow soil. They generally are not specifically distinguished in soil mapping but are likely as heterogeneous as other spruce-fir soils.

Hydrology: As with other Spruce–Fir Forests, this community is generally wet to mesic, sometimes saturated for long periods by active rainfall and fog. However, the shallow soil is more prone to becoming dry in periods without rain or fog.

Vegetation: The Rhododendron Subtype has a closed to open tree canopy dominated by *Abies fraseri*, sometimes with small numbers of *Picea rubens*, *Sorbus americana*, *Betula alleghaniensis*, or *Prunus pensylvanica*. The canopy trees may be small and stunted. There generally are no other understory species, though *Acer spicatum*, *Amelanchier laevis*, or other understory species of other subtypes might be present. There is a dense shrub layer, generally dominated by *Rhododendron catawbiense* or *Rhododendron carolinianum*. Other shrubs may include *Rhododendron (Menziesia) pilosum* or *Diervilla sessilifolia.* Herbs are sparse, sometimes completely absent except on small rock outcrops within the community. However, bryophytes may be abundant in some places, with *Hylocomium splendens*, *Sphagnum* spp., and *Polytrichum ohioense* being noted by Crandall (1958).

Range and Abundance: Ranked G1. This subtype is one of the rarest of Spruce–Fir Forests, occurring only as small patches within a matrix of the Herb Subtype. It is confined to just a few mountain ranges: the Black Mountains, Smokies, Richland Balsam, and Grandfather Mountain. It is present on Mount LeConte and Clingmans Dome in Tennessee but is otherwise endemic to North Carolina.

Associations and Patterns: The Rhododendron Subtype is associated with the Herb Subtype, and often also with High Elevation Rocky Summit.

Variation: Examples may be heterogeneous over very fine scales, with the transition to adjacent communities or with occurrence of small rock outcrops within them.

Dynamics: All aspects of general Spruce-Fir Forest dynamics are expected to be similar in this subtype, except that the more extreme sites may have more frequent natural disturbance and slower tree regeneration.

Comments: This subtype appears to be very rare and is often absent even on exposed ridge tops. Some literature suggests it is part of a regularly occurring community pattern, but this is not the case in the author's experience.

Rare species:
Vascular plants – *Calamagrostis canadensis var. canadensis, Cystopteris fragilis, Phegopteris connectilis, Poa palustris, Rubus strigosus,* and *Rugelia nudicaulis.*

Nonvascular plants – *Bazzania nudicaulis, Hylocomiastrum umbratum, Hypotrachyna sinuosa, Hypotrachyna virginica, Leptodontium excelsum, Leptoscyphus cuneifolius, Lobarina scrobiculata, Plagiochila austinii, Plagiochila exigua, Polytrichastrum alpinum, Sphagnum squarrosum,* and *Sphenolobopsis pearsonii*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Microtus chrotorrhinus carolinensis, Mustela nivalis, Poecile atricapillus, Setophaga coronata,* and *Setophaga magnolia*.

Invertebrate animals – *Eilema bicolor, Entephria separata, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Hydriomena exculpata, Korscheltellus gracilis, Microhexura montivaga, Pallifera hemphilli, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata.*

RED SPRUCE–FRASER FIR FOREST (HERB SUBTYPE)

Concept: Red Spruce–Fraser Forests are high mountain forests in which *Picea rubens*, with or without *Abies fraseri* or hardwoods, is naturally dominant. The Herb Subtype is the most typical subtype, encompassing examples with a mix of *Picea* and *Abies* dominating and with lower strata consisting of deciduous shrubs, herbs, and mosses.

Distinguishing Features: Red Spruce–Fraser Fir Forests are distinguished by canopy dominance of *Picea rubens* alone or with *Abies fraseri*, *Betula alleghaniensis, Sorbus americana*, or occasionally other hardwoods, in a high elevation upland setting. The Herb Subtype is distinguished from the Rhododendron Subtype and Low Rhododendron Subtype by dominance of the lower strata by herbs or deciduous shrubs, rather than by *Rhododendron* spp. It is distinguished from the Birch Transition Herb Subtype and Birch Transition Shrub Subtype by having less than 33% cover of *Betula alleghaniensis* or other hardwoods (other than *Sorbus americana)* in the canopy, counting gaps recently occupied by now-dead *Abies fraseri*. The Herb Subtype is distinguished from the Boulderfield Subtype, which also has a deciduous shrub, herb, and moss undergrowth, by having boulder cover less than 90 percent, having a richer herb layer, and having *Ribes* spp., *Polypodium appalachianum*, and other boulderfield species present in no more than small numbers.

Crosswalks: *Picea rubens - (Abies fraseri) / Vaccinium erythrocarpum / Dryopteris campyloptera / Hylocomium splendens* Forest (CEGL007131).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Herb Subtype occurs on ridge tops and slopes at high elevations, generally 5500-6200 feet.

Soils: Any of the soils typical of high mountains may support this community. See the discussion of soils for the Spruce-Fir Forests theme as a whole.

Hydrology: Red Spruce-Fraser Fir Forests are mesic to wet due to high rainfall, long periods bathed in fog, low temperatures, and, usually, high water-holding capacity in the organic-rich soil.

Vegetation: In a natural state, the Herb Subtype is a closed forest, except for small to medium canopy gaps. It is dominated by *Picea rubens* with varying amounts of *Abies fraseri* and limited amounts of *Betula alleghaniensis* and *Sorbus americana*. *Betula cordifolia* and other tree species may be present only in small numbers. *Betula alleghaniensis* is usually present but comprises less than 33% of the canopy in unaltered stands. *Abies* is usually present but may be absent. Watson-Cook (2017) found an average of 25-50% cover each of *Picea* and *Abies* in the cluster of typical plots of this community. *Betula alleghaniensis* averaged 10-25% cover; *Sorbus* average cover was very low.

The understory is sparse to moderate except in canopy gaps. All three main canopy dominants may be fairly abundant in the understory. Other species may include *Acer spicatum*, *Acer rubrum*, *Acer pensylvanicum*, *Fagus grandifolia*, and *Amelanchier laevis*. The shrub layer may be sparse to dense. Sometimes saplings of spruce or fir dominate. *Vaccinium erythrocarpum*, *Vaccinium corymbosum*, *Vaccinium simulatum*, *Viburnum lantanoides*, *Viburnum cassinoides*, and *Sambucus racemosa* var. *pubens* are reported as relatively frequent and abundant in most site descriptions. *Rubus canadensis* has become frequent and often abundant after widespread canopy opening from a variety of causes. However, Watson-Cook (2017), analyzing plot data generally from the 1990s-2000s, found *Rhododendron maximum* to be the most constant shrub species, and the most abundant on average. The other shrub species were less constant and had lower average abundance. The herb layer may range from nearly absent to a lush cover of ferns or forbs over a thick bed of moss. Most often dominant species are *Dryopteris campyloptera, Dryopteris intermedia, Athyrium asplenioides, Sitobolium* (*Dennstaedtia*) *punctilobulum*, *Oclemena acuminata, Oxalis montana*, *Ageratina roanensis* and, in the Smokies, *Rugelia nudicaulis*. Other frequent and abundant herbs include *Carex intumescens*, *Circaea alpina*, *Chelone glabra*, *Eurybia chlorolepis*, *Glyceria melicaria*, *Clintonia borealis*, *Viola blanda*, *Tiarella cordifolia*, *Huperzia lucidula*, *Solidago glomerata,* and *Dryopteris intermedia* (Watson-Cook 2017; Crandall 1958; Whittaker 1956; Pittillo 1984. Bryophytes are usually particularly prominent in these communities. *Hylocomium splendens*, *Ptilimnium crista-castrensis*, *Polytrichum* spp., and *Atrichum* spp. may form dense beds, alone or beneath fern or forb cover. Epiphytic mosses and liverworts are also characteristic, with several species specialized for bark of mature fir trees. This lush, bryophyte-rich herb layer is now uncommon but was common in older stands with intact canopy in the author's experience in the 1980s. It is emphasized by almost all earlier literature.

Range and Abundance: Ranked G2. This appears to be the most widespread of the spruce-fir communities, probably because it is more broadly defined than most, but it is still extremely limited by the scarcity of land area at high elevation and by losses in the early 1900s. The bulk of the global range of this community and corresponding NVC association is in North Carolina; it extends into Tennessee and Virginia. The southern limit is Richland Balsam and the central Smoky Mountains; the northern limit of its relatively contiguous range is Mt. Rogers in Virginia, but some disjunct stands farther north in Virginia and West Virginia are also attributed to the association. Spruce-fir forests of all subtypes are absent from several mountain ranges within their geographic and elevation range, such as the Craggy Mountains and Elk Knob.

Associations and Patterns: The Herb Subtype is usually associated with other subtypes of Red Spruce-Fraser Fir Forest, grading to the Rhododendron Subtype around rock outcrops, to the Birch Transition Herb and Birch Transition Shrub Subtypes at lower elevation. It grades to Fraser Fir Forest at higher elevations. Northern Hardwood Forest (Beech Gap Subtype) may occur in the same elevational range, on upper south-facing concave slopes.

Variation: This is the most broadly defined of the spruce-fir subtypes, representing the most common version in the middle range of its environment. As such, there is substantial variation in vegetation, especially in the lower strata. Variation is now confused because of widespread alteration caused by balsam woolly adelgid, and variable recovery since that time. There are floristic and vegetational differences among Red Spruce–Fraser Fir Forest in different mountain ranges (Pittillo 1984; Schwartzkopf 1974), but most such differences are much less than the variation within single stands. Crandall (1958), working in old-growth forests of the Smokies before balsam woolly adelgid disturbance, described five undergrowth types in spruce-fir forests of the Smokies, three of which would fall within this subtype. Her *Oxalis-Hylacomium* and

Viburnum-Vaccinium-Dryopteris, said to be associated with different elevational ranges, do not seem to be readily distinguishable throughout the range of the community. Her third, *Cacalia rugelia* (*Rugelia nudicaulis*) type is distinctive for biogeographic reasons, because the species is limited to the Great Smoky Mountains. Watson-Cook (2017), analyzing CVS data representing most sites other than the Smokies, post-adelgid, found four floristic clusters within this subtype that she chose to recognize. One is transitional to the Birch Transition Herb Subtype, one is transitional to the Rhododendron Subtype, and one represents a more herbaceous/less shrubby set, relative to the fourth, classic version. The numbers of plots representing those clusters other than the classic is small, generally three, and the level of difference seems too small to recognize as variants, though further consideration is warranted.

Thus, two variants are recognized:

1. Typic Variant has variable deciduous shrub, forb, fern, and moss dominance in the lower strata. It remains heterogeneous, and study of occurrences if they stabilize and recover from recent disturbances may lead to confirmation of the Crandall (1958) subtypes or recognition of other subtypes.

2. Ragwort Variant is a biogeographic variant having *Rugelia nudicaulis* as the predominant herb. This species occurs only in the Great Smoky Mountains, where it often dominates the herb layer. This variant co-occurs with the Typic Variant in the Smokies and occurs nowhere else.

Dynamics: All of the dynamics discussed in the theme description apply to this subtype.

Comments: Most of the extensive study of Spruce-Fir Forests in general has been carried out in examples of this subtype.

Rare species:
Vascular plants – *Athyrium angustum, Betula cordifolia, Calamagrostis canadensis var. canadensis, Cardamine clematitis, Carex projecta, Cystopteris fragilis, Gentiana latidens, Lilium grayi, Monarda media, Phegopteris connectilis, Poa palustris, Rhododendron vaseyi, Rugelia nudicaulis, Rubus strigosus, Sceptridium oneidense, Stachys clingmanii,* and *Streptopus amplexifolius var. amplexifolius*.

Nonvascular plants – *Acrobolbus ciliatus, Arthonia cupressina, Bazzania nudicaulis, Brachydontium trichodes, Brachythecium rotaeanum, Cetrelia cetrarioides, Coniarthonia kermesina, Diplophyllum taxifolium* var. *mucronatum, Frullania appalachiana, Gymnoderma lineare, Herzogiella turfacea, Hylocomiastrum umbratum, Hypotrachyna sinuosa, Hypotrachyna virginica, Lecanora anakeestiicola, Leptodontium excelsum, Leptodontium flexifolium, Leptohymenium sharpii, Leptoscyphus cuneifolius, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Plagiochila exigua, Polytrichastrum alpinum, Ptilidium ciliare, Rhytidiadelphus subpinnatus, Sphagnum squarrosum,* and *Sphenolobopsis pearsonii*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Desmognathus organi, Desmognathus wrightii, Glaucomys sabrinus coloratus, Loxia* *curvirostra, Microtus chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata, Setophaga magnolia,* and *Sylvilagus obscurus.*

Invertebrate animals – *Eilema bicolor, Entephria separata, Eulonchus marialiciae, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Hydriomena exculpata, Korscheltellus gracilis, Microhexura montivaga, Pallifera hemphilli, Pallifera ohioensis, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata*.

RED SPRUCE–FRASER FIR FOREST (RHODODENDRON SUBTYPE)

Concept: Red Spruce–Fraser Forests are high mountain forests in which *Picea rubens*, with or without *Abies fraseri* or hardwoods, is naturally dominant. The Rhododendron Subtype covers those examples with a substantial evergreen heath shrub layer, generally associated with exposed topography and shallow soils.

Distinguishing Features: Red Spruce–Fraser Fir Forests are distinguished by canopy dominance of *Picea rubens* alone or with *Abies fraseri*, *Betula alleghaniensis, Sorbus americana*, or occasionally other hardwoods, in a high elevation upland setting. The Rhododendron Subtype is distinguished from the Low Rhododendron Subtype by occurrence at higher elevations, in topographically exposed sites, and generally by having substantial *Rhododendron catawbiense* or *Rhododendron carolinianum* rather than strong dominance by *Rhododendron maximum*. It is distinguished from the Herb Subtype and Boulderfield Subtype by its well-developed evergreen shrub layer. It is distinguished from the Birch Transition Subtypes by having less than 33% cover of *Betula* in the canopy when not disturbed. This subtype may be transitional to Heath Bald, but can be distinguished by a well-developed, though sometimes open, tree canopy.

Crosswalks: *Picea rubens* - (*Abies fraseri*) / (*Rhododendron catawbiense, Rhododendron maximum*) Forest (CEGL007130).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Rhododendron Subtype occurs on sharp ridge tops and convex slopes, generally at 5500-6200 feet, generally with shallow soils or associated with rock outcrops.

Soils: This subtype occurs in association with rock outcrops and in other areas that appear to have shallow soil. Soils are mapped similarly to other Spruce-Fir Forests but may be inclusions within those map units.

Hydrology: As with other Spruce-Fir Forests, the Rhododendron Subtype is generally wet to mesic, sometimes saturated for long periods. However, the shallow soil is more prone to becoming dry in periods without rain or fog.

Vegetation: The Shrub Subtype has a closed to open tree canopy dominated by *Picea rubens*, with varying amounts of *Abies fraseri*, *Betula alleghaniensis*, and *Sorbus americana*. While the canopy may be open due to fir mortality, it may also be open due to the presence of rock outcrops and possibly due to greater canopy mortality related to shallow soils. Watson-Cook (2017) reported an average of 25-50% spruce cover, with other species much less abundant. The understory, if present, consists primarily of the canopy species. *Amelanchier laevis* is the only other understory species she noted. There is a dense shrub layer dominated by *Rhododendron catawbiense* and *Rhododendron maximum*. Other shrubs reported as abundant in some places are *Viburnum cassinoides*, *Vaccinium simulatum*, *Viburnum lantanoides*, *Diervilla sessiliflora*, *Pieris floribunda*, *Aronia melanocarpa*, *Vaccinium stamineum*, and *Vaccinium pallidum* (Watson-Cook 2017; Crandall 1958). The latter species is uncertain; it might possibly represent *Vaccinium altomontanum*. Herbs are generally sparse and consist of the same species as in the Herb Subtype.

Dryopteris campyloptera and *Carex brunnescens* are among the species noted in studies, though Watson-Cook (2017) had a number of other species in plots that were transitional to the Herb Subtype.

Range and Abundance: Ranked G1. This subtype is much less extensive than the Herb Subtype. Even in areas with extensive spruce-fir forest, such as the central Smokies, it is limited to small patches. It appears to be present in fewer sites, but this is uncertain given that it is not distinguished in many site descriptions.

Associations and Patterns: The Rhododendron Subtype generally grades to the Herb Subtype, but it may grade to any other subtype, to Fraser Fir Forest, Heath Bald, or High Elevation Rocky Summit.

Variation: Examples are often heterogeneous over very fine scales, with the transition to adjacent communities or with occurrence of small rock outcrops within them. Crandall (1958) loosely recognized a rhododendron-viburnum type, codominated by *Viburnum lantanoides*. Watson-Cook (2017) recognized a variant cluster transitional to a community resembling the Herb Subtype and also recognized within the Herb Subtype a more shrubby version transitional to the Rhododendron Subtype. In both cases, the author regards these as ecotonal and not distinct enough to recognize as formal variants. More distinctive variants might be found amid the variations in shrub composition among ranges, such as the abundance of *Pieris floribunda* in examples at Shining Rock, but these need further study before recognizing.

Dynamics: All aspects of general Spruce-Fir Forest dynamics are expected to be similar in this subtype, except that the more extreme sites may have more frequent natural disturbance and slower tree regeneration. Though not well known, it appears that landslides, abundant in some mountain ranges, may create habitat for this subtype.

Comments: As with the Rhododendron Subtype of Fraser Fir Forest, this subtype appears to be very rare and is often absent even on exposed ridge tops. Some literature suggests it is part of a regularly occurring community pattern, but this is not the case in the author's experience.

The CVS data set analyzed by Watson-Cook appears to under-represent this subtype, with only a few plots from a very limited number of sites. This is to be expected given the frequent steepness and difficulty of working in this community. Older qualitative site descriptions usually don't distinguish this subtype from others, making it difficult to characterize.

Rare species:
Vascular plants – *Betula cordifolia, Cystopteris fragilis, Glyceria nubigena Phegopteris connectilis, Rhododendron vaseyi, Rubus strigosus,* and *Solidago spithamaea*.

Nonvascular plants – *Arthonia cupressina*, *Bazzania nudicaulis, Brachydontium trichodes, Brachythecium rotaeanum, Cetrelia cetrarioides, Coniarthonia kermesina, Diplophyllum taxifolium* var. *mucronatum, Frullania appalachiana, Gymnoderma lineare, Herzogiella turfacea, Hylocomiastrum umbratum, Lecanora anakeestiicola, Leptodontium excelsum, Leptodontium flexifolium, Leptohymenium sharpii, Leptoscyphus cuneifolius, Lobarina scrobiculata, Metzgeria* *consanguinea, Metzgeria violacea, Plagiochila exigua, Polytrichastrum alpinum, Ptilidium ciliare, Rhytidiadelphus subpinnatus, Sphagnum squarrosum,* and *Sphenolobopsis pearsonii*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Desmognathus organi, Desmognathus wrightii, Glaucomys sabrinus coloratus, Loxia curvirostra, Microtus chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata, Setophaga magnolia,* and *Sylvilagus transitionalis.*

Invertebrate animals – *Eilema bicolor, Entephria separata, Eulonchus marialiciae, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Korscheltellus gracilis, Microhexura montivaga, Polygonia faunus, Pallifera hemphilli, Pallifera ohioensis, Syngrapha alias,* and *Xestia perquiritata*

RED SPRUCE–FRASER FIR FOREST (BOULDERFIELD SUBTYPE)

Concept: Red Spruce–Fraser Forests are high mountain forests in which *Picea rubens*, with or without *Abies fraseri* or hardwoods, is naturally dominant. The Boulderfield Subtype covers *Picea*-dominated boulderfields. Plants capable of rooting in moss mats or shallow soil make up most of the community. This subtype is transitional to the High Elevation Birch Boulderfield Forest type of lower elevations, but it is more similar to other spruce-fir forests than lower elevation boulderfields are to Northern Hardwood Forests.

Distinguishing Features: Red Spruce–Fraser Fir Forests are distinguished by canopy dominance of *Picea rubens* alone or with other species, in a high elevation upland setting. The Boulderfield Subtype is distinguished from all other subtypes by occurring on a well-developed boulderfield. It has near 100% ground cover of large rocks, with open spaces beneath the boulders, and with soil present only as small pockets on top of rock. The herb layer consists primarily of species that can root on moss mats or small soil pockets, such as *Polypodium appalachianum* and mosses. While many spruce-fir forests of all subtypes are rocky and have shallow soil, this subtype is reserved for the rare extreme setting of well-developed boulderfields.

Crosswalks: *Picea rubens / Ribes glandulosum* Forest (CEGL007128).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Boulderfield Subtype occurs on steep high elevation slopes. Boulderfields are either talus beneath large rock outcrops or are colluvial deposits that apparently result from periglacial processes during the Pleistocene.

Soils: Soils probably represent an unnamed series. Boulders, often up to several meters across, cover all of the surface, and generally are piled several deep. Voids between the boulders below the surface distinguish them from the common rocky soils of the high mountsins. Soil is limited to shallow accumulations of organic matter on top of rocks or in pockets between them.

Hydrology: The general setting is mesic to wet due to high rainfall, long periods bathed in fog, and low temperatures; however, water-holding capacity is low in the small soil pockets and drainage is rapid through the large voids. Conditions may become dry in even short periods of drought.

Vegetation: The Boulderfield Subtype has a closed or somewhat open canopy dominated by *Picea rubens* and *Betula alleghaniensis*, sometimes with small numbers of *Abies fraseri* or *Tsuga canadensis*. The understory is dominated by *Acer spicatum*, with *Sorbus americana* the only other likely species other than canopy species. There may be a very open shrub layer, with *Viburnum lantanoides* the most constant and abundant species. Other shrubs sparsely present may include *Vaccinium erythrocarpum*, *Rhododendron catawbiense*, and *Ribes cynosbati* or *Ribes glandulosum*. The herb layer consists primarily of species able to live on bare rock. There is often extensive moss cover. *Polypodium appalachianum* is extensive in most places. Other herbs typical of spruce-fir forests are present in favorable soil pockets, including *Dryopteris campyloptera*, *Dryopteris intermedia*, *Oxalis montana,* and *Huperzia lucidula*.

Range and Abundance: Ranked G1. This appears to be the rarest of Spruce–Fir Forest subtypes. Extensive examples are known only from Grandfather Mountain, but small examples are present in other mountain ranges. It is either endemic to North Carolina or has a small occurrence in Tennessee.

Associations and Patterns: The Boulderfield Subtype grades to other subtypes of Red Spruce–Fraser Fir Forest.

Variation: Examples vary with the transition to adjacent communities.

Dynamics: Dynamics are intermediate between those of the Spruce–Fir Forests theme in general and of other boulderfield communities. Canopy gaps can be expected to persist longer because of the difficulty of tree establishment. The extent of the ground surface where tree seedlings can establish is limited, though it is sufficient to lead to a full forest canopy. The boulderfields seem to be stable but shifting or falling of rocks may occur occasionally and lead to local disturbance.

Comments: This is one of the least studied spruce-fir subtypes, yet it is perhaps the most distinctive in flora and ecology. It is not mentioned in any of the earlier published literature. It has been observed by the author, several CVS plots document it, and it was recognized in Watson-Cook (2017) based on these plots.

Recognition of well-developed boulderfields is easy in person, where the near total cover of moss- and fern-covered rocks is very distinctive and the near impossibility of walking is obvious. But boulderfields can be difficult to recognize in both qualitative descriptions and plot data, since many spruce-fir sites have abundant boulders and since boulderfield communities can have many species of deeper soils present in small numbers.

Though *Ribes* was mentioned in earlier drafts of the 4th approximation and is included in the NVC association name, no species of *Ribes* is abundant in any of the plots or in known examples of this community.

Rare species:
Invertebrate animals – *Nesticus mimus*.

RED SPRUCE–FRASER FIR FOREST (BIRCH TRANSITION HERB SUBTYPE)

Concept: Red Spruce–Fraser Forests are high mountain forests in which *Picea rubens*, with or without *Abies fraseri* or hardwoods, is naturally dominant. The Birch Transition Herb Subtype covers forests on open slopes in the broad transition zone where Red Spruce–Fraser Fir Forest grades to Northern Hardwood Forest with a fairly even mix of *Betula alleghaniensis* and *Picea rubens* in the canopy. A dense ericaceous shrub layer is absent. This is the lower elevation equivalent of the Herb Subtype.

Distinguishing Features: The Birch Transition Herb Subtype is distinguished from most other subtypes by canopy composition, which naturally includes more than 33% cover of *Betula alleghaniensis* and more than 33% cover of *Picea rubens* in a well-developed, undisturbed canopy. It is distinguished from the Birch Transition Shrub Subtype, which has a similar canopy, by having lower strata dominated by deciduous shrubs and herbs, instead of evergreen shrubs. It is distinguished from the Boulderfield Subtype by having less than 90 percent boulder cover and having only small amounts of characteristic boulderfield species.

Crosswalks: *Picea rubens - (Betula alleghaniensis, Aesculus flava) / Viburnum lantanoides / Solidago glomerata* Forest (CEGL006256).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Birch Transition Herb Subtype occurs on open slopes and upper valleys in the lower elevational range of spruce-fir forests, generally 4500-5500 feet elevation.

Soils: It is unclear how much the discussion of soils for the Spruce-Fir Forests theme applies to the Birch Transition Herb Subtype. Soils likely are similar to those of other spruce-fir forests but may be deeper and better developed in the somewhat lower elevation and warmer climate.

Hydrology: Moisture levels are high, as in other spruce-fir forests, but warmer temperatures and occurrence below the zone of maximum fog likely makes this community less wet.

Vegetation: The Birch Transition Herb Subtype forest canopy is closed except for recent gaps. The canopy is codominated by a combination of *Picea rubens* and *Betula alleghaniensis*. *Abies fraseri* may or may not be present, and a variety of lower elevation trees may occur in smaller numbers, including *Aesculus flava, Acer rubrum*, *Acer saccharum*, *Betula lenta*, *Fagus grandifolia*, and *Quercus rubra*. Watson-Cook (2017) described this community in detail, based on CVS plot data. The understory is generally dominated by *Acer pensylvanicum*, *Acer spicatum*, or some of the canopy species. Deciduous shrubs may be of moderate density, with *Vaccinium erythrocarpum*, *Viburnum lantanoides*, and *Ilex montana* often abundant. *Rhododendron catawbiense* and *Rhododendron maximum* may be present in small amounts. The herb layer is well developed and tends to be dominated by vascular plants rather than bryophytes. The most frequent and abundant species are *Maianthemum canadense, Oclemena acuminata, Oxalis montana, Huperzia lucidula, Dryopteris intermedia*, *Clintonia borealis*, *Dryopteris intermedia*, and *Carex pensylvanica.* A number of shrub and herb species shared with lower elevation communities may be present, including *Eurybia chlorolepis*, *Maianthemum racemosum*, *Medeola virginica*, *Amauropelta* (*Parathelypteris*) *noveboracensis*, *Smilax herbacea*, *Viola pallens*, *Trillium erectum*, and *Hamamelis virginiana*. Other species of high elevations, such as *Dryopteris campyloptera*, may also be present. Crandall (1958) also noted *Rudbeckia laciniata, Nabalus altissima, Polygonatum pubescens, Hydrangea arborescens, Viburnum cassinoides, Solidago curtissii, Laportea canadensis*, and a variety of additional herbaceous species in this community in the Smokies.

Range and Abundance: Ranked G2. The equivalent NVC association is attributed only to North Carolina and Tennessee, though comparable communities may exist in Virginia. It is of one the most common subtypes but is nevertheless of very limited extent.

Associations and Patterns: The Birch Transition Herb Subtype is intermediate between the Herb Subtype and Northern Hardwood Forest, and grades to both. It may be associated with the Birch Transition Shrub Subtype or Low Rhododendron Subtype locally. Its pattern of occurrence on the landscape appears to be patchy and irregular, with the communities that are ostensibly of higher and lower elevations often interspersed within the same elevation. This is often attributed to the effects of logging, with an assumption that spruce was once present in areas that now appear to be Northern Hardwood Forest, or that the mixed canopy indicates a loss of spruce. This may sometimes be true but cannot be assumed. A similar patchwork pattern is visible in the unlogged forests of the Great Smoky Mountains. This pattern needs further investigation.

Variation: Examples vary with the transition to adjacent communities. Watson-Cook (2017) identified several groupings within the CVS data. Two she recommended as new associations and two as more minor variations that appear to be related to the transition to adjacent communities. These are not adopted as new subtypes at this time but some are recognized as variants. They should be investigated for consistent occurrence and may warrant recognition as subtypes in the future. Crandall (1958) recognized two groupings within the range covered by the subtype. One she called a *Viburnum* type, which had high cover of deciduous shrubs. The other, called *Aster* type, had a diversity of forbs.

Three variants are recognized:
1. Typic Variant fits the general description of the subtype.
2. Rich Variant contains a higher diversity of species in all strata and contains species suggestive of richer soil, such as *Laportea canadensis* and *Brachyelytrum erectum*. Four plots were identified as this group, all in the Balsam Mountains near Shining Rock, and all substantially altered by logging and slash fires. Crandall's *Aster* type may have affinities to this as well, as it contains *Laportea*. This variant is almost well enough marked to be treated as a subtype. Further investigation may find it so, especially if it is found in other mountain ranges where conditions would seem to be appropriate for it, such as Roan Mountain and the Black Mountains.
3. Heartleaf Birch Variant contains an appreciable component of *Betula cordifolia* along with the typical dominants. Two plots were identified as this group, both in the Black Mountains, the only range where the species occurs in North Carolina.

Dynamics: The dynamics of this subtype have not been specifically addressed separately from the widely studied higher elevation Herb Subtype. They likely are similar, but the warmer, less exposed environment allows greater competitiveness of *Betula* and allows a number of additional species to persist. These lower elevation sites are closer to areas that naturally burned regularly, but they are still generally separated from more fire-adapted communities by a zone of the less flammable Northern Hardwood Forest. The abundance of fire-intolerant spruce suggests fire is not a significant influence.

Because this subtype has little or no fir, it has not been devastated by balsam woolly adelgid the way higher elevation subtypes have. It apparently was still affected by the slowing of growth that was believed to be caused by air pollution and acid deposition.

Logging and slash fires in the early 1900s affected this subtype to varying degrees. Because of the higher concentration of spruce at higher elevation, logging railroads were built above it and logging reached it with varying levels of intensity. Slash fires too, spreading downhill, may sometimes have halted or lost intensity before reaching it. In some places, there are remnant patches of this subtype where the other subtypes uphill were devastated by logging and fires. In other places, forests are in a young or successional state across this zone, making it difficult to tell the natural proportions of trees and thus difficult to distinguish the communities.

This subtype often occurs in a mosaic or interfingered pattern with other Red Spruce—Fraser Fir Forest subtypes and with Northern Hardwood Forests. The natural drivers that lead to this patchiness and the specific locations are not known and need investigation.

Comments: This subtype is conceptually intermediate between Red Spruce–Fraser Fir Forest and Northern Hardwood Forest. It could perhaps be placed as easily in either type. It could also be regarded as ecotonal and not worthy of recognition at all. It is accepted here because of its ability to occupy extensive areas in natural landscapes. It appears to be optimal habitat for *Glaucomys sabrinus coloratus*, which uses a mix of spruce and birch.

Ulrey's (2002) analysis of 1273 mountain forest plots found a yellow birch-spruce community, which was included in the group of northern hardwood forests rather than the spruce-fir group. It seems to include both the Birch Transition Herb and Birch Transition Shrub subtypes. However, *Rhododendron maximum* had high 81% constancy among the 16 yellow birch-spruce plots. The only species with high constancy in Ulrey (2002) (combined herb and shrub subtypes) is *Ilex montana.*

The Birch Transition Herb Subtype is sometimes assumed to be a degraded forest that once had stronger spruce dominance. Mixed stands, or stands of hardwood with only a few spruce, often regenerated where spruce-dominated forests were logged in the Central Appalachians. In the Southern Appalachians, most places where spruce forests that were logged and burned did not recover to spruce dominance, but mixed successional stands are less common and are often ambiguous. More often, logged and burned areas lack a full forest canopy altogether, while logged areas that did not burn became dominated by fir. Mixed forests are extensive in the lower elevational range of spruce in the unlogged portions of the Great Smoky Mountains and other mountain ranges, where they must be regarded as the natural state. These areas often interfinger with patches of denser spruce or with no spruce at the same elevation, again with no evidence of human alteration. Thus, below 5500 feet elevation, mixed forests or forests lacking spruce, even adjacent to forests with more spruce, cannot be assumed to be altered or in need of restoration without further evidence.

Rare species:
Vascular plants – *Athyrium angustum, Betula cordifolia, Calamagrostis canadensis var. canadensis, Cardamine clematitis, Carex projecta, Cystopteris fragilis, Gentiana latidens, Lilium grayi, Monarda media, Phegopteris connectilis, Poa palustris, Rhododendron vaseyi, Rubus strigosus, Sceptridium oneidense, Stachys clingmanii,* and *Streptopus amplexifolius var. amplexifolius*.

Nonvascular plants – *Acrobolbus ciliatus, Arthonia cupressina, Bazzania nudicaulis, Brachydontium trichodes, Brachythecium rotaeanum, Cetrelia cetrarioides, Coniarthonia kermesina, Diplophyllum taxifolium* var. *mucronatum, Frullania appalachiana, Gymnoderma lineare, Herzogiella turfacea, Hylocomiastrum umbratum, Hypotrachyna sinuosa, Hypotrachyna virginica, Lecanora anakeestiicola, Leptodontium excelsum, Leptodontium flexifolium, Leptohymenium sharpii, Leptoscyphus cuneifolius, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Plagiochila exigua, Pohlia lescuriana, Polytrichastrum alpinum, Ptilidium ciliare, Rhytidiadelphus subpinnatus, Sphagnum squarrosum,* and *Sphenolobopsis pearsonii*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Desmognathus organi, Desmognathus wrightii, Glaucomys sabrinus coloratus, Loxia curvirostra, Microtus chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata, Setophaga magnolia,* and *Sylvilagus transitionalis.*

Invertebrate animals – *Eilema bicolor, Entephria separata, Eulonchus marialiciae, Fumonelix orestes, Fumonelix roanensis, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Hydriomena exculpata, Korscheltellus gracilis, Microhexura montivaga, Pallifera hemphilli, Pallifera ohioensis, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata*.

RED SPRUCE–FRASER FIR FOREST (BIRCH TRANSITION SHRUB SUBTYPE)

Concept: Red Spruce–Fraser Fir Forests are high mountain forests in which Picea rubens, with or without Abies fraseri or hardwoods, is naturally dominant. The Birch Transition Shrub Subtype covers forests in the broad transition zone on open slopes, where Red Spruce–Fraser Fir Forest grades to Northern Hardwood Forest with a fairly even mix of *Betula alleghaniensis* and *Picea rubens*, and where a dense evergreen shrub layer is present. It is a lower elevation analogue of the Rhododendron Subtype. The shrub layer is usually *Rhododendron catawbiense* or *Rhododendron maximum*, but in the Smokies, *Leucothoe fontanesiana* may dominate.

Distinguishing Features: The Birch Transition Shrub Subtype is distinguished from most other subtypes by canopy composition, which naturally includes more than 33% cover of *Betula alleghaniensis* and more than 33% cover of *Picea rubens* in a well-developed, undisturbed canopy. It is distinguished from the Birch Transition Herb Subtype by having a dense evergreen shrub layer rather than deciduous shrubs and herbs.

Crosswalks: Crosswalks: *Picea rubens - (Betula alleghaniensis, Aesculus flava) / Rhododendron (maximum, catawbiense)* Forest (CEGL004983).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Birch Transition Shrub Subtype occurs on sharp ridge tops and convex slopes, generally at 4500-5500 feet elevation, generally with shallow soils or associated with rock outcrops.

Soils: Soils are usually mapped as Inceptisols (Humadepts) of the Burton, Craggey, and Wayah series, but may represent inclusions of a shallower series.

Hydrology: As with other Spruce-Fir Forests, the Birch Transition Shrub Subtype is generally wet to mesic, sometimes saturated for long periods. However, the shallow soil is more prone to becoming dry in periods without rain or fog. Warmer temperatures and occurrence below the zone of maximum fog likely makes this community less wet than higher elevation subtypes.

Vegetation: The Birch Transition Shrub Subtype has a closed to open tree canopy codominated by *Picea rubens* and *Betula alleghaniensis*. Other trees may include *Quercus rubra*, *Tsuga canadensis*, *Fagus grandifolia*, and *Acer rubrum*. The understory may also include *Amelanchier laevis*, *Acer spicatum*, and *Acer pensylvanicum*. The dense shrub layer is usually dominated by *Rhododendron maximum*, with *Rhododendron catawbiense* much less frequent. Deciduous shrubs such as *Viburnum lantanoides, Vaccinium erythrocarpum*, and *Ilex montana* may be present in small amounts. The herb layer is sparse. Species are those typical of other spruce-fir forests, such as *Dryopteris campyloptera, Dryopteris intermedia,* and *Oclemena acuminata*. *Polypodium appalachianum* may be abundant where rock cover is high (Watson-Cook 2017; Crandall 1958).

Range and Abundance: Ranked G1?. This subtype was once thought confined to the Smokies, but it appears to be present in several other ranges. The association ranges into adjacent Tennessee and southern Virginia.

Associations and Patterns: The Birch Transition Shrub Subtype grades to the Birch Transition Herb Subtype on deeper soils and less exposed topography. It may grade to other subtypes or to Northern Hardwood Forest.

Variation: No variants are recognized.

Dynamics: The dynamics of this subtype have not been specifically addressed as distinct from the widely studied higher elevation Herb Subtype. They likely are similar, but the warmer, less exposed environment allows greater competitiveness of *Betula*. These lower elevation sites are closer to areas that naturally burned regularly, but they are still generally separated from more fire-adapted communities by a zone of the less flammable Northern Hardwood Forest. The abundance of fire-intolerant spruce suggests fire is not a significant influence. However, the ridge top locations may make them more susceptible to lightning.

Comments: The association corresponding to this subtype was created for vegetation in the Great Smoky Mountains. It is unclear if it occurs in any other parts of North Carolina. It may only questionably be distinct from the Low Rhododendron Subtype.

Rare species:
Vascular plants – *Athyrium angustum, Betula cordifolia, Calamagrostis canadensis var. canadensis, Cystopteris fragilis, Gentiana latidens, Lilium grayi, Phegopteris connectilis, Poa palustris, Rhododendron vaseyi, Rubus strigosus,* and *Sceptridium oneidense.*

Nonvascular plants – *Acrobolbus ciliatus, Arthonia cupressina, Bazzania nudicaulis, Brachydontium trichodes, Brachythecium rotaeanum, Cetrelia cetrarioides, Coniarthonia kermesina, Diplophyllum taxifolium* var. *mucronatum, Frullania appalachiana, Gymnoderma lineare, Herzogiella turfacea, Hylocomiastrum umbratum, Lecanora anakeestiicola, Leptodontium excelsum, Leptodontium flexifolium, Leptohymenium sharpii, Leptoscyphus cuneifolius, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Plagiochila exigua, Pohlia lescuriana, Polytrichastrum alpinum, Ptilidium ciliare, Rhytidiadelphus subpinnatus, Sphagnum squarrosum,* and *Sphenolobopsis pearsonii*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Desmognathus organi, Desmognathus wrightii, Glaucomys sabrinus coloratus, Loxia curvirostra, Microtus chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata, Setophaga magnolia,* and *Sylvilagus transitionalis.*

Invertebrate animals – *Eilema bicolor, Entephria separata, Eulonchus marialiciae, Fumonelix orestes, Fumonelix roanensis, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Hydriomena exculpata, Korscheltellus gracilis, Microhexura montivaga, Pallifera hemphilli, Pallifera ohioensis, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata*.

RED SPRUCE–FRASER FIR FOREST (LOW RHODODENDRON SUBTYPE)

Concept: Red Spruce–Fraser Forests are high mountain forests in which *Picea rubens*, with or without *Abies fraseri* or hardwoods, is naturally dominant. The Low Rhododendron Subtype covers the lowest elevation examples of Red Spruce–Fraser Forest Forests, in moist, topographically sheltered sites. This subtype is transitional from spruce-fir forest to Acidic Cove Forest. *Picea rubens* dominates or codominates with other mesophytic trees and there is an evergreen shrub layer.

Distinguishing Features: Red Spruce–Fraser Fir Forests are distinguished by canopy dominance of *Picea rubens* alone or with *Abies fraseri*, *Betula alleghaniensis, Sorbus americana*, or occasionally other hardwoods, in a high elevation upland setting. The Low Rhododendron Subtype is distinguished from other lower elevation Red Spruce–Fraser Fir Forests subtypes by the combination of sheltered concave topography with a dense shrub layer of *Rhododendron maximum*, generally at lower elevation than other subtypes. If other tree species are present, they often are species of lower elevation mesic sites, such as *Tsuga canadensis* but may include *Betula alleghaniensis*. This subtype often represents a situation of inverted zonation, occurring downhill of Northern Hardwood Forest or Mountain Oak Forest. The Birch Transition Shrub Subtype and Rhododendron Subtype may also have abundant *Rhododendron maximum* but occur on convex topography such as ridges and have associated species of drier sites.

Crosswalks: *Picea rubens - (Tsuga canadensis) / Rhododendron maximum* Forest (CEGL006152).
G632 Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group.
Central and Southern Appalachian Spruce-Fir Forest Ecological System (CES202.028).

Sites: The Low Rhododendron Subtype occurs on north-facing slopes, sheltered slopes, valley heads, and ravines, generally at lower elevations than other subtypes. The full elevational range is not well known, but examples are known down to near 4000 feet. Some examples occur as downward extensions of spruce from extensive spruce-fir forests into upper valleys, while a few are anomalous occurrences in high valleys distant from other spruce-fir forests. Cold air drainage may be important for their occurrence at these low elevations.

Soils: Soils are not well known for this subtype.

Hydrology: Conditions are mesic due to topographic sheltering, but this subtype occurs below the elevation of frequent fog and high rainfall, and its water input may be much lower than higher elevation subtypes. Some occurrences are associated with Swamp Forest–Bog Complex, where wetter conditions may be present.

Vegetation: The Low Rhododendron Subtype has a closed to open tree canopy dominated by *Picea rubens*, sometimes codominated by *Tsuga canadensis* or *Betula alleghaniensis*. Other trees may include *Acer rubrum*, *Sorbus americana*, and in the understory, *Acer spicatum,* or *Amelanchier laevis*. There is a dense shrub layer dominated by *Rhododendron maximum*. *Kalmia latifolia* may be fairly abundant, and though not reported, it is possible that *Leucothoe fontanesiana* could dominate. Other shrubs include those typical of other spruce-fir forests, such as *Viburnum* *lantanoides*, *Vaccinium erythrocarpum*, and *Vaccinium simulatum*, and sometimes species shared with nearby wetlands, such as *Viburnum cassinoides* and *Sorbus melanocarpa*.

Range and Abundance: Ranked G2G3 This subtype is often not mentioned or described well enough to be recognized in past reports, making its abundance difficult to know. The corresponding NVC association is broadly defined, and is considered to range northward to West Virginia, where it may be more abundant, as well as into Tennessee.

Associations and Patterns: Most examples of the Low Rhododendron Subtype occur in the highest mountain ranges where other subtypes are present. However, unusual examples of this subtype occur without other spruce-fir forests in lower elevation sites at Alarka Laurel and Long Hope Valley. In other sites, the Birch Transition Shrub or Birch Transition Herb Subtype may be present uphill, but this subtype often extends below the elevational range of other spruce-fir forests, so that it is surrounded by Northern Hardwood Forest on adjacent ridges. Downhill may be Acidic Cove Forest. A couple of unusual examples are associated with Swamp Forest–Bog Complex (Spruce Subtype).

Variation: Variation is not well known, other than that *Tsuga canadensis* may or may not codominate. No formal variants are recognized.

Dynamics: The dynamics of this unusual subtype are virtually unknown and may be different from the rest of the Spruce-Fir Forests theme.

Comments: The corresponding NVC association may be more broadly defined than this subtype. Its description mentions occurrence on ridges as well as in valleys in parts of the range and mentions *Rhododendron catawbiense* sometimes mixed in the shrub layer. This would appear to overlap the concept of the Birch Transition Shrub Subtype and its equivalent association, and it is unclear how they would be distinguished in such vegetation. This may represent variation in states farther north, where the Birch Transition Shrub Subtype or Rhododendron Subtype are not recognized.

Early versions of the 4th approximation recognized a Hemlock Subtype at lower elevations. This has been lumped into this subtype. The NVC association corresponding to it, *Picea rubens - Tsuga canadensis / Rhododendron maximum* Forest (CEGL006272), has also been lumped.

Rare species:
Vascular plants – *Cystopteris fragilis, Gentiana latidens, Phegopteris connectilis,* and *Sceptridium oneidense.*

Nonvascular plants – *Acrobolbus ciliatus, Frullania appalachiana, Herzogiella turfacea, Hylocomiastrum umbratum, Leptohymenium sharpii, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Pohlia lescuriana, Rhytidiadelphus subpinnatus,* and *Sphagnum squarrosum*.

Vertebrate animals – *Aegolius acadicus, Catharus guttatus, Catharus ustulatus, Certhia americana, Desmognathus organi, Desmognathus wrightii, Loxia curvirostra, Microtus* *chrotorrhinus carolinensis, Mustela nivalis*, *Poecile atricapillus, Setophaga coronata, Setophaga magnolia,* and *Sylvilagus transitionalis.*

Invertebrate animals – *Eilema bicolor, Entephria separata, Fumonelix orestes, Fumonelix roanensis, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Korscheltellus gracilis, Microhexura montivaga, Nesticus mimus, Pallifera hemphilli, Pallifera ohioensis, Polygonia faunus, Syngrapha alias,* and *Xestia perquiritata*.

GRASS AND HEATH BALDS THEME

Concept: Grass and Heath Balds are non-forested high elevation communities occurring on well-developed soils with only limited rock outcrops. They may be dominated by shrubs or herbs, and they have sparse or no trees.

Distinguishing Features: Grass and Heath Balds are distinguished by natural dominance of dense grasses, sedges, or shrubs with little or no tree cover at high to fairly high elevation (3600 feet or above). Soils are deep, or shallow and rocky, but are well-developed, in contrast to those of glade communities.

Heath Balds are distinguished by dense shrub layers dominated by R*hododendron catawbiense, Rhododendron minus, Kalmia buxifolia*, or other Ericaceae, with the dominant shrubs distinguishing the subtypes. Most Grassy Balds are dense herbaceous vegetation dominated by grasses or sedges. The Alder Subtype has an open to dense shrub layer of *Alnus crispa* with a moderate to sparse herb layer beneath.

Sites: Grass and Heath Balds communities occur on higher elevation ridges and upper slopes. Most examples are at high elevation, 4000 feet to over 6000 feet, but a few subtypes extend as low as 3600 feet. Heath Balds often occur on sharp, narrow spur ridges or narrow ridge tops but may occur on broad domes or knobs or on convex slopes associated with rock outcrop communities. Grassy Balds usually occur on broader ridge tops, knobs, and saddles.

Soils: Grass and Heath Balds occur on a wide variety of high elevation soils, mostly Inceptisols. They may be rocky but, other than locally around embedded rock outcrops, are not unusually shallow or rocky. Heath Bald soils sometimes have a thick organic layer that may constitute the bulk of the soil.

Hydrology: Sites for balds have good drainage but are mesic because of high rainfall, long periods bathed in fog, and low temperatures.

Vegetation: The Grass and Heath Balds theme encompasses two kinds of non-forest vegetation. Heath Balds are shrublands that usually have dense, tall to short shrub canopies dominated by *Rhododendron catawbiense, Rhododendron minus*, or other evergreen Ericaceae. Some deciduous shrubs, such as *Vaccinium* spp., may also be present. Grassy Balds have dense herbaceous vegetation generally dominated by *Danthonia compressa* or *Carex* spp., with various other graminoids and forbs sometimes abundant. Grassy Bald (Alder Subtype) is intermediate in structure, with an open to dense shrub layer of *Alnus crispa* and varying herbaceous cover beneath. Some examples of Grassy Bald have developed sparse to dense stands of *Rubus allegheniensis*, *Rubus canadensis*, or various shrubs in recent decades. Sparse trees, often stunted, may be present in either Grassy Balds or Heath Balds. Some balds show more recent substantial invasion by trees which is not believed to be natural.

Dynamics: Dynamics appear to vary among different bald communities and may be particularly different between Grassy Bald and Heath Bald. Details are discussed for the individual communities. All of the balds occur in sites prone to severe weather and extreme conditions, but all are surrounded by forests in similar climate. The ecological processes or factors that keep them open under natural conditions are not always well known, and ideas are sometimes controversial.

Comments: There has been confusion caused by varying meanings of the term “bald” in both scientific and popular usage. Some known historic clearings are called balds in place names and by various authors. Many forested mountain peaks are named as balds (e.g. Cheoah Bald) and this has sometimes been used to argue that they should be cleared of their trees, though they may have old forest and offer no evidence that they ever were treeless. It should be noted that the word “bald” when applied to people, though it now means hairless, once also meant white-headed. Given the tendency of snow and rime ice to form or persist only at higher elevations, it is possible we should be looking to the bald eagle rather than the turkey vulture as an avian analogue for these names.

KEY TO GRASS AND HEATH BALDS

1. Community dominated by grasses or sedges, or known to be formerly open and only recently invaded by woody vegetation. Local shrub patches or more extensive invading shrubs or young trees may be present in some examples.

2. Community dominated by grasses, generally *Danthonia spicata*, or of mixed herbaceous vegetation in which grasses predominate over sedges.................**Grassy Bald (Grass Subtype)**

2. Community dominated by sedges, generally *Carex* spp., or of mixed herbaceous vegetation in which sedges predominate over grasses. ....**Grassy Bald (Sedge Subtype)**

1. Community dominated by shrubs over the long term and apparently naturally. Area not known to have been naturally open herb-dominated in the past. High grass or sedge cover is rarely present beneath the shrub layer.

3. Community dominated by *Alnus crispa*, in a dense or open stand. Grasses or sedges sometimes with substantial cover. Rare community known only in the Roan Mountain area........................ ....**Grassy Bald (Alder Subtype)**

3. Community not dominated by *Alnus crispa*. The species generally completely absent. Dominated by shrubs in the Ericaceae.

4. Community strongly dominated by *Kalmia (Leiophyllum) buxifolia*. Larger shrubs, if present, a minor component...**Heath Bald (Sand Myrtle Subtype)**

4. Community not strongly dominated by *Kalmia buxifolia*, though the species may be present and occasionally abundant.

5. Community strongly dominated by *Rhododendron carolinianum*, occurring on quartzite substrate, often at lower elevations where *Kalmia latifolia* is present. Likely to occur only in Linville Gorge.. **Heath Bald (Carolina Rhododendron Subtype)**

5. Community not strongly dominated by *Rhododendron carolinianum;* the species codominant to absent. *Rhododendron catawbiense* dominant, codominant, or abundant.

6. Community strongly dominated by *Rhododendron catawbiense*, or mixed with *Vaccinium* spp., occurring at mid to very high elevation……………………………. .... **Heath Bald (Catawba Rhododendron Subtype)**

6. *Rhododendron catawbiense* not strongly dominant, but mixed with *Kalmia latifolia, Pieris floribunda, Rhododendron carolinianum*, or other shrub species.

7. Community occurring at lower elevations, generally 5000 feet or lower. *Kalmia latifolia*, *Rhododendron maximum*, or other species of lower elevations abundant along with *Rhododendron catawbiense*.........................**Heath Bald (Low Elevation Subtype)**

7. Community generally occurring at higher elevations. *Kalmia latifolia, Rhododendron maximum*, and other species of lower elevations scarce or absent. Species of higher elevations, such as *Picea rubens* or *Sorbus americana,* often present in small numbers.

8. Community dominated by a mix of *Rhododendron catawbiense, Rhododendron carolinianum, Kalmia buxifolia*, and possibly *Rhododendron smokianum*, occurring on slate substrate. Known only in the Great Smoky Mountains ……………………… ……………………………………………………………**Heath Bald (Slate Subtype)**

8. Community dominated by a mix of *Rhododendron catawbiense* with *Pieris floribunda, Vaccinium* spp., and other species, but without *Rhododendron carolinianum* or *Kalmia buxifolia. Known only south of Asheville. Particularly abundant in the Balsam Mountains*. ....**Heath Bald (Southern Mixed Subtype)**

GRASSY BALD (GRASS SUBTYPE)

Concept: Grassy Bald (Grass Subtype) is a natural high elevation meadow with a dense herb layer dominated by grasses, though patches of forbs and sedges are present and some examples now have extensive patches of shrubs or *Rubus*. Grassy Balds have well-developed soils that contrast with those of rock outcrop communities and glades. *Danthonia compressa* is typically the dominant grass, but pasture grasses such as *Phleum pratense* may have become abundant in the more heavily grazed examples.

Distinguishing Features: Grassy Balds are distinguished from other natural communities by the natural dominance of dense herbaceous vegetation in high elevation upland sites that are not rock outcrops or glades. Small rock outcrops and shallow soil patches may be embedded but do not make up most of the area. High Elevation Rocky Summit communities, in contrast, contain substantial bare rock, though they may contain small patches of herbaceous vegetation with some of the same species. High Elevation Mafic Glades and Low Elevation Acidic or Basic Glades contain more grass but are clearly related to very shallow soil.

True Grassy Balds can be difficult to distinguish from old high elevation pastures and burn scars. Some extensive grassy areas, e.g., Graveyard Fields and areas near Mount Mitchell, are known to have originated from logging and burning of spruce-fir forest in the 1900s and should not be regarded as Grassy Balds. The classification should be used only if there is reason to believe an area has been grassy from prehistoric times. Artificial grasslands may be dominated by *Danthonia compressa* but are less likely to contain rare plants and more often contain substantial weedy flora. However, heavily grazed natural Grassy Balds also may contain weedy flora, and many have been invaded by *Rubus* or various shrubs and are no longer herb dominated. Some examples may remain ambiguous.

The Grass Subtype is distinguished from the Sedge Subtype by dominance of grasses, usually *Danthonia compressa*, rather than *Carex* spp. It is distinguished from the Alder Subtype by the absence of substantial cover of *Alnus crispa.*

Crosswalks: *Danthonia compressa - (Sibbaldiopsis tridentata)* Grassland (CEGL004242).
G657 Southern Appalachian Grass Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: Grassy Balds occur on gentle to moderate slopes, ridgetops, and broad domes at high elevation. Examples range from around 5000 feet to over 6000 feet in elevation.

Soils: Grassy Balds occur on relatively deep soils, where tree presence apparently is not precluded by soil depth. Most are mapped as the Burton series (Typic Haplumbrept). Cain (1931) found that Grassy Bald soils in the Smokies were less acidic than other soils at similar elevations, although it is unclear if this is caused by the distinctive vegetation or is the result of it.

Hydrology: Grassy Balds generally occur on high convex slopes and are well drained, though seeps may be embedded in them. They are mesic due to high rainfall, frequent fog, and low temperatures, but are exposed to drying winds.

Vegetation: Grassy Bald (Grass Subtype) is characteristically dominated by dense herbaceous vegetation, with *Danthonia compressa* the dominant species. Patches may be dominated by *Sibbaldiopsis tridentata*, *Packera schweinitziana,* or *Rumex acetosella*. Other frequent herbs in CVS plot data include *Carex pensylvanica, Avenella* (*Deschampsia*) *flexuosa, Potentilla simplex, Poa compressa, Achillea borealis, Carex brunnescens* var. *sphaerostachya*, and *Athyrium asplenioides*. *Phleum pratense, Poa compressa*, and *Poa pratensis* are also fairly frequent, presumably because of a history of grazing. Other species less frequent in plots but often prominent in observations include *Houstonia serpyllifolia, Fragaria virginiana, Lilium grayi*, *Athyrium angustum*, *Athyrium asplenioides*, *Gentiana austromontana*, and the moss *Polytrichum commune*. Grassy Balds may be purely herbaceous or may have shrubs and trees of varying density. *Rubus canadensis* or *Rubus alleghaniensis* have invaded many Grassy Balds that were grazed and then removed from grazing and may be dominant over large patches where not kept in check by deliberate management. *Vaccinium altomontanum, Rhododendron calendulaceum, Rhododendron catawbiense*, *Vaccinium simulatum, Kalmia latifolia, Rhododendron* (*Menziesia*) *pilosum*, *Abies fraseri, Picea rubens, Fagus grandifolia,* and *Quercus rubra* may be present in sparse-to-moderate density. These species too are considered invaders and may eventually shade out the herb layer.

Range and Abundance: Ranked G1. Only a few examples are known, scattered throughout the higher mountains from the Great Smoky Mountains northward. The overall abundance and range is confused by the presence of ambiguously natural grassy areas in several places and the widespread use of the term bald for artificial grasslands. This community is nearly endemic to North Carolina, but a few examples occur in adjacent Tennessee and Virginia.

Associations and Patterns: The Grass Subtype may be associated with the Sedge Subtype and, on Roan Mountain, the Alder Subtype. Grassy Balds are sometimes associated with Heath Bald, High Elevation Red Oak Forest, or Northern Hardwood Forest communities. High Elevation Rocky Summit or High Elevation Boggy Seep patches may be embedded. Transitions to adjacent forests sometimes seem gradual, sometimes abrupt. Because of recent management and unknown past management, it is impossible to know the nature of natural ecotones. Even examples of natural origin were grazed and may have been expanded by clearing at their edges. Encroachment of shrubs and trees into Grassy Bald often appears to progress from the edges.

Variation: Grassy Balds vary with grazing history, exposure, and unknown factors. No variants are recognized.

Dynamics: The factors that produced and maintained Grassy Balds have been the subject of intense scientific interest over the years, and much has been written about them, but consensus has not been reached (see Smathers 1980, summary by Peterson 1980, and views expressed in Billings and Mark 1957, Bratton and White 1980, Brown 1941, Cain 1931, Gersmehl 1973, Lindsay and Bratton 1976a, 1976b, Lindsay and Bratton 1980, Mark 1958, Smathers 1980, Stratton and White 1982, and Wells 1937, 1956). Hypotheses of origin include human action such as clearing and grazing of cattle by early settlers; clearing and burning by Native Americans; presettlement grazing and trampling by native large mammals; natural disturbances such as fire, windthrow, or insects; and changing climatic conditions. New Grassy Balds are not being created from forests at present, and existing examples do not seem to be maintaining themselves. Johnson (1995) documented the loss of grassy area in the Craggy Mountains, and a management team has tracked the changes in Grassy Balds at Roan Mountain for decades. The question of the origin of Grassy Balds is given urgency by their ecological instability at present. All examples appear to be experiencing invasion by shrubs or trees, though trees are much slower to establish and spread than in disturbed forests. Balds that are not actively being managed to remove woody vegetation are losing their open grassy character.

The question of recent human creation is confused by the existence of grassy areas that clearly are recently created, either by logging and burning of spruce-fir forests or by clearing and grazing by early settlers. Some of these areas have place names of "bald" and are treated as grassy balds by some authors. However, there is evidence that other grassy areas were present when settlers arrived, and these are the focus of the Grassy Bald community defined here. Though Grassy Balds are not floristically similar to northern alpine tundra (Stratton and White 1982), and many of their species are present in other open natural communities, they likely developed from Pleistocene alpine tundra that is generally believed to have existed in the Southern Appalachians. The balds contain some shade-intolerant species, such as *Packera schweinitziana* and *Sibbaldiopsis tridentata*, which are not in surrounding forests. Such species are not observed spreading into new sites, and their presence suggests great antiquity for balds such as those on Roan Mountain. The potential for creation by Native Americans is more difficult to rule out, given their longer tenancy and the range of possible human behavior. However, the sites of Grassy Balds are not suited for agriculture or long-term settlement and were not particularly close to Native American settlements. Prehistoric people hunted throughout the region and ignited fires throughout the region, but there is no reason to expect them to have focused such activities on particular ridge tops sufficiently to replace forest with grassland. With the exception of spruce-fir forests, even severely burned forest areas quickly begin returning to tree cover. Only frequent burning, more frequent than either the natural or anthropogenic background rate, or ongoing cattle grazing, tend to prevent tree establishment at present. More plausibly, the previous existence of grassy meadows led to a focus on such places for cattle grazing and, probably in earlier times, for hunting. Weigl and Knowles (2013) discuss several such lines of evidence against human creation of Grassy Balds.

Known natural disturbances also do not seem sufficient to explain the origin or persistence of Grassy Balds. Where forests have been disturbed by wind storms, ice storms, or natural fire at high elevations, they quickly grow back in trees. With the more catastrophic disturbance caused by logging and slash fires, or by introduction of the balsam woolly adelgid, spruce-fir forests developed open successional vegetation that can be readily distinguished from Grassy Bald vegetation. While the grassy vegetation can burn, especially outside of the growing season, fire seems unlikely to ever have occurred frequently enough to maintain balds. The moist foggy climate limits flammable periods. The spruce-fir and northern hardwood communities that surround most Grassy Balds are not very flammable, nor do they contain species favored by frequent fire. Only High Elevation Red Oak Forests, less frequent neighbors, are likely to have burned very often.

Weigl and Knowles (2013) advanced an argument for grazing by native animals as a means of creating Grassy Balds and maintaining them. A diverse fauna of large grazing mammals existed in the Pleistocene and they presumably grazed in open tundra created by the Pleistocene climate, perhaps helping to exclude trees from it. The more crucial question, however, is why any open areas created or maintained by climate or these animals would have persisted for the 13,000 years since those species became extinct. The native herd-forming grazing animals in the region since that time have been elk and bison. If these species gravitated to previously existing open grasslands, they may have contributed to excluding trees as the climate became more favorable for trees. This needs further investigation. With their populations extirpated early by European settlers, the past behavior of Eastern native grazers is not well known. There is no reason to expect it, or its ecological effects, to be identical to those of domesticated cattle. However, it may have included habitual return to places that had remained grassy and may have contributed to keeping them open.

The climate in Grassy Bald sites is harsh. Forests that are destroyed at high elevations are slower to recover compared to those at lower elevations, but balds are surrounded by forests that persist in similarly harsh climates. Cogbill, et al. (1997) estimated that the elevation of the hypothetical timberline in the Southern Appalachians in the current climate would be around 8000 feet, considerably higher than any existing balds. Nevertheless, harsh climate may amplify the effects of other processes and contribute to keeping balds open.

Understanding of the natural dynamics of Grassy Balds and their current instability is hampered by the universal history of cattle grazing after European settlement. The current invasion of woody plants into balds often is associated with the end of cattle grazing as lands were brought into conservation status in the mid-to-late 1900s, and the removal of cattle is often blamed for the encroachment. However, the relationship between grazing and grasslands here, as more widely, is complex. Cases in other regions include not only maintenance by grazers but also cases of grazing increasing woody encroachment (e.g., Briggs et al. 2002 in tallgrass prairie). Crawford and Kennedy (2009), looking at ages of trees that had invaded Grassy and Heath Balds at Craggy Gardens, found rapid canopy closure after cattle were removed in 1925; however, they also found that tree patches had established in four separate episodes from 1760-1925, though cattle grazing did not start until the late 1800s. Thus, encroachment apparently was happening both before cattle arrived and during their presence. Stratton and White (1982) noted that most of the prominent invading shrubs in Great Smoky Mountains Grassy Balds had been present in the 1930s while grazing was still occurring, though they became more extensive after release from grazing. Brown (1941) noted the disappearance of Grassy Bald on the western part of Roan Mountain by invasion of spruce. He reported that the upper 50 meters of spruce forest on western Roan Mountain had few trees more than 150 years old, though trees 300-350 years old occurred farther into the forest interior. He also noted open-grown forms of trees near the edge. He took this as evidence of ongoing shrinkage of balds. This would suggest a slow invasion dating back to at least the late 1700s, either early in the period of grazing or perhaps predating it and extending throughout its duration. However, given the history of the Cloudland Hotel on this side of the mountain, we cannot rule out the possibility either that older trees were cut near the edge, or that the open area he saw disappearing beneath spruce invasion in the 1930s had been cleared forest rather than Grassy Bald.

Cattle trample woody plants, and at sufficient grazing intensity can prevent succession to forest as long as they are present. They have numerous other effects, including soil disturbance, selective increase or decrease of different species of plants, and if grazing is heavy, creation of conditions favorable to ruderal plants rather than long-lived competitive plants of grasslands. Such effects reduce the competitiveness of the native grasses, possibly making them more susceptible to invasion than they were before cattle were introduced. The rapid spread of woody vegetation immediately after grazing ended, compared to the slower establishment of trees and shrubs at present, and the slower encroachment in the rare cases documenting pre-grazing dynamics, suggest this. The recent historic encroachment may thus be a legacy of cattle grazing rather than fundamentally an effect of its removal.

Most remaining Grassy Balds have some Eurasian pasture species that became established during grazing, and some have substantial exotic plant cover. Balds that are still actively grazed often have low plant cover and an increased component of unpalatable herbs. Some of the most prolific native plants invading Grassy Balds, such as *Rubus*, are species that readily established after severe disturbance but that can continue to spread vegetatively once established. Weigl and Knowles (2013) and others before them have argued that the cattle have replaced the role of native grazers in a natural process to maintain balds. However, given the distant taxonomic relationship of cattle to bison and elk, the alteration of their behavior by domestication as well as active human herding, and their absence in the natural evolution of bald communities, they are better regarded as an exotic species. They may be a means of artificial maintenance comparable to mowing, but one with its own suite of side effects. The abundance of exotic plants in remote mountaintop locations is an indication of the alteration caused by cattle grazing. Maintenance by cattle grazing can be expected to perpetuate the state of alteration produced by European settlement. At present, the appropriate natural means of maintaining Grassy Balds is not known, and management techniques must be selected for their ecological effects without benefit of this knowledge.

Comments: The previous distinction between a Northern Grass Subtype (*Danthonia compressa - Sibbaldiopsis tridentata* Herbaceous Vegetation [CEGL004258]) and Southern Grass Subtype has been dropped. The distinction with the Sedge Subtype has been retained but needs further investigation into whether it is justified given the uncertainties caused by grazing history.

Grassy Bald is a rare and very threatened community type. The debate about Grassy Bald origins raises questions regarding their naturalness, and some scientists regard them as an artificial vegetation type. Because of their distinctive vegetational character, however, and because they appear to date to prehistoric times, they are best regarded as natural communities worthy of protection. While active artificial maintenance is required, such management should be oriented toward imitating natural processes to the extent that they are understood, eliminating exotic species, allowing natural vegetation to recover, and minimizing disturbance to the site.

Rare species:
Vascular plants – *Agrostis mertensii, Alnus crispa, Athyrium angustum, Botrychium matricariifolium, Bromus ciliatus, Carex cristatella, Crocanthemum bicknellii, Crocanthemum propinquum, Delphinium exaltatum, Geocarpon groenlandicum, Geum radiatum, Houstonia montana, Lilium grayi, Lilium philadelphicum* var. *philadelphicum, Monarda media, Packera schweinitziana, Phlox subulata, Poa palustris, Rhynchospora alba, Sceptridium multifidum,* and *Stachys clingmanii.*

Nonvascular plants – *Heterodermia erecta* and *Rhytidium rugosum*.

Vertebrate animals – *Catharus ustulatus, Microtus chrotorrhinus carolinensis, Pooecetes gramineus,* and *Sylvilagus obscurus*.

GRASSY BALD (SEDGE SUBTYPE)

Concept: Grassy Bald (Sedge Subtype) is a natural high elevation meadow with dense herb cover dominated by species of *Carex*, though patches with grasses and forbs are also present and some examples now have extensive patches of shrubs or *Rubus*. The Sedge Subtype often occurs in a mosaic with other Grassy Bald subtypes. Sedge-dominated wetlands and areas resulting from recent forest clearing should not be included.

Distinguishing Features: Grassy Balds are distinguished from other natural communities by the natural dominance of dense herbaceous vegetation in high elevation upland sites that are not rock outcrops or glades. The Sedge Subtype is distinguished from the Grass Subtype by the dominance of *Carex* spp. It is distinguished from the Alder Subtype by the absence or only sparse presence of *Alnus crispa*. High Elevation Rocky Summit communities may contain some of the same species but have limited herbaceous vegetation and extensive bare rock. Northern Hardwood Forest (Beech Gap Subtype) has similar *Carex* dominated herbaceous cover but has a well-developed tree canopy.

Crosswalks: *Carex pensylvanica* Grassland (CEGL004094).
G657 Southern Appalachian Grass Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Sedge Subtype occurs in settings similar to the other subtypes, on gentle to moderate slopes, ridgetops, and broad domes at high elevation.

Soils: Most soils are mapped as the Burton series (Typic Haplumbrept).

Hydrology: Sites are high convex slopes and are well drained, though seeps may be embedded in them. They are mesic due to high rainfall, frequent fog, and low temperatures but are exposed to drying winds.

Vegetation: The Sedge Subtype has dense herbaceous vegetation dominated by species of *Carex*. *Carex pensylvanica* usually is the dominant species, and *Carex flexuosa* and *Carex brunnescens* var. *sphaerostachya* are frequent. *Danthonia compressa* and other grasses are often intermixed. Other high constancy species in CVS plot data include *Sitobolium* (*Dennstaedtia*) *punctilobulum, Angelica triquinata, Rumex acetosella,* and *Anemone quinquefolia*. *Rubus canadensis* also is present in most plots. Species that are fairly frequent include *Houstonia serpyllifolia,* and *Erythronium americanum* ssp. *americanum*. Additional species in CVS plots include *Luzula echinata, Lysimachia ciliata, Nabalus* sp., and *Lilium grayi*. Additional species are noted in the NVC description, including *Carex debilis, Sibbaldiopsis tridentata, Fragaria virginiana, Ageratina roanensis*, and *Bromus pubescens*. Some areas are invaded by woody species, which may include *Vaccinium* spp., *Rhododendron catawbiense*, *Fagus grandifolia, Aesculus flava, Abies fraseri*, and others, as well as *Rubus*.

Range and Abundance: Ranked G1. The Sedge Subtype is reported only from the Roan Mountain highlands of North Carolina and adjacent Tennessee and possibly from one additional site in

Watauga County. Since it can occur in association with the Grass Subtype, a few more examples may be overlooked.

Associations and Patterns: In the primary known location, the Sedge Subtype occurs in a mosaic with the Grass Subtype and Alder Subtype and may be bordered by Northern Hardwood Forest.

Variation: Variation is not well known, other than local variation with the transition to adjacent communities and the variation in the degree of woody species encroachment.

Dynamics: The uncertainties and controversies discussed for the dynamics of the Grass Subtype of Grassy Bald also apply to the Sedge Subtype.

Comments: The relationship between the Sedge Subtype and Grass Subtype is particularly poorly known. It may be related to subtle site differences but may equally easily be related to differences in successional state or to differences in degree of alteration by grazing. The subtypes are recognized based on the NVC, but they may be only marginally distinct. The widespread alteration of Grassy Bald communities by grazing, woody plant invasion, and later management make the distinguishing of appropriate herbaceous dominance problematic.

Rare species:
Vascular plants – *Agrostis mertensii, Alnus crispa, Athyrium angustum, Botrychium matricariifolium, Bromus ciliatus, Carex cristatella, Crocanthemum bicknellii, Crocanthemum propinquum, Delphinium exaltatum, Geocarpon groenlandicum, Geum radiatum, Houstonia montana, Lilium grayi, Lilium philadelphicum* var. *philadelphicum, Monarda media, Packera schweinitziana, Phlox subulata, Poa palustris, Rhynchospora alba, Sceptridium multifidum,* and *Stachys clingmanii.*

Nonvascular plants – *Heterodermia erecta* and *Rhytidium rugosum*.

Vertebrate animals – *Catharus ustulatus, Microtus chrotorrhinus carolinensis, Pooecetes gramineus,* and *Sylvilagus obscurus*.

GRASSY BALD (ALDER SUBTYPE)

Concept: Grassy Bald (Alder Subtype) is a high elevation shrubland dominated by *Alnus crispa*, often with a grass or sedge herb layer beneath. This subtype is confined to the Roan Mountain highlands.

Distinguishing Features: The Alder Subtype is distinguished from all other communities in North Carolina by the dominance of *Alnus crispa*.

Crosswalks: *Alnus viridis ssp. crispa / Carex pensylvanica* Shrubland (CEGL003891).
G657 Southern Appalachian Grass Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Alder Subtype occurs in settings similar to the other subtypes, on gentle to moderate slopes, ridgetops, and broad domes at high elevation.

Soils: Mapped as the Burton series (Typic Haplumbrept). Donaldson, et al. (2014) found soils in the Alder Subtype to have pH of 4-5, more acidic than either other Grassy Bald or Heath Bald soils. The nitrogen fixation carried on by *Alnus* acidifies the soil, so this likely is a result of the vegetation. The Alder Subtype also have higher cation exchange capacity and organic matter than other Grassy Balds or than Heath Balds.

Hydrology: Sites are high convex slopes and are well drained, though seeps may be embedded in them. They are mesic due to high rainfall, frequent fog, and low temperatures, but are exposed to drying winds.

Vegetation: The Alder Subtype is a shrubland dominated by *Alnus crispa*, which may range from dense to open. *Rhododendron calendulaceum*, *Vaccinium altomontanum*, or *Vaccinium corymbosum* may be present in small numbers. In some areas, *Rubus canadensis* is present, and it may be dense. The herb layer varies in cover, but usually is extensive where *Rubus* is not abundant. *Carex pensylvanica* dominates, and *Carex flexuosa, Poa compressa, Houstonia serpyllifolia, Erythronium americanum* ssp. *americanum* are often present. Other herbs may include *Avenella flexuosa, Danthonia compressa, Sitobolium* (*Dennstaedtia*) *punctilobulum, Carex brunnescens* var. *sphaerostachya*, and *Rumex acetosella*. *Abies fraseri, Fagus grandifolia*, *Aesculus flava*, or other trees may be established in some areas.

Range and Abundance: Ranked G1. This community is known only in a small portion of the Roan Mountain highlands on the North Carolina-Tennessee border. Its entire global range is less than 200 acres. The population of *Alnus crispa* represents a long distance disjunction; the nearest native population is in Pennsylvania, where it too is a disjunct from a widespread population in New England, Canada, the upper Midwest, and Greenland.

Associations and Patterns: Grassy Bald (Alder Subtype) occurs in association with the Grass Subtype and Sedge Subtype. It also may border Northern Hardwood Forest and High Elevation Rocky Summit.

Variation: Examples vary in shrub density and herbaceous composition.

Dynamics: Most of the uncertainties and controversies discussed for the dynamics of the Grass Subtype of Grassy Bald also apply to the Alder Subtype, with the addition of uncertainty about its relationship to the other subtypes. *Alnus crispa* has sometimes been regarded as a woody invader of the Grass and Sedge subtypes, spreading vegetatively since the cessation of cattle grazing and representing a threat to them similar to *Rhododendron* and *Rubus*. Brown (1941) briefly indicated he thought vigorous alder growth was slowly invading open Grassy Bald. He included it as an alternative successional pathway from grass to spruce forest. However, historical information is not detailed enough about the boundaries between these adjacent communities to be certain that alder has expanded. The turnover of stems makes it impossible to age the shrubs.

However, the *Alnus* is a long-distance disjunct population, apparently persisting at this location since the Pleistocene. It does not occur in adjacent forests, and its presence is one of the indicators of great antiquity of open balds on Roan Mountain. It has shown no tendency to spread even into the separate Grassy Bald patches near its occurrence, neither the heavily grazed balds of Little Hump Mountain or Big Yellow Mountain nor the less grazed Round Bald. Donaldson, et al. (2014) noted that the species was reported on Roan Mountain before 1850 and that its cover seems to have declined rather than increased, though the loss appears to be due to tree encroachment rather than spread of other Grassy Bald subtypes. It thus seems appropriate to regard it as a natural community and to not manage for open grassland at its expense. At the same time, the Alder Subtype, just as the other subtypes, is at risk of losing its distinctive character due to invasion by other woody species, with the herbaceous layer especially threatened. Areas that have been invaded by *Rubus* have greatly reduced herb cover and diversity. The mowing and hand cutting that have reversed the increase of *Rubus* cover in the nearby balds, is not possible amid the shrubs.

Donaldson, et al. (2014) noted that alder in other regions plays a role in primary succession, enhancing the soil through its ability to fix atmospheric nitrogen, and that it can account for a significant portion of the nitrogen in and even near its populations. It is not clear that it plays a similar role in Grassy Balds. Unlike in northern glaciated areas, the Grassy Bald soils likely have been present for a very long time, and there is no obvious reason to regard the Alder Subtype areas as later in primary succession than the other Grassy Bald subtype. They also found nitrogen levels to be extremely variable in the Alder Subtype, and not consistently higher than in other balds.

The interaction of the Alder Subtype with grazing is unclear. Cattle are widely regarded as preventing the establishment or spread of woody plants, but the population of *Alnus* survived the era of cattle grazing, and it is not clear if it decreased or increased during it. No records suggest that *Alnus* was present in the more heavily grazed balds nearby, though it is conceivable that early heavy grazing eliminated an unrecorded population. Interactions with long lost native grazers is even less clear.

Comments: This community was treated as a subtype of Heath Bald in early drafts of the 4th Approximation and was included with Heath Bald in the 3rd Approximation. However, the dominant shrubs are not heaths, and unlike Heath Balds, there is often substantial herb cover beneath the shrub canopy, primarily consisting of the same species found in Grassy Balds. It appears to be more closely related to the Sedge Subtype than to the Grass Subtype. It is unclear if the locations of the Alder Subtype are determined by subtle site differences, by successional dynamics, or simply result from the chance persistence of the defining species in particular places.

Rare species:
Vascular plants – *Alnus crispa* and *Poa palustris*.

Nonvascular plants – *Xanthoparmelia monticola*.

Vertebrate animals – *Empidonax alnorum, Microtus chrotorrhinus carolinensis,* and *Sylvilagus obscurus*.

HEATH BALD (CATAWBA RHODODENDRON SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Catawba Rhododendron Subtype is the most abundant subtype, dominated by *Rhododendron catawbiense*, with or without abundant *Kalmia latifolia* or *Vaccinium* spp., occurring on high elevation narrow ridgetops, broad high elevation domes, or in smaller patches bordering rock outcrops.

Distinguishing Features: Heath Balds are distinguished from all other community types by natural dominance or occasional codominance of dense evergreen Ericaceous shrubs, with few or no trees, over a substantial area (one acre or more). Examples generally range from 4000 to over 6000 feet elevation. Several other communities may have dense evergreen shrub layers but have a well-developed closed or open tree canopy under normal natural conditions. Examples that have suffered canopy mortality may be difficult to tell from Heath Balds, but most will show evidence of having had trees in the recent past. The shrubby subtypes of Red Spruce–Fraser Fir Forest and High Elevation Red Oak Forest may have similar shrub layers, but have a well-developed tree canopy or at least evidence that a canopy once existed. The more abundant Pine–Oak/Heath and Swamp Forest–Bog Complex communities occur at lower elevations and are more likely to have shrub layers dominated by *Rhododendron maximum*, *Kalmia latifolia,* or species not characteristic of Heath Balds.

Small patches that closely resemble Heath Bald vegetation may occur as part of the complex of vegetation in rock outcrop communities such as High Elevation Granitic Dome or High Elevation Rocky Summit. Classification as Heath Bald should be reserved for shrub communities not associated with substantial rock outcrops and for exceptionally large patches associated with rock outcrops (comparable to the open rock in extent).

The Catawba Rhododendron Subtype is distinguished from all other subtypes of Heath Bald by the dominance of *Rhododendron catawbiense* with little cover of the shrub species that distinguish other subtypes.

Crosswalks: *Rhododendron catawbiense* Shrubland (CEGL003818).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: Heath Bald (Catawba Rhododendron Subtype) occurs in three different kinds of sites. One is narrow, often steeply plunging spur ridges on the flanks of higher ridges. The second is on broad knobs or domes at higher elevations, where it may occupy substantial area. A few examples occur on less distinctive ridge tops or upper slopes on the edges of rock outcrop communities. Examples generally range from 4000 feet to over 6000 feet in elevation.

Soils: Heath Bald soils often are shallow and rocky and may have a thick organic layer built up because of the slow decomposition of the litter from the evergreen shrubs. The examples on spur ridges and around rock outcrops generally are inclusions in soil map units. Large examples are mapped as Wayah (Typic Haplumbrept), Burton (Typic Humadept), Craggey (Lithic Haplumbrept), or Clingman (Lithic Udifolist). More of the smaller patches may be Lithic

Udifolists. Cain (1930) found that Heath Bald soils were more acidic than soils in forest communities at the same elevations, though Donaldson et al. (2014) found that Grassy Bald (Alder Subtype) soils were even more acidic. Conkle and Young (2004) noted high aluminum levels as well. These soil chemistry differences probably are the result of the vegetation rather than the cause of it.

Hydrology: Despite occurrence on steep and often sharply convex topography, the Catawba Rhododendron Subtype generally is mesic because of high rainfall, frequent fog, and low temperatures. Where the soil has a thick organic layer, it may hold substantial water, but the shallow soil in many examples may lead to drought stress in drier weather.

Vegetation: The Catawba Rhododendron Subtype is dominated by *Rhododendron catawbiense*, sometimes overwhelmingly so, sometimes with codominant *Kalmia latifolia* or *Vaccinium corymbosum*. Other shrub species with high constancy but usually with limited cover in CVS and NatureServe plot data are *Sorbus americana* and *Aronia melanocarpa*. Fairly frequent species include *Vaccinium erythrocarpum, Ilex montana,* and *Viburnum cassinoides*. Additional shrubs that are characteristic include *Rhododendron (Menziesia) pilosum, Clethra acuminata*, and *Eubotrys recurva*. *Galax urceolata* is the only high constancy species in the herb layer, and it may have large cover. Other herbs that are frequent in plots are *Angelica triquinata* and *Maianthemum canadense*, and species such as *Athyrium asplenioides, Medeola virginiana, Lysimachia quadrifolia*, *Sitobolium* (*Dennstaedtia*) *punctilobulum*, and *Oclemena acuminata* may less frequently occur. Other herbs often mentioned in reports or on site lists include species associated with small openings or small rock outcrops, such as *Micranthes (Hydatica, Saxifraga*) *petiolaris*, *Danthonia compressa, Krigia montana*, and *Sibbaldiopsis tridentata.*

Range and Abundance: Ranked G2**.** Examples are scattered throughout the higher mountains, though most are north of Asheville. The equivalent NVC association ranges into adjacent Virginia, Tennessee, and possibly Georgia, but most of its global range is in North Carolina.

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Associations and Patterns: Heath Balds generally are surrounded by high elevation forests of the Spruce–Fir Forests or Northern Hardwood Forests themes. Some may occur in association with rock outcrop communities such as High Elevation Rocky Summit or High Elevation Granitic Dome or with Grassy Bald. The Catawba Rhododendron Subtype does not generally occur with other subtypes.

Variation: Examples vary in amount of shrubs other than *Rhododendron catawbiense*. Examples codominated by *Kalmia latifolia* or by *Vaccinium* spp. may warrant recognition as variants. McLeod (1988) emphasized the occurrence of both dense thickets and open "garden" Heath Balds.

Dynamics: The dynamics of Heath Balds in general have been the subject of much discussion, though such discussion often can't be attributed to particular subtypes. Cain (1930) found evidence that all of the Heath Balds he sampled in the Smokies (probably a combination of Catawba Rhododendron, Slate, and Carolina Rhododendron subtype) had burned multiple times in the past. He suggested that a variety of disturbances, including fire, landslides, and windthrows, and also extreme environmental conditions, were responsible for their occurrence. Whittaker (1956) suggested that Heath Balds were successional in part, but that they seemed to be able to maintain themselves under present conditions. White et al. (2001) indicated a similar view, rejecting the idea that Heath Balds represent primary succession or are maintained by ongoing erosion. They suggested these communities were created by existing heath shrub layers taking over after fire destroyed a previous tree canopy, with the shrubs then inhibiting tree recovery. Part of their argument was that terrain modeling they conducted showed that most sites topographically comparable to Heath Bald sites supported forests. However, terrain modeling focused on a single community or species often drastically overpredicts occurrence, so this in itself is not strong evidence that many other sites should be expected to be Heath Bald. At the same time, though they emphasized that the two watersheds with the largest and most numerous Heath Balds had experienced severe fires after logging in the early 1900's, they also found that Heath Balds are much more abundant on the northern Tennessee side of the Smokies in general. They suggested several possible environmental reasons rather than disturbance history for this pattern. And they described several cases where fires or other disturbances have not led to formation of Heath Balds.

In contrast to the Smokies, some open Heath Balds on Roan Mountain and the Craggy Mountains are being invaded by trees (Brown 1941, Crawford and Kennedy (2009). McLeod (1988) regarded Heath Balds as secondary successional communities after disturbances in extreme sites. These sites have large expanses of Heath Bald on knobs and less steep slopes.

It may be that Heath Balds have multiple drivers and that all views are partially correct. Some are clearly primary successional communities, occurring on landslide scars and the edges of rock outcrops. Others are not obviously so but show evidence of fire. These may represent secondary succession or maintenance by chronic natural disturbance. The location of most Heath Balds on the driest, most exposed microsites in their vicinity presumably makes them more susceptible to lightning fires and makes natural fires more severe than in surrounding forests. Severe site conditions and the competitiveness of dense shrub cover at least contribute to persistence of Heath Balds and inhibition of tree growth, and these may be sufficient to maintain some in the long run. Conkle and Young (2004) and Conkle, et al (2003) found radiocarbon dated organic soils in Heath Balds to range from 100-3000 years old, with clusters of ages at 2900, 1100, and 120 years. Though they appeared to regard these dates at the bottom of the organic deposit as being the origin of the Heath Bald, it is also plausible that it represents a severe fire in what was already a Heath Bald. Conkle and Young (2004) also noted that organic deposits, protected from decomposition by extreme acidity and aluminum saturation, appeared to be spreading into adjacent forests, suggesting the possibility that some balds were expanding.

Vegetation resembling Heath Bald can also result from logging and severe burns in spruce-fir forests in historical times, but such examples are better regarded as altered vegetation. Other heath-dominated areas have resulted from invasion of Grassy Balds by shrubs.

Comments: Heath Balds occupy a relatively small area in the mountains as a whole. In general they are in inaccessible, well protected sites, but some, particularly the open, garden-like examples, may be threatened by trampling and by natural succession. Exclusion of fire may be a long-term threat to all Heath Balds, but the proper management is not known.

Rare species:
Vascular plants – *Rhododendron vaseyi, Rubus strigosus,* and *Stenanthium leimanthoides.*

HEATH BALD (CAROLINA RHODODENDRON SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Carolina Rhododendron Subtype is a rare subtype that is strongly dominated by *Rhododendron carolinianum*, occurring on quartzite or potentially on other rocks but not on slate. It is known primarily in the area of Linville Gorge.

Distinguishing Features: The Carolina Rhododendron Subtype is distinguished from most other subtypes by the strong dominance of *Rhododendron carolinianum*. It occurs at somewhat lower elevation, associated with pine communities rather than spruce-fir or northern hardwood forests. The Slate Subtype of the Great Smoky Mountains also has *Rhododendron carolinianum* dominant but in combination with other species and usually in more open stands.

Crosswalks: *Rhododendron carolinianum* Shrubland (CEGL003816).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Carolina Rhododendron Subtype occurs on both steep spur ridges and on ridge tops near rock outcrops of quartzite or related rocks. Elevations are around 3600-4000 feet.

Soils: Soils are generally fairly shallow, with bedrock near the surface. The quartzite substrate may create even more acidic conditions than in other Heath Balds.

Hydrology: The relatively low elevation setting of the Carolina Rhododendron Subtype, combined with the steep convex slopes and shallow soils, makes for dry conditions, perhaps much drier than the mesic higher elevation subtypes.

Vegetation: The Carolina Rhododendron Subtype is a tall or short shrubland dominated or codominated by *Rhododendron carolinianum*. The shrub canopy may be very dense or fairly open. *Kalmia* (*Leiophyllum*) *buxifolia* is usually present and often abundant. Other shrubs with high constancy in the few CVS plots include *Vaccinium corymbosum, Clethra acuminata, Ilex montana, Kalmia latifolia, Eubotrys recurvus, Aronia arbutifolia, Gaylussacia baccata,* and *Fothergilla major*. *Xerophyllum asphodeloides* and *Galax urceolata* are present in all plots. Almost all other herbs are associated with open rock inclusions: *Bryodesma tortipilum, Trichophorum cespitosum, Liatris helleri,* and *Carex umbellata*, though *Lysimachia quadrifolia* is also present.

Range and Abundance: Ranked G2, but possibly better treated as G1. All North Carolina examples are in a small area on the rim of Linville Gorge, but the NVC also reports the association as occurring in Tennessee in the area around Mount LeConte in the Great Smoky Mountains.

Associations and Patterns: The Carolina Rhododendron Subtype is closely associated with High Elevation Rocky Summit (Quartzite Subtype) communities. It may also grade to Pine–Oak/Heath and potentially to various dry acidic forest communities.

Variation: Examples vary in density of the shrub layer, with the transition to adjacent communities.

Dynamics: This subtype is related to the extreme site conditions that include relatively shallow soil, excessive drainage, and extreme soil acidity. However, within those conditions, fire appears to be an important factor in driving its presence. Some areas may depend on periodic fire to remain as more open rock outcrop communities, and Heath Bald may encroach on them in the absence of fire. Similarly, Pine–Oak/Heath may encroach on these relatively low elevation Heath Balds with insufficient fire.

Comments: The concept of this subtype has been narrowed by the creation of the Slate Subtype. *Rhododendron carolinianum* has a very patchy distribution and is not even present in most Heath Balds. Communities where it dominates are rare. Understanding of its distribution is further complicated by the recognition of *Rhododendron smokianum*. This subtype may exist only at Linville Gorge but may be found in a few other places.

The subtypes of Heath Bald are more finely divided than most natural communities, following the lead of the NVC. Given the different geologic settings and dominant vegetation, the distinctions appear justified.

Rare species:
Vascular plants – *Fothergilla major, Liatris helleri, Poa palustris, Rhododendron vaseyi, Stenanthium leimanthoides*, and *Trichophorum cespitosum*.

Nonvascular plants – *Cetrelia cetrarioides* and *Xanthoparmelia monticola*.

HEATH BALD (SOUTHERN MIXED SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Southern Mixed Subtype encompasses high elevation examples containing *Pieris floribunda* as well as other shrubs, usually codominant with *Rhododendron catawbiense*. This subtype is confined to south of the Asheville Basin.

Distinguishing Features: The Southern Mixed Subtype is distinguished from all other subtypes by the substantial presence of *Pieris floribunda*, though it may not dominate. Other Heath Balds at high elevations south of Asheville and codominated by other evergreen shrub species not typical of the Catawba Rhododendron Subtype may also be classified here. The distinction with the Low Elevation Subtype may be particularly difficult.

Crosswalks: *Rhododendron catawbiense - Pieris floribunda* Shrubland (CEGL004516).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Southern Mixed Subtype may occur in sites similar to the Catawba Rhododendron Subtype: steeply plunging spur ridges, broad knobs or domes at higher elevations, or small patches associated with rock outcrops. Elevations range from 4000-6000 feet.

Soils: The range of soils is not well known, but presumably is similar to those for the Catawba Rhododendron Subtype.

Hydrology: Despite occurrence on steep and often sharply convex topography, the Southern Mixed Subtype probably is mesic because of high rainfall, frequent fog, and low temperatures. Where the soil has a thick organic layer, it may hold substantial water, but the shallow soil in many examples may lead to drought stress in drier weather.

Vegetation: The Southern Mixed Subtype is codominated by *Rhododendron catawbiense*, usually in combination with *Pieris floribunda*. The shrub canopy may be very dense or somewhat open. Other shrubs frequent in the limited CVS plots data include *Diervilla sessilifolia, Vaccinium simulatum, Ilex montana, Kalmia latifolia, Vaccinium erythrocarpum, Vaccinium corymbosum, Viburnum cassinoides*, and *Vaccinium stamineum*. The herb layer may be sparse where shrub cover is high but may be extensive in more open areas. High constancy species in plots are *Sitobolium* (*Dennstaedtia*) *punctilobulum, Carex pensylvanica, Oclemena acuminata, Avenella* (*Deschampsia*) *flexuosa*, and *Angelica triquinata*. Other frequent species include *Danthonia compressa, Solidago curtissii, Diphasiastrum digitatum, Athyrium asplenioides, Trillium undulatum, Houstonia serpyllifolia, Eurybia macrophylla*, and *Hieracium paniculatum*. A few trees are found in many plots; these include *Picea rubens, Betula alleghaniensis, Sorbus americana, Prunus pensylvanica, Amelanchier laevis*, and *Quercus rubra*.

Range and Abundance: Ranked G1. It may be better treated as G2, but its abundance is confused by several occurrences of uncertain classification, as well as the difficulty in distinguishing it from successional disturbed forests. The Southern Mixed Subtype is most abundant in the Balsam

Mountains, but other occurrences scattered in the area farther southwest have been attributed to it. The equivalent association is also attributed to Tennessee.

Associations and Patterns: The Southern Mixed Subtype is generally surrounded by high elevation forests of the Spruce-Fir Forests or Northern Hardwood Forests themes, or by High Elevation Red Oak Forest. Some may occur in association with rock outcrop communities such as High Elevation Rocky Summit or High Elevation Granitic Dome.

Variation: Variation is not well known and is confused by uncertain classification of some examples.

Dynamics: The dynamics of the Southern Mixed Subtype are presumably similar to those in the Catawba Rhododendron Subtype, but this is not fully certain. The best documented examples are in the Balsam Mountains, an area that had particularly heavy impacts of logging and slash fires in the early 1900s. Although natural Heath Bald presumably was present before these disturbances, some of the examples may represent secondary succession in degraded spruce-fir forests. The frequency of trees in plots attributed to this subtype suggests secondary succession.

Comments: This subtype, originally intended to cover several southern variations, was narrowed by the creation of the Slate Subtype. The narrowed Southern Mixed Subtype reportedly does not occur in the Great Smoky Mountains. Nevertheless, the appropriate classification for several occurrences attributed to it outside of the Great Balsam Mountains area remains uncertain.

Rare species:
Vascular Plants – *Rhododendron vaseyi*.

HEATH BALD (SLATE SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Slate Subtype encompasses examples occurring on slate substrate, known only in the Great Smoky Mountains. The vegetation is somewhat more mixed and more open than most other subtypes.

Distinguishing Features: The Slate Subtype is distinguished by the combination of *Rhododendron carolinianum* (perhaps *R. smokianum*), *Rhododendron catawbiense*, and *Kalmia* (*Leiophyllum*) *buxifolia* on a slate substrate. The Carolina Rhododendron Subtype may have the same dominant species but occurs on quartzite and has a different overall flora. Other subtypes may be dominated by *Rhododendron catawbiense* in combination with other shrub species. The Heath Subtype of Red Spruce–Fraser Fir Forest, Fraser Fir Forest, and High Elevation Red Oak Forest also has a shrub layer dominated by *Rhododendron catawbiense* but has a well-developed tree canopy or at least evidence that a canopy once existed.

Crosswalks: *Rhododendron carolinianum - Rhododendron catawbiense - Leiophyllum buxifolium* Shrubland (CEGL007876).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Slate Subtype occurs on steep spur ridges and steep high elevation steep slopes with slate substrate, often with thin soils. Examples range from 5500 feet to over 6000 feet. Some sites are clearly old landslide scars.

Soils: Soils are shallow and may or may not have thick organic layers. Most, if not all, are smaller than the minimum map unit for soil mapping.

Hydrology: The Slate Subtype is well drained and has shallow soil but is generally mesic because of cool temperatures, high rainfall, and frequent fog. It may become dry during dry weather.

Vegetation: The Slate Subtype is a dense to open shrubland dominated by a combination of *Rhododendron catawbiense, Rhododendron carolinianum*, and *Kalmia buxifolia*. There is some confusion whether *Rhododendron minus* may also be present. The only other shrub present with fairly high frequency in NatureServe plots was *Vaccinium corymbosum*, but a variety of species may occur occasionally, including *Aronia melanocarpa, Rhododendron (Menziesia) pilosum, Vaccinium erythrocarpum, Viburnum cassinoides, Kalmia latifolia, Ilex montana, Pieris floribunda*. Stunted *Picea rubens* and *Sorbus americana* also are fairly frequent. Because the shrubland is often open and contains small rock outcrops, a variety of herbaceous species are shared with high Elevation Rocky Summits as well as with the surrounding Red Spruce–Fraser Fir Forests. These include *Micranthes* (*Hydatica*) *petiolaris, Carex misera, Dryopteris campyloptera, Solidago glomerata, Oxalis montana, Sitobolium* (*Dennstaedtia*) *punctilobulum, Galax urceolata, Cinna latifolia, Angelica triquinata, Carex pensylvanica*, and even *Calamagrostis cainii*, as well as mosses and *Cladonia* lichens.

Range and Abundance: Ranked G1. This subtype is known only in the Great Smoky Mountains, primarily in Tennessee but with some patches believed to occur in North Carolina.

Associations and Patterns: The Slate Subtype occurs surrounded by Red Spruce–Fraser Fir Forest. It may possibly be associated with High Elevation Rocky Summit.

Variation: Examples vary in density and stature of shrubs and in amount of rock outcrop.

Dynamics: As with other Heath Balds, the dynamics of the Slate Subtype are not well known. The slate is prone to slippage, making landslides more likely. This may be an important factor in the occurrence of this subtype and probably is the basis for the suggestion that it is important for Heath Balds more generally. Most examples may be primary successional communities developed on the bare rock of landslide tracks. Given their typical high elevation and context of spruce-fir forest, fire probably is not a major influence. Yet, the sharply convex, highly exposed position of many patches may make them prone to lightning and to local fires. Given their occurrence in the Great Smoky Mountains, they presumably are among the Heath Balds Cain (1930) reported as universally showing evidence of fire, and for which White, et al. (2001) discussed potential causes for occurrence. It is possible that in the absence of further landslides or small patch fires these Heath Balds may succeed to Red Spruce–Fraser Fir Forest; however, Heath Balds may occur in their distinctive environment because this setting is prone to these natural disturbances.

Comments: This association was created by NatureServe to cover examples in the Great Smoky Mountains. It may be too narrowly defined. It is somewhat unclear how distinct it is from the Carolina Rhododendron Subtype. Both quartzite and the sulfidic slate of the Great Smoky Mountains form extremely acidic soils. But the slate is also prone to landslides and is less stable. Both characteristics may make for distinctive vegetation.

Rare species:
Vascular plants – *Calamagrostis cainii* and *Rhododendron smokianum*.

Nonvascular plants – *Hypotrachyna virginica*.

HEATH BALD (SAND MYRTLE SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Sand Myrtle Subtype encompasses examples dominated by *Kalmia (Leiophyllum) buxifolia*, known primarily at Grandfather Mountain and the Great Smoky Mountains.

Distinguishing Features: The Sand Myrtle Subtype is distinguished by the dominance of *Kalmia buxifolia* over the whole community. It is distinguished from rock outcrop communities, which may contain moderate sized patches of *Kalmia buxifolia*, by being more extensive and contiguous, having the bulk of the community dominated by shrub cover rather than rock or herbs.

Crosswalks: *Leiophyllum buxifolium* Dwarf-shrubland (CEGL003951).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Sand Myrtle Subtype occurs on sharp spur ridges, steep slopes, and shallow soils near rock outcrops, perhaps associated with quartzite or other very acidic metasedimentary rocks. Most examples are above 5000 feet in elevation.

Soils: Soils are generally shallow over bedrock. They presumably are extremely acidic.

Hydrology: As with most other Heath Balds, the Sand Myrtle Subtype is well drained and has shallow soil but is generally mesic because of cool temperatures, high rainfall, and frequent fog. However, drought stress may occur during dry periods.

Vegetation: The Sand Myrtle Subtype is a short shrubland dominated by *Kalmia buxifolia*. The shrubs may be only 0.5 meter tall, and the shrub layer may be patchy, with significant areas of bare rock interspersed. *Rhododendron catawbiense, Vaccinium pallidum, Rhododendron (Menziesia) pilosum*, and *Vaccinium erythrocarpum* are frequent species in plot data, along with stunted *Picea rubens, Betula alleghaniensis*, and *Sorbus americana*. *Rhododendron carolinianum* may also occur. Most herbs are in open areas or associated with embedded rock outcrops. Species at high frequency in plot data include *Micranthes* (*Hydatica*) *petiolaris, Galax urceolata, Carex misera, Oclemena acuminata,* and *Trichophorum cespitosum*. The NVC description also notes *Vaccinium corymbosum, Avenella* (*Deschampsia*) *flexuosa, Bryodesma tortipilum*, *Carex umbellata,* and *Stenanthium leimanthoides*.

Range and Abundance: Ranked G1. Examples are known at Grandfather Mountain and in the Great Smoky Mountains, with a reported occurrence at Linville Gorge. The NVC also questionably attributes the equivalent association to South Carolina and Georgia, but this seems unlikely. Though *Kalmia buxifolia* occurs there, the distinctive high elevation setting of this community is unlikely.

Associations and Patterns: The Sand Myrtle Subtype often occurs associated with High Elevation Rocky Summit and may occur with other subtypes of Heath Bald. Examples grade to various spruce-fir forest communities or high elevation hardwood forest communities.

Variation: Examples are somewhat heterogeneous at fine scales and vary with the gradation to adjacent communities.

Dynamics: Dynamics of the Sand Myrtle Subtype likely are similar to the Slate Subtype. The extreme environment of high elevations and shallow soils prevents not only trees but also other shrubs from becoming dominant. This subtype probably is best regarded as a primary successional community, developing slowly on landslide scars or on bedrock and perhaps eventually succeeding to taller Heath Bald subtypes. Natural fire is unlikely in the spruce-fir forests that surround most examples of the Sand Myrtle Subtype, but the exposed topographic position may promote occasional lightning strikes and local fires.

Comments: The Sand Myrtle Subtype is more closely related to rock outcrop communities than are other Heath Balds. The distinction between well-developed occurrences of this Heath Bald subtype and *Kalmia buxifolia* patches in High Elevation Rocky Summit communities can be subtle. The CVS plots used in the description of vegetation here were all collected by Susan Wiser in the course of her study on high elevation rock outcrops (Wiser et al. 1996).

Rare species:
Vascular plants – *Calamagrostis cainii, Liatris helleri, Solidago spithamaea, Stenanthium leimanthoides,* and *Trichophorum cespitosum*.

HEATH BALD (LOW ELEVATION SUBTYPE)

Concept: Heath Balds are persistent natural high elevation shrublands, dominated by various evergreen Ericaceous shrubs. The Low Elevation Subtype covers warmer, lower elevation examples, dominated by *Kalmia latifolia* and generally with a greater diversity of shrub species. The term low elevation applies only in comparison to other Heath Bald subtypes.

Distinguishing Features: The Low Elevation Subtype is distinguished from the Catawba Rhododendron Subtype by having a larger amount of *Kalmia latifolia*, making up more than 50 percent of cover, along with the presence of associated lower elevation species such as *Rhododendron maximum, Quercus rubra,* and *Quercus montana*, rather than high elevation species such as *Picea rubens, Abies fraseri*, and *Sorbus americana*. It lacks significant amounts of *Pieris floribunda* or *Kalmia (Leiophyllum) buxifolia* though they may be present in small numbers. While some trees may be present, this community should be recognized only where shrub-dominated vegetation appears to be persisting in association with severe site conditions. Shrub-dominated areas that were forested in the recent past and are succeeding back to forest should not be included. Pine–Oak/Heath occurrences that have lost their canopy due to southern pine beetles and exclusion of fire should not be included here.

Crosswalks: *Kalmia latifolia - Rhododendron catawbiense - (Gaylussacia baccata, Pieris floribunda, Vaccinium corymbosum*) Shrubland (CEGL003814).
G658 Southern Appalachian Shrub Bald Group.
Southern Appalachian Grass and Shrub Bald Ecological System (CES202.294).

Sites: The Low Elevation Subtype occurs on spur ridges, steep slopes, and large areas of shallow soil near rock outcrops, on a variety of substrates but at lower elevations or in warmer settings than most other Heath Bald subtypes, generally below 5000 feet.

Soils: Soils are shallow and may or may not have thick organic layers.

Hydrology: The Low Elevation Subtype is well drained and may become dry. It presumably is less mesic than the other subtypes which occur at higher elevations.

Vegetation: The Low Elevation Subtype is a dense tall shrubland, generally dominated by *Kalmia latifolia* and *Rhododendron catawbiense*. Other shrubs with high constancy in CVS and NatureServe plot data are *Gaylussacia baccata, Vaccinium corymbosum, Ilex montana, Clethra acuminata, Aronia arbutifolia, Kalmia buxifolia, Viburnum cassinoides*, and *Eubotrys recurvus*. *Acer rubrum, Picea rubens*, and *Quercus rubra* also are highly constant, though individuals are sparse and small. The NatureServe description also notes *Rhododendron carolinianum, Vaccinium stamineum*, and *Pieris floribunda*, as well as several additional tree species. Herbs are generally sparse beneath the dense shrubs, with *Galax urceolata* the only species having high constancy. Fairly frequent herbs include *Gaultheria procumbens, Pteridium latiusculum, Melampyrum lineare, Xerophyllum asphodeloides, Solidago* spp., *Iris verna* var. *smalliana*, and *Coreopsis major*.

Range and Abundance: Ranked G2G3. Examples are scattered throughout the mountains of North Carolina and occur in adjacent Tennessee, Georgia, and Virginiana. The equivalent NVC association is also reported in Kentucky. This subtype may be overlooked in some site descriptions, making its abundance less clear than for other subtypes. Its lower elevation habitat is potentially more extensive than for other subtypes, but tree growth is more vigorous at lower elevations. Microsites capable of supporting long term Heath Bald at lower elevation may be scarcer.

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Associations and Patterns: Associated communities are not well known. Examples may be associated with rock outcrop communities. They may be surrounded by a wide variety of forest communities, perhaps usually High Elevation Red Oak Forest and Northern Hardwood Forest but potentially including other oak forests.

Variation: Variation is poorly known.

Dynamics: The Low Elevation Subtype presumably is more dependent on fire than the other subtypes, because the lower elevation climate is more favorable to tree growth and to soil formation. Examples may be less persistent than other subtypes, though this subtype is intended for communities that persist at least for decades. Persistence must necessarily depend on severe site conditions as well as fire, since the prevailing historical fire regime clearly allowed the occurrence of forest over most of the landscape. Forest community patches with catastrophic natural or artificial disturbance show fairly rapid secondary succession back to forest and do not persist as Heath Balds. As with other subtypes, the occurrence of the Low Elevation Subtype on highly exposed topography may make it particularly prone to lightning strikes and to local fires at a rate greater than the landscape as a whole.

Comments: The description of the equivalent association in the NVC is problematic; it suggests lumping of short-term successional vegetation created by logging with more persistent natural shrublands.

Aronia melanocarpa - Gaylussacia baccata / Carex pensylvanica Shrubland (CEGL008508) is a G1? association defined in Virginia and stated to potentially occur in North Carolina. It is described as a mosaic of shrub, herbs, and bare rock, so it would not be considered a Heath Bald. *Menziesia pilosa - Vaccinium (erythrocarpum, simulatum, corymbosum) - Sorbus americana* Shrubland (CEGL004819) has been defined for Mount Rogers in Virginia, where it occurs in association with rock outcrops. Communities like it could be found North Carolina but are not known.

Rare species: No rare species are specifically known to be associated with this community.

NORTHERN HARDWOOD FORESTS THEME

Concept: Northern Hardwood Forests are mesophytic hardwood forests of high elevations in the Mountain Region, generally dominated by a small set of tree species, particularly *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, and *Aesculus flava*. Examples may be excluded from particular slope aspects but extend across a broad range of topography and are not confined to concave valleys as Mountain Cove Forests are.

Distinguishing Features: Northern Hardwood Forests are distinguished from Spruce–Fir Forests by the predominance of hardwoods over *Picea rubens* and *Abies fraseri* under long term natural conditions. They are distinguished from Mountain Oak Forests by the predominance of the mesophytic hardwoods over oaks in canopy cover or basal area. Some Mountain Oak Forests have developed mesophytic understories of Northern Hardwood Forests species and have greater stem density of these than of oaks, while basal area remains dominated by oaks. Placing the boundary between Northern Hardwood Forests from Mountain Cove Forests is particularly difficult, because many mesophytic species are shared. In general, Northern Hardwood Forests are lower in tree diversity and contain a subset of the species typical of Mountain Cove Forests, with at least one of the characteristic species very abundant. These particular species are rarely dominant over more than local patches in Mountain Cove Forests. Northern Hardwood Forests lack a number of low elevation species such as *Liriodendron tulipifera*, *Juglans nigra*, and usually, *Magnolia* spp.

Sites: Northern Hardwood Forests occur on ridges, open slopes, and upper coves at fairly high elevations. Most examples are above 3600 feet, and they range to 5500 feet or higher, the highest elevations of any hardwood forests. In most of this elevational range they are primarily on the cooler slope aspects, but at the highest elevations they may occur on any aspect.

Soils: Northern Hardwood Forests occur on a range of high elevation Inceptisols, particularly Humic Dystrudepts, Typic Humadepts, and some Lithic Humadepts. A special case is the High Elevation Birch Boulderfield community, which occurs on very coarse colluvial deposits that are relict periglacial features.

Hydrology: Sites are well drained, but are mesic because of the cool temperatures, high rainfall, and frequent fog associated with high elevations.

Vegetation: Northern Hardwood Forests are dominated by varying mixtures of mesophytic tree species. *Betula alleghaniensis* or *Fagus grandifolia* may sometimes strongly dominate, almost to the exclusion of other species. In most places, one or both of these species is mixed with *Aesculus flava, Acer saccharum*, or minority amounts of *Quercus rubra*. *Tsuga canadensis* or *Picea rubens* may be present in small amounts. In the Basic Subtype, *Fraxinus americana, Prunus serotina, Tilia americana* var. *heterophylla*, *Carya ovata*, or other species of richer soils may also be abundant. The understory usually consists of the same set of species, but *Amelanchier laevis* and *Swida* (*Cornus*) *alternifolia* are also characteristic. Shrubs layers are usually moderate in cover, but they can range from dense to nearly absent. The herb layer usually is well developed, sometimes with moderate diversity but sometimes consisting of a dense carpet of a few, or only one, species. *Carex pensylvanica*, *Ageratina roanensis, Oclemena acuminata, Eurybia chlorolepis, Athyrium asplenioides, Sitobolium* (*Dennstaedtia*) *punctilobulum, Amauropelta*

(*Parathelypteris*) *noveboracensis, Angelica triquinata*, and in the spring, *Erythronium umbilicatum* var. *monostolum* and *Claytonia caroliniana* are frequent species that often are very abundant.

Dynamics: Northern Hardwood Forests are like most of North Carolina's hardwood forests in naturally occurring primarily as old-growth, uneven-aged stands. Most tree reproduction is in small canopy gaps created by the death of one or a few trees, resulting in a fine-scale mosaic of tree ages across the forest. Wind, lightning, and ice damage are important sources of mortality. Disease is now a source of mortality for *Fagus* in particular and may kill larger patches. Sites that were logged or severely burned in the past may have *Prunus pensylvanica*, *Robinia pseudoacacia*, or increased numbers of *Betula alleghaniensis*, which presumably will be replaced over time with the more typical canopy. Where the canopy has been partially disturbed by wind or ice, *Rubus canadensis* or *Rubus alleghaniensis* sometimes becomes abundant.

Fire was not frequent in these communities. The mesophytic hardwood litter is not very flammable and the moist conditions limit times when fire will spread. The characteristic trees have thin bark and are not well equipped to survive any but low intensity fires. Their prevalence over large areas even before the advent of effective fire suppression suggests little fire spread into these areas, despite frequent fire at lower elevations. Any fire that did occur might be a significant natural disturbance, much more than in oak forests, but the ability of the dominant hardwoods to sprout would limit changes in dominance resulting from rare fires.

The ecotones of Northern Hardwood Forests with adjacent communities may be affected by changing forest dynamics. The boundary with High Elevation Red Oak Forests likely was determined at least partly by fire behavior. Since the advent of effective fire suppression, many High Elevation Red Oak Forests have developed substantial mesophytic understories, which limit oak regeneration and appear poised to take over the canopy. If this trend continues, more areas that have been High Elevation Red Oak Forest may become indistinguishable from Northern Hardwood Forests.

The transition to Red Spruce–Fraser Fir Forest is a very gradual shift in tree dominance, generally occurring with increasing elevation but in a patchy, irregular pattern. There has been concern that the widespread logging of spruce forests in the early 1900s led to replacement of spruce with hardwoods, as happened over large areas in West Virginia. This is difficult to document at elevations much below 5800 feet, because the pattern of the transition is irregular and occurs over a range of elevations even in areas that were never logged. As the climate becomes warmer, this boundary between Northern Hardwood Forests and Spruce–Fir Forests presumably will shift to higher elevation; however, if frequent fog persists, warming may be less extreme at higher elevations than lower. Conversely, if warming leads to less fog and especially if it leads to severe drought, wildfire may cause rapid loss of spruce and lead to its replacement by Northern Hardwood Forests. At present, individual spruce trees may be observed establishing in Northern Hardwood Forests and High Elevation Red Oak Forests below the elevations where they dominate, suggesting they do not yet suffer from the present climate. Increased rainfall in the late 1900s, suggested by McEwan et al. (2011) as a driver of mesophication of oak forests, could possibly lead to such downhill expansion of spruce.

Comments: Northern Hardwood Forests are named for their resemblance to mesophytic hardwood forests of New England, the upper Midwest, and Canada. Like those northern forests, they occupy a climatic zone roughly between oak forests and spruce–fir forests. However, the analogy is only general. The Northern Hardwood Forests of the Southern Appalachians contain some regional endemic species and lack characteristic widespread northern species such as *Betula papyrifera* and *Populus tremuloides*. The catastrophic natural disturbances that favor such successional species also seem to be rare in the Southern Appalachians, giving our Northern Hardwood Forests a different ecological character from those in the north.

While the concept of Northern Hardwood Forests in our region has been widely used, it has also been widely considered problematic. Some authors of regional vegetation studies have specifically rejected the name or have not attempted to distinguish it from cove forests. Whittaker (1956) called it upper cove forest, even while describing numerous ways in which it differed from the classic cove forests. McLeod (1988) did not use the name and distinguished only the low diversity beech and birch forests above 4800 feet as distinct. Newell (1997), however, distinguished communities clearly comparable to these. Ulrey (2002) analyzed rich cove forests data that appear to include at least part of the concept of Northern Hardwood Forest (Rich Subtype), based on elevation ranges. While Northern Hardwood Forests and Rich Cove Forests do share much flora and extensively intergrade, the tremendous range in composition and environments between both, spanning some 5000 feet of elevation, calls for a division even if the transition is gradual. The reduced species richness, the shift in dominance, and the change in relationship to topography seem sufficient reason to create a break approximately where it is recognized here. It should be remembered, though, that the boundary is necessarily arbitrary, and examples on both sides of the boundary may closely resemble each other.

KEY TO NORTHERN HARDWOOD FORESTS

1. Ground nearly entirely covered by boulders, generally piled on deeper boulders, with abundant spaces beneath the rocks. Canopy strongly dominated by *Betula alleghaniensis*. Lower strata with few species, primarily *Acer spicatum, Ribes* spp., and ferns and bryophytes growing on rock……. .... **High Elevation Birch Boulderfield Forest**

1. Ground not entirely covered by boulders; if rocky, rocks are embedded in soil and do not have large amounts of open space. Canopy various. *Betula alleghaniensis* may dominate but only at the highest elevations will it be strongly dominant.

   2. Forest strongly dominated by *Fagus grandifolia*, often stunted, with *Aesculus flava* the only other likely abundant species; herb layer generally a lawn-like bed of *Carex pensylvanica*; generally occurring at very high elevations, in concave areas adjacent to Spruce-Fir Forests or on open mountain tops. .... **Northern Hardwood Forest (Beech Gap Subtype)**

   2. Forest not strongly dominated by *Fagus grandifolia*, though the species is often present and may be codominant; lawn-like areas of *Carex pensylvanica* absent or limited in extent; topographic settings various.

      3. Forest containing tree species indicative of richer soils, such as *Tilia americana* var. *heterophylla, Fraxinus americana, Prunus serotina*, and *Carya ovata*; herb layer containing species indicative of richer soils or shared with Rich Cove Forests, such as *Collinsonia canadensis, Caulophyllum thalictroides, Actaea pachypoda, Actaea racemosa*, and *Hydrophyllum virginianum*…............................**Northern Hardwood Forest (Rich Subtype)**

      3. Forest not containing trees or herbs indicative of richer soils as above; canopy a mix of *Betula alleghaniensis, Aesculus flava, Fagus grandifolia*, and *Acer saccharum*, herb layer sparse or dense but lacking the above species……………………………………………….. ……………………………………………… .**Northern Hardwood Forest (Typic Subtype)**

NORTHERN HARDWOOD FOREST (TYPIC SUBTYPE)

Concept: Northern Hardwood Forests are the mesophytic deciduous forests of higher elevations, occurring on exposed or somewhat sheltered sites and generally dominated by *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. The Typic Subtype represents the most common examples, which lack the flora of rich sites and do not have the characteristics of the other subtypes.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak Forests and Red Spruce–Fraser Fir Forests by the predominance of mesophytic hardwood species over *Quercus rubra, Picea rubens*, or *Abies fraseri*. High Elevation Birch Boulderfield Forest also is dominated by mesophytic hardwoods but has over 90% cover of boulders, with substantial open space beneath them. The ground cover vegetation in boulderfields is dominated by plants rooted on rock and in shallow soil pockets rather than in deep soil. Though Northern Hardwood Forest sites may be very rocky, most plants are rooted in deep soil and the rocks do not visibly change the nature of the vegetation.

The boundary between the Rich Cove Forest and Northern Hardwood types is one of the most difficult to define. Many species in all strata may be shared, and the gradation is particularly gradual. The transition tends to occur around 4000 feet elevation but may be shifted considerably up or down in response to slope aspect, exposure, and latitude. The distinction is best made by the vegetation, based on the presence of species that are confined to high or low elevations. Typical cove species not expected in Northern Hardwood Forest include *Liriodendron tulipifera, Magnolia fraseri, Magnolia acuminata, Ostrya virginiana*, and *Benthamidia* (*Cornus*) *florida*. Northern Hardwood species uncommon in Rich Cove Forests are fewer, but include *Viburnum lantanoides*, *Rhododendron catawbiense,* and *Picea rubens*.

The Typic Subtype is distinguished most easily by lacking the characteristics of the other subtypes. The herb layer may be dense but is not highly diverse, and the species of rich soils which characterize the Rich Subtype are largely absent from all strata. While *Fagus grandifolia* may be codominant in the Typic Subtype, the Beech Gap Subtype has strong *Fagus* dominance in combination with a lawn-like herb layer dominated by *Carex pensylvanica*,

Crosswalks: *Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides / Eurybia chlorolepis - Dryopteris intermedia* Forest (CEGL007285).
G742 Central Appalachian-Northeast Mesic Forest Group.
Southern Appalachian Northern Hardwood Forest Ecological System (CES202.029).

Sites: Northern Hardwood Forest (Typic Subtype) occurs on convex to concave slopes and ridges at high elevations. Most examples are above 3600 feet, and they can range to 5600 feet or higher. At all but the highest elevations, most examples are on north or east-facing slopes, concave slopes, or otherwise sheltered sites.

Soils: Northern Hardwood Forests occur on a variety of Inceptisols. Common mapped soils include Typic Haplumbrepts (Plott, Wayah), Humic Dystrudepts (Balsam, Porters, Tusquitee), and Typic Humadepts (Burton).

Hydrology: Sites are well drained but are mesic due to cool temperatures and high rainfall at their high elevations. Northern Hardwood Forests are more moist than oak forests at the same elevations, because they occur on cooler slope aspects.

Vegetation: Northern Hardwood Forest (Typic Subtype) is dominated by varying combinations of *Betula alleghaniensis, Fagus grandifolia, Aesculus flava*, and *Acer saccharum*. Some forests are nearly pure *Betula*, while others are a mix of the other species with little *Betula*. *Quercus rubra* (presumably var. *ambigua*) is usually present in all but the highest elevation examples. Other canopy tree species are scarce, though some *Picea rubens* or *Abies fraseri* may be present at higher elevations while *Tsuga canadensis*, *Prunus serotina*, or other species may be present at the lower elevations. *Acer pensylvanicum* has high constancy in the understory and *Acer spicatum* is also frequent; either of these, or canopy species, may dominate the understory. The shrub layer may be sparse or fairly dense. *Rubus canadensis* may be abundant where there has been widespread natural or artificial disturbance. *Viburnum lantanoides* and *Ilex montana* are frequent. Though less frequent, species such as *Vaccinium erythrocarpum, Vaccinium simulatum*, *Sambucus racemosa* var. *pubens*, and *Rhododendron catawbiense* indicate the high elevation affinities of this community. The herb layer generally is well developed and may be dense. High constancy species in CVS plot data are *Dryopteris intermedia, Athyrium asplenioides, Polystichum acrostichoides, Carex pensylvanica*, and *Arisaema triphyllum*, and all but the last may dominate substantial patches. Earlier in the spring, *Erythronium umbilicatum* var. *monostolum* and *Claytonia caroliniana* may dominate the herb layer. Other frequent and sometimes locally dominant species in plots include *Eurybia chlorolepis, Amauropelta* (*Parathelypteris*) *noveboracensis, Ageratina roanensis*, *Angelica triquinata*, and *Maianthemum canadense*. Other frequent species include *Trillium erectum, Maianthemum racemosum, Dioscorea villosa, Tiarella cordifolia*, and *Viola* spp., while species such as *Clintonia borealis, Dryopteris campyloptera*, and *Carex intumescens* var. *intumescens* show the community's high elevation affinities.

Range and Abundance: Ranked G3G4. The Typic Subtype is the most abundant of the Northern Hardwood Forests. It is scattered throughout the mountain region at higher elevations. The equivalent association also occurs in Tennessee and southern Virginia.

Associations and Patterns: The Typic Subtype occurs as a large patch community, often occupying the cooler slope aspects while High Elevation Red Oak Forest covers the warmer aspects. The Typic Subtype may grade upslope to Red Spruce–Fraser Fir Forest. It may grade downslope to Rich Cove Forest in sheltered topography or to Chestnut Oak Forest or Montane Oak–Hickory Forest in more exposed areas. High Elevation Birch Boulderfield, Grassy Bald, Heath Bald, High Elevation Rocky Summit, Rich Montane Seep, High Elevation Boggy Seep, or other small patch communities may be embedded. The Typic Subtype may grade to the Rich Subtype or Beech Gap Subtype.

Variation: The Typic Subtype is a very broad category, with much variation in species composition, structure, and overall diversity. Several variants can be recognized:

1. Birch Variant occurs at the highest elevations. *Betula alleghaniensis* usually strongly dominates, but *Picea rubens* may be abundant in the transition to Red Spruce–Fraser Fir Forest.

2. Ridge variant occurs on other high, exposed ridgetops or peaks, where *Fagus grandifolia* is dominant. This variant is transitional to the Beech Gap Subtype but has a full stature canopy.

3. Typic Variant occurs at somewhat lower elevations and generally has a more mixed canopy containing three or four of the characteristic tree species.

4. Mesic Variant occurs in the transition to Acidic Cove Forest, where *Tsuga canadensis, Rhododendron maximum*, and other species of lower elevations may occur.

Dynamics: Dynamics of the Typic Subtype are similar to those of the theme as a whole.

Comments: In the southern part of the mountains, beyond the geographic range of spruce and fir, Northern Hardwood Forests of the Birch or Ridge Variants may occupy large areas on high peaks. A similar pattern appears in several areas within the range of spruce and fir, where mountains reach high enough elevations to support these conifers but lack them. The Craggy Mountains and Elk Knob are examples. The trees in the Northern Hardwood Forest are often small or stunted in these areas. It has been noted that these mountain ranges are slightly lower in elevation than those that do support spruce and fir, and it has been suggested that the species were eliminated from them in a time of warmer climate several thousand years ago. The suggestion is that the spruce–fir forests were "pushed off the top of the mountain" by the shifting of vegetation zones in that warmer climate. An underlying assumption is that the conifers lack the ability to disperse back to these ranges. It must be noted, however, that the Craggy Mountains are connected at high elevation to the extensive spruce–fir forests of the Black Mountains, and that spruce appears to be dispersing into them at present. At Elk Knob, an anomalous population of spruce occurs in the valley downslope of the stunted Northern Hardwood Forest.

Rare species:
Vascular plants – *Aconitum reclinatum, Athyrium angustum, Betula cordifolia, Cardamine clematitis, Carex arctata, Dendrolycopodium dendroideum, Gentiana latidens, Geum geniculatum, Glyceria nubigena, Lilium grayi, Lonicera canadensis, Lysimachia borealis, Meehania cordata, Monarda media, Nabalus albus, Platanthera grandiflora, Platanthera peramoena, Pyrola elliptica, Rhododendron vaseyi, Scutellaria saxatilis, Spiranthes ochroleuca, Stachys clingmanii,* and *Streptopus amplexifolius* var. *amplexifolius.*

Nonvascular plants – *Bazzania nudicaulis, Brachydontium trichodes, Cephaloziella spinicaulis, Frullania appalachiana, Drepanolejeunea appalachiana, Hypotrachyna virginica, Leskeella nervosa, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Pannaria conoplea, Plagiochila austinii*, and *Sticta limbata*.

Vertebrate animals – *Catharus guttatus, Coccyzus erythropthalmus, Desmognathus organi, Desmognathus wrighti, Plethodon welleri,* and *Vireo gilvus*.

Invertebrate animals – *Arctia caja, Platarctia parthenos, Entephria separata, Eulonchus marialiciae, Fumonelix roanensis, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes,* *Inflectarius ferrissii, Korscheltellus gracilis, Lithophane georgii, Platarctia parthenos,* and *Polygonia progne.*

NORTHERN HARDWOOD FOREST (RICH SUBTYPE)

Concept: Northern Hardwood Forests are the mesophytic forests of higher elevations, occurring on exposed or somewhat sheltered sites, and generally dominated by *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. The Rich Subtype encompasses the rare examples on mafic or calcareous rock substrates, which contain flora of rich soils, including many species shared with Rich Cove Forest.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak Forests and Red Spruce–Fraser Fir Forests by the predominance of mesophytic hardwood species over *Quercus rubra, Picea rubens*, or *Abies fraseri*. High Elevation Birch Boulderfield Forest also is dominated by mesophytic hardwoods but has over 90% cover of boulders, with substantial open space beneath them. The ground cover vegetation in boulderfields is dominated by plants rooted on rock and shallow soil pockets rather than in deep soil. Though Northern Hardwood Forest sites may be very rocky, most plants are rooted in deep soil and the rocks do not visibly change the nature of the vegetation.

The Rich Subtype is distinguished from the other subtypes of Northern Hardwood Forest by having several canopy and herbaceous species indicative of richer soil conditions. *Fraxinus americana, Tilia americana* var. *heterophylla*, *Prunus serotina*, *Carya ovata*, or *Magnolia acuminata* are typically present in the canopy. Herbs characteristic of the Rich Subtype and not of other subtypes include *Actaea racemosa, Actaea pachypoda, Caulophyllum thalictroides, Collinsonia canadensis, Osmorhiza claytonia, Hydrophyllum virginianum*, and a number of other species.

The boundary between the Rich Cove Forest and Northern Hardwood types is particularly difficult to define for the Rich Subtype. The overlap of species is much greater than for other subtypes. Some of the species that are confined to lower elevations on more typical acidic substrates, such as *Magnolia acuminata* and *Ostrya virginiana*, extend to higher elevation in the Rich Subtype. However, *Liriodendron tulipifera* is confined to Rich Cove Forest, while the presence of high elevation species such as *Picea rubens, Viburnum lantanoides*, or *Sambucus racemosa* var. *pubens* is indicative of Northern Hardwood Forest. Further analysis is needed to clarify additional indicators to distinguish these communities. The transition tends to occur around 4000 feet elevation but may be shifted uphill or downhill in response to slope aspect, exposure, and latitude.

Crosswalks: *Aesculus flava - Betula alleghaniensis - Acer saccharum / Caulophyllum thalictroides - Actaea podocarpa* Forest (CEGL004973).
G742 Central Appalachian-Northeast Mesic Forest Group.
Southern Appalachian Northern Hardwood Forest Ecological System (CES202.029).

Sites: Northern Hardwood Forest (Rich Subtype) occurs on high elevation convex to concave slopes and ridges which are underlain by mafic or calcareous rock. Most examples are above 3600 feet, and they can range to 5600 feet or higher. At all but the highest elevations, most examples are on north or east-facing slopes, concave slopes, or otherwise sheltered sites.

Soils: Soils in the Rich Subtype are influenced by mafic or, much less frequently, calcareous rock. They have higher pH and base saturation than typical soils in the region. Most are mapped as the same series of Typic Haplumbrepts, Humic Dystrudepts, and Typic Humadepts as in the Typic Subtype.

Hydrology: Sites are well drained but are mesic due to cool temperatures and high rainfall at their high elevations. Northern Hardwood Forests are more moist than oak forests at the same elevations, because they occur on cooler slope aspects.

Vegetation: The Rich Subtype has a diverse canopy that contains the characteristic Northern Hardwood Forest species *Acer saccharum, Aesculus flava, Fagus grandifolia,* and *Betula alleghaniensis* along with several other species shared with Rich Cove Forests. Additional trees with high constancy in CVS plots data are *Prunus serotina, Tilia americana* var. *heterophylla*, and *Fraxinus americana*. Also at least fairly frequent are *Quercus rubra, Carya cordiformis*, *Betula lenta*, and *Magnolia acuminata*. The understory may be dominated by *Acer pensylvanicum* or, less often, *Acer spicatum* or *Ostrya virginiana*. *Swida* (*Cornus*) *alternifolia* is also frequent. The shrub layer is sparse to moderate in density. *Hydrangea arborescens* is the only species with fairly high frequency in plot data, but *Viburnum lantanoides, Ilex montana*, and *Sambucus racemosa* var. *pubens* sometimes occur. The herb layer is diverse and often dense and lush and shares a large pool of species with Rich Cove Forest. *Laportea canadensis* can dominate in late summer, but otherwise there usually are not clear dominant species. Highly constant species in CVS plot data are *Arisaema triphyllum, Polystichum acrostichoides, Maianthemum racemosum, Laportea canadensis, Prosartes lanuginosa, Caulophyllum thalictroides, Trillium erectum, Actaea podocarpa, Impatiens pallida, Stellaria pubera, Tiarella cordifolia, Polygonatum biflorum, Dryopteris intermedia, Eurybia divaricata, Solidago curtisii*, and *Osmorhiza claytonia*. Additional frequent species include *Angelica triquinata, Athyrium asplenioides, Lilium superbum, Viola rotundifolia, Allium tricoccum, Hydrophyllum canadense, Viola canadensis, Huperzia lucidula, Oclemena acuminata, Galium triflorum, Carex pensylvanica, Anemone quinquefolia, Amauropelta noveboracensis, Streptopus lanceolatus* var. *lanceolatus, Collinsonia canadensis, Dioscorea villosa, Dryopteris marginalis, Monarda didyma, Botrypus virginianus, Actaea pachypoda, Ageratina roanensis, Festuca subverticillata*, and *Veratrum parviflorum*. A large number of additional species are present at frequencies below 30%. *Solidago flaccidifolia* and *Solidago flexicaulis* may also be characteristic.

Range and Abundance: Ranked G3. The Rich Subtype is scattered throughout the high mountain of North Carolina, but with fewer sites and much less acreage than the Typic Subtype. The related association, as defined, ranges not only to Georgia, Tennessee and Virginia, but into West Virginia.

Associations and Patterns: The Rich Subtype occurs as a large patch or small patch community. It may be associated with the Typic Subtype and may give way to High Elevation Red Oak Forest or Montane Oak–Hickory Forest on warmer slope aspects. As with the Typic Subtype, it may grade upslope to Red Spruce–Fraser Fir Forest. It may potentially contain embedded High Elevation Birch Boulderfield, Grassy Bald, Heath Bald, High Elevation Rocky Summit, Rich Montane Seep, High Elevation Boggy Seep, or other small patch communities, though no cases are known for some of these associations. The Rich Subtype may grade the Typic Subtype with a change in substrate.

Variation: Examples may vary in the apparent richness of the site as reflected by the flora. It is possible that there could be variants analogous to those in the Typic Subtype, but these have not been clarified.

Dynamics: Dynamics of the Typic Subtype are similar to those of the theme as a whole.

Comments: Rohrer (1983) noted that substrate (metabasalt vs. arkose) shifted the boundary between Northern Hardwood Forest (this subtype) and High Elevation Red Oak Forest. This suggests that the soil nutrient status or soil texture may interact with moisture conditions and the effects of topography.

It is particularly difficult to distinguish the Rich Subtype from Rich Cove Forest in literature, as it is in the field. Many regional study areas, such as the Joyce Kilmer-Slickrock Wilderness and Shining Rock Wilderness studied by Newell (1997), and the Great Smoky Mountains (Whittaker 1956), have little of the appropriate geology to support the Rich Subtype. The Black and Craggy Mountains do have a broad range of geology, and the presence of the Rich Subtype may have contributed to McLeod's (1988) choice not to distinguish distinct Northern Hardwood Forest. Ulrey (2002) distinguished two high elevation groupings of rich cove forest plots, which appear to partially overlap this subtype of Northern Hardwood Forest.

Rare species:
Vascular plants – *Aconitum reclinatum, Allium allegheniense, Clematis occidentalis var. occidentalis, Dactylorhiza viridis, Dendrolycopodium dendroideum, Geum geniculatum, Glyceria nubigena, Houstonia montana, Ilex collina, Lilium grayi, Lonicera canadensis, Monarda media, Nabalus albus, Platanthera grandiflora, Platanthera peramoena, Pyrola elliptica, Rhododendron vaseyi, Scutellaria saxatilis, Spiranthes ochroleuca, Stachys clingmanii,* and *Streptopus amplexifolius.*

Nonvascular plants – *Bazzania nudicaulis, Brachydontium trichodes, Cephaloziella spinicaulis, Frullania appalachiana, Drepanolejeunea appalachiana, Hypotrachyna virginica, Leskeella nervosa, Lobarina scrobiculata, Metzgeria consanguinea, Metzgeria violacea, Pannaria conoplea,* and *Sticta limbata*.

Vertebrate animals – *Catharus guttatus, Coccyzus erythropthalmus, Desmognathus organi, Desmognathus wrighti, Plethodon welleri,* and *Vireo gilvus.*

Invertebrate animals – *Platarctia parthenos, Entephria separata, Eulonchus marialiciae, Fumonelix roanensis, Fumonelix wheatleyi clingmanicus, Gazoryctra sciophanes, Inflectarius downieanus, Inflectarius ferrissii, Korscheltellus gracilis, Lithophane georgii, Paravitrea andrewsae, Platarctia parthenos, Polygonia progne*, and *Ventridens collisella*.

NORTHERN HARDWOOD FOREST (BEECH GAP SUBTYPE)

Concept: The Beech Gap Subtype encompasses forests strongly dominated by *Fagus grandifolia* at very high elevation, usually as small areas around ridge top gaps surrounded by spruce–fir forest, but sometimes as large expanses on open peaks in areas that lack spruce and fir.

Distinguishing Features: The Beech Gap subtype is distinguished from other high elevation forests by having a canopy strongly dominated by *Fagus grandifolia*, with *Aesculus flava* being the only other common species. The trees are generally stunted, sometimes strikingly so, and the overall floristic composition is low in diversity. The herb layer may be either a lawn of *Carex pensylvanica* or a moderate to dense bed of forbs. The Beech Variant of Northern Hardwood Forest (Typic Subtype) is generally less strongly dominated by *Fagus*, has larger tree stature, and is somewhat more diverse. The Beech Gap Subtype is a narrowly defined extreme community with distinctive structure and appearance.

Crosswalks: *Fagus grandifolia / Carex pensylvanica - Ageratina altissima var. roanensis* Forest (CEGL006130).
G742 Central Appalachian-Northeast Mesic Forest Group.
Southern Appalachian Northern Hardwood Forest Ecological System (CES202.029).

Sites: The Beech Gap Subtype characteristically occurs in south-facing ridge top gaps or on exposed peaks and open ridges in mountain ranges that lack spruce and fir. Most examples are above 5000 feet in elevation, but a few occurrences attributed to the subtype occur at to 4000 feet or lower. Russell (1953) noted that Great Smoky Mountains beech gaps had more severe microclimate, with larger temperature extremes, than surrounding forests.

Soils: The Beech Gap Subtype likely has soils similar to those of the Typic Subtype and is generally mapped as the same series of Typic Haplumbrepts, Humic Dystrudepts, and Typic Humadepts. Russell (1953) noted that beech gaps had less litter accumulation and higher pH than surrounding spruce-fir forests. This probably results from the lack of coniferous litter rather than being a cause of vegetation differences.

Hydrology: Sites are mesic due to cool temperatures and high rainfall at their high elevations. They presumably are well drained but those on concave slopes and in gaps may be less so than the other subtypes of Northern Hardwood Forest.

Vegetation: Beech Gap Subtype forests have short canopies, often gnarled and appearing stunted. *Fagus grandifolia* generally strongly dominates, but small numbers of *Aesculus flava, Betula alleghaniensis, Picea rubens*, or *Acer saccharum* may be present. These forests generally have limited understory cover, which most often includes *Acer spicatum* and as well as species from the canopy. Shrubs generally are sparse, with saplings of *Fagus* and other trees typically most abundant in the stratum. If the canopy has been disturbed, *Rubus alleghaniensis* or *Rubus canadensis* may be abundant. The herb layer generally is dense. *Carex pensylvanica* characteristically strongly dominates. Other frequent species reported by Russell (1953) include *Laportea canadensis, Poa alsodes, Athyrium asplenioides, Carex debilis,* other *Carex* spp., *Stellaria pubera*, and *Trillium erectum*. Additional herbs highly constant or frequent in CVS plot data include *Arisaema triphyllum, Solidago curtisii, Dryopteris intermedia, Eurybia chlorolepis, Oclemena acuminata, Angelica triquinata*, *Maianthemum racemosum, Maianthemum canadense*, *Smilax herbacea*, and *Epifagus virginiana*.

Range and Abundance: Ranked G1. Examples are scattered in the higher mountains. The equivalent association also occurs in Tennessee and possibly in Georgia.

Associations and Patterns: The Beech Gap Subtype may occur either as a small patch community surrounded by spruce-fir forest or as a large patch community occupying the tops of mountains and grading downslope to other subtypes of Northern Hardwood Forest or to High Elevation Red Oak Forest.

Variation: Two variants are recognized, based on the two characteristic landscape patterns more than vegetation, and warranting further study of differences:

1. Gap Variant occurs in ridge top gaps surrounded by spruce–fir forest. This is the original concept of beech gap, as described by Russell (1953) and Whittaker (1956) and is the source of the name.

2. Ridge Variant occurs on peaks and ridge tops, generally in areas without spruce–fir forest. It may occupy a larger range of environments because of the lack of competition with spruce and fir.

Dynamics: These communities are apparently stable climaxes under current climatic conditions. Trees may be quite old, although small. The forest may periodically be damaged by severe wind or ice storms. These sites are marginal environments for the occurrence of the dominant tree species, and growth and reproduction are relatively slow. Most reproduction may be by clonal sprouts rather than seeds. In the last decade or two, beech bark disease has killed patches of *Fagus* canopy. Such stands appear to be regenerating from root sprouts, but the long term fate of these areas is uncertain.

The question of why these high elevation sites are not occupied by spruce and fir has been of interest to ecologists. Pavlovic (1981), sampling across a red spruce – beech gap ecotone, found a relatively sharp boundary and found that the Beech Gap received spruce and birch seed rain. Russell (1953) concluded that cold temperatures and high winds were responsible for the occurrence of Beech Gaps and that their sites experienced more extreme temperature fluctuations than surrounding sites. Fuller (1977) suggested several other factors, including allelopathic effects of beech litter on spruce and seed predation under beech litter.

Comments: The concept of the beech gap community appears to have originated in the Great Smoky Mountains and to have been limited to what is here called the Gap Variant. As with many narrowly defined, extreme communities, there is a risk of losing sight of a distinctive phenomenon by broadening its concept. The addition of what is here called the Ridge Variant recognizes another extreme community but one that is more difficult to distinguish from other Northern Hardwood Forests. Further investigation is needed into whether these two variants belong together in one subtype.

A separate forb-dominated Beech Gap community was recognized in earlier versions of the 4th Approximation guide, as well as in the NVC. This distinction has been dropped, as most examples appear to be mixes of sedges and forbs. The former association, *Fagus grandifolia / Ageratina altissima var. roanensis* Forest (CEGL006246), has been lumped into this one.

Rare species:
Vascular Plants – *Lilium grayi, Platanthera grandiflora,* and *Spiranthes ochroleuca*.

Vertebrate animals – *Catharus guttatus* and *Microtus chrotorrhinus carolinensis*.

Invertebrate animals – *Eulonchus marialiciae*.

HIGH ELEVATION BIRCH BOULDERFIELD FOREST

Concept: High Elevation Birch Boulderfield Forests are vegetated boulderfields at high elevations (generally above 4000 feet), with canopies strongly dominated by *Betula alleghaniensis*. Well-developed boulderfields have nearly 100 percent ground cover of large rocks, with voids present beneath the rocks, and with the structure and composition of the lower strata determined by rock cover.

Distinguishing Features: High Elevation Birch Boulderfield Forests are distinguished from the Boulderfield Subtype of Rich Cove Forest by higher elevation and lower species richness. High Elevation Birch Boulderfield Forests have virtually no other canopy trees than *Betula alleghaniensis*. Rich Cove Forest (Boulderfield Subtype) may have *Betula alleghaniensis* as a codominant species, but also contains a variety of species of Rich Cove Forests. *Tilia americana var. heterophylla* is in most examples, but *Fraxinus americana, Liriodendron tulipifera*, and other species may also occur. High Elevation Birch Boulderfield Forests are generally above 4000 feet; Rich Cove Forests (Boulderfield Subtype) may extend above 4000 feet, higher than other Rich Cove Forest subtypes, but most are at lower elevation. High Elevation Birch Boulderfield Forests lack lower elevation species such as *Isotrema macrophyllum* and *Ribes cynosbati* and often have minor amounts of higher elevation species such as *Picea rubens, Sorbus americana, Sambucus racemosa* var. *pubens)*, and *Viburnum lantanoides*.

Crosswalks: Boulderfield Forest. *Betula alleghaniensis / Ribes glandulosum / Polypodium appalachianum* Forest (CEGL006124).
Boulderfield Forest (3rd Approximation).
G742 Central Appalachian-Northeast Mesic Forest Group.
Southern Appalachian Northern Hardwood Forest Ecological System (CES202.029).

Sites: High Elevation Birch Boulderfield Forests occur on coarse colluvial deposits. Large rocks cover virtually the entire ground surface and are piled on top of each other so that there is a substantial amount of void space beneath them. Most boulderfields are believed to be relict Pleistocene periglacial features. They typically occur on north-facing slopes, usually in upper coves or other steep concave slopes but occasionally on steep open slopes. A smaller number of boulderfields appear to be talus on steep slopes below rock outcrops.

Soils: Soil consists of accumulations of organic matter on and among the boulders (Lithic Dystrochrepts).

Hydrology: Conditions are mesic due to cool microclimate, high rainfall, and frequent fog at their high elevations, but soil moisture may vary drastically at a very fine scale. Shallow soil pockets maybe become dry very quickly. Some boulderfields have seepage that creates moist conditions locally. In some, water may be heard flowing rapidly beneath the rocks, and some of this may be accessible to plant roots.

Vegetation: High Elevation Birch Boulderfield Forests have a closed to somewhat open canopy, strongly dominated by *Betula alleghaniensis*. Often no other canopy trees are present, but *Aesculus flava, Picea rubens*, or *Fagus grandifolia* may sometimes occur. *Acer spicatum* usually forms an understory with low to moderate cover. *Ribes glandulosum* is the most frequent and characteristic shrub, sometimes having substantial cover but sometimes absent or sparse. Other shrubs, sparser and at lower frequency, include *Ribes rotundifolium, Ribes cynosbati, Viburnum lantanoides*, *Euonymus obovatus*, and *Hydrangea arborescens*. The herb layer is dominated by species that can grow on bare rock. There usually is extensive cover of mosses, more than all vascular herbs. *Polypodium appalachianum* or *Polypodium virginianum* may have extensive cover, and *Dryopteris marginalis* or *Dryopteris intermedia* may be abundant. Other herbs typical of Northern Hardwood Forests are often rooted in the deeper soil pockets. The abundance of such species is difficult to quantify in plot data, because inclusion of even small amounts of an adjacent community can substantially increase their cover in a plot. Frequent species include *Eurybia chlorolepis, Tiarella cordifolia, Athyrium asplenioides, Arisaema triphyllum, Oclemena acuminata*, and *Ageratina altissima*. If seepage or flowing water is present at the surface, *Impatiens pallida, Monarda didyma*, and *Diphylleia cymosa* may occur in pockets.

Range and Abundance: Ranked G2G3 but likely should be G2. High Elevation Birch Boulderfield Forest is scattered through the higher mountains. It also occurs in adjacent Tennessee, Virginia, and possibly Georgia. The equivalent association has also been questionably attributed to West Virginia.

Associations and Patterns: High Elevation Birch Boulderfield Forest occurs in small patches, surrounded by Northern Hardwood Forest (Typic Subtype), High Elevation Red Oak Forest, Red Spruce–Fraser Fir Forest, or other high elevation communities.

Variation: Examples vary with the amount of water seeping or flowing among the rocks and with gradation to adjacent communities.

Dynamics: While stand dynamics likely are similar to Northern Hardwood Forest, canopy gaps last longer because of the difficulty of tree establishment. Chafin and Jones (1989) found windthrow to be more common and canopy gaps more abundant in Boulderfield Forests than in nearby Rich Cove Forests. The ability of *Betula alleghaniensi*s to germinate and establish on top of logs and rocks, with its roots wrapping around these features and continuing downward until they reach soil, allows it to dominate in this unique environment.

The Southern Appalachian boulderfields apparently are relict features created by periglacial action during the Pleistocene. Though the boulders presumably once moved downhill, they do not appear to move at present. Weathering and sediment accumulation might be expected to eventually develop more typical soils in them, but their apparent persistence for thousands of years suggests that they may be stable for a long time to come. The rapid drainage of rainwater through the boulders presumably limits chemical weathering of the rocks and carries away any weathering products.

Comments: High Elevation Birch Boulderfield Forests are rare communities of a distinctive extreme environment. They are clearly related to Northern Hardwood Forest but have a consistent composition and structure distinct enough to treat as a separate type. Other Boulderfield communities are treated as subtypes of Rich Cove Forest and Red Spruce–Fraser Fir Forest, because they are somewhat less distinct. While rocky soils and substantial rock cover occur in many mountain communities, only at this extreme, where multiple layers of rock are present and voids beneath the rocks are abundant, do distinctive communities develop. When well developed, the aspect of large trees and moss-covered boulders is striking, as is the distinctive species composition.

Rare species:
Vascular plants – *Aconitum reclinatum, Cardamine clematitis*, *Conioselinum chinense, Geum geniculatum, Glyceria nubigena, Lonicera canadensis, Meehania cordata, Phegopteris connectilis,* and *Stachys clingmanii.*

Nonvascular plants – *Lejeunea blomquistii*.

Vertebrate animals – *Sorex dispar blitchi* and *Plethodon ventralis*.

Invertebrate animals – *Nesticus mimus*.

MOUNTAIN COVE FORESTS THEME

Concept: Mountain Cove Forests are mesic communities of low to middle elevations in the Mountain Region and foothills. They occur in broad to narrow valley bottoms, ravines, and on lower slopes. They are forested with mixtures of mesophytic hardwoods, usually containing moderate to large numbers of tree species and may or may not include *Tsuga canadensis*.

Distinguishing Features: Mountain Cove Forests are distinguished from drier forests by the dominance of mesophytic trees. Oaks, hickories, and occasionally pines are generally present but do not dominate. Mountain Cove Forests are distinguished from Piedmont and Mountain Floodplains, which may contain many of the same mesophytic tree and other plant species, by lacking species such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*, which are characteristic of sites with regular flooding and alluvial deposition. Some of the tree-dominated communities of the Mountain Bogs and Fens theme also may share many species. Those communities are distinguished by containing additional species characteristic of acidic saturated wetlands, such as *Osmundastrum cinnamomeum, Juncus gymnocarpus, Carex folliculata, Carex leptalea, Vaccinium macrocarpon, Rosa palustris*, and *Sphagnum* spp.

The distinction between Mountain Cove Forests and Northern Hardwood Forests is particularly difficult, especially in the transitional elevation zone around 3500-4500 feet. Northern Hardwood Forests share most of their species with Mountain Cove Forests but are more strongly dominated by one or two species, generally *Betula alleghaniensis, Fagus grandifolia, Acer saccharum*, or *Aesculus flava*. A number of lower elevation species are common in Rich Cove Forests but rarely or never occur in Northern Hardwood Forests, including *Liriodendron tulipifera, Magnolia acuminata, Juglans nigra, Lindera benzoin*, *Rhododendron maximum*, and *Amphicarpaea bracteata*.

Within Mountain Cove Forests, Rich Cove Forests are distinguished by a diverse canopy and diverse herb layer that contains numerous species associated with richer soils. Tree species such as *Tilia americana* var. *heterophylla, Fraxinus americana, Prunus serotina, Acer saccharum*, *Juglans nigra*, and *Magnolia acuminata* are present in Rich Cove Forests but largely absent in Acidic Cove Forests. The characteristic species of Acidic Cove Forest, such as *Liriodendron tulipifera, Betula lenta*, *Acer rubrum*, and *Halesia tetraptera,* are also present in Rich Cove Forest. Canada Hemlock Forests are distinguished by canopy dominance by *Tsuga canadensis*. Similar compositional distinctions occur in the herb layer. Species such as *Actaea racemosa, Caulophyllum thalictroides, Laportea canadensis, Osmorhiza claytonia, Sanguinaria canadensis,* and *Viola canadensis* are common to most Rich Cove Forests but largely absent in Acidic Cove Forests and Canada Hemlock Forests.

Sites: Mountain Cove Forests occur in mesic sites at low to moderate elevations, in small to large valley bottoms, in ravines, and on lower slopes. They more often occur on concave slopes but can be found on convex slopes that are sheltered. Most are below 4000 feet elevation, but a few range higher in sheltered or warm environments.

Soils: Mountain Cove Forests occur on a wide range of typical mountain soils, most often on Typic Dystrudepts or Typic Hapludults, sometimes on Lithic Dystrudepts, Typic Humadepts, or other types. Soils range from extremely acidic and infertile to circumneutral and rich.

Hydrology: Sites are mesic because of water accumulation on concave slopes and lower slopes, as well as topographic sheltering.

Vegetation: Mountain Cove Forests are dominated by mixtures of mesophytic trees, with the mix varying among sites in response to soil chemistry as well as varying widely within and among comparable sites. Common to most are *Liriodendron tulipifera, Acer rubrum*, and *Betula lenta*, as well as *Quercus rubra* and formerly, *Castanea dentata*. Also fairly frequent across communities are *Halesia tetraptera, Fagus grandifolia*, *Tsuga canadensis, Pinus strobus*, *Quercus alba*, and *Quercus montana*. Acidic Cove Forests consist largely of these species. *Tsuga canadensis* dominates in Canada Hemlock Forests. Rich Cove Forests share a number of additional tree species, most frequently *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Aesculus flava, Prunus serotina*, and *Acer saccharum*. Lower strata vary. Acidic Cove Forests usually have dense shrub layers of evergreen Ericaceae but may have a well-developed herb layer of a few acid-tolerant species with few shrubs. Rich Cove Forests usually have limited shrubs, mostly deciduous, and have a lush herb layer. Herb species richness is high at both local and regional scales in Rich Cove Forests. Most examples have many species and some species are present in most examples, but there is a large pool of species that occur with moderate to low frequency.

Dynamics: Mountain Cove Forests are like most of North Carolina's hardwood forests in naturally occurring primarily as old-growth, uneven-aged stands. Trees up to several centuries old are common in uncut forests. Most tree reproduction is in small, less often medium size, canopy gaps created by the death of one or a few trees, resulting in a fine-scale mosaic of tree ages across the forest and relative stability of the forest cover over large areas. Lorimer (1980), working in virgin cove forests at Joyce Kilmer Memorial Forest, noted that trees are of multiple ages in areas as small as 1/10-1/2 hectare and that major tree species were present in most 10-year age classes up to 400 years old. However, he also noted that there were peaks of tree reproduction that suggest widespread disturbance. Wind, lightning, and ice damage are important sources of mortality. Lightning creates gaps at a relatively steady rate, but probably is less frequent in the sheltered settings of coves than it is on ridges. Large wind storms may create numerous gaps at once, while leaving the majority of canopy cover intact. Lorimer (1980) estimated that the average canopy mortality in a decade was 5.5%, with 3.8% in nondisturbance decades and up to 14% in decades with major disturbances. Runkle (1982) and Runkle and Yetter (1987) found that gaps formed at a rate of 1% of the land surface/year in their study areas. Runkle (1982) estimated for old-growth mesic forests in general that recognizable gaps occupied 17.3% of the canopy in Joyce Kilmer Memorial Forest and 8.9-24.2% in the Great Smokies.

Many of the characteristic trees of Mountain Cove Forests are tolerant of shade and regenerate readily beneath the canopy. However, other frequent trees, such as *Liriodendron*, are regarded as early successional species intolerant of shade. *Liriodendron's* abundance in old-growth forests was regarded as a paradox, but Buckner and McCracken (1978), Lorimer (1980), and Clebsch and Busing (1989) all addressed this problem by noting that the single-tree and few-tree gaps in old-growth forests are large enough to allow its regeneration. *Liriodendron* itself, as the largest of cove forest trees, is capable of forming gaps that allows its regeneration, but a number of other tree species can become almost as large and create large gaps.

Fire appears to be of limited importance in Mountain Cove Forests. The newly recognized frequency of fire in the low- and mid-elevation mountain landscapes suggests they were exposed to it regularly. However, the prevalence in coves of plant species not very tolerant of fire, a prevalence that is described in early studies and recorded in long-lived trees dating to before the time of fire suppression, indicates that fire was not an important ecological influence. The moist site conditions, shelter from wind, the tendency of mesophytic leaf litter to mat down and hold moisture, and the location downhill of most directions of fire spread would all dampen fire behavior. Where present day prescribed fires are allowed to burn into coves or ravines, the fires sometimes go out and sometimes spread with low intensity that has little effect on even the thin-barked trees. Wildfires during droughts can have more effect but rarely are hot enough to cause widespread tree mortality in coves. The importance of fire in oak forests, despite their being dissected by bands of cove forest, suggests that fires usually crossed the coves. Ignition sources were not dense enough to create even moderate fire frequency without fires spreading over large areas. It is possible that the influence of topography and moisture on fire behavior was an important influence on the boundary between mesophytic forests and oak forests. Feedbacks created by the different flammability of oak and mesophytic leaf litter, as well as by different shrub and herb layers, may have sharpened and stabilized this boundary.

After heavy logging or clearing, Mountain Cove Forests usually regenerate in successional stands dominated by *Liriodendron tulipifera, Pinus strobus*, or *Robinia pseudo-acacia*, occasionally with yellow pines also becoming important. Logging also appears to increase abundance of other small-seeded trees such as *Betula lenta* and *Acer rubrum*, and sometimes may increase the amount of oak. Other species, such as *Aesculus flava*, frequently are scarce or lacking in second growth forests and may be very slow to return.

Much less is known about the dynamics of the lower strata of Mountain Cove Forests. Rich Cove Forests support dense and diverse herb layers of species that are shade-tolerant and do not depend on fire or other frequent disturbance to maintain diversity. Environmental heterogeneity and fine-scale niche differentiation may be important in the coexistence of so many species. Extensive spatial and ecological analysis by Tessell (2017) suggests that dispersal limitation is also an important factor in determining the presence of many species, not just on a regional scale but at individual sites within their ranges. Many herbs have no apparent adaptation for seed dispersal, and reproduction occurs only near parent plants. Dispersal limitation could explain the low constancy of many herb species and be an important influence on composition of individual community occurrences.

Herb layers appear stable over time, but little is known about stability on a fine scale. Most of the species probably are conservative, have long life spans, and reproduce by seed infrequently. Most coves that were cultivated in the past can be observed to have low herb density or to have higher density but low species richness even after many decades of recovery. A suggestion by Duffy and Meier (1992) that cove herb layers may also be very slow to recover from clearcutting sparked a rapid and heated response (e.g., Johnson, et al. 1993) but not a definitive answer. Greenlee (1974) found that a cove that had been selectively logged had very different canopy structure and herb composition from a virgin cove forest. Even-aged, young canopies resulting from clearing or heavy logging may have reduced rate of gap formation and size of gaps. Such gaps may be necessary for maintaining high diversity. Observations readily made in second growth forests suggest that effects of past logging have been variable. Some successional cove forest stands have lush and diverse herb layers even though the canopy is young and heavily altered. Other successional coves have little herb cover or have low herb diversity even after many decades of recovery from logging. This appears to suggest that cove herb layers sometimes survive logging and survive the dense shade of young stands of regeneration, but they do not recover readily if they do not survive these stages. But it is possible that some other aspect of history, perhaps the intensity of forest grazing, is responsible for these differences.

There is similar uncertainty about the dynamics of the shrub layer in Acidic Cove Forests and some Canada Hemlock Forests. The concerns about an increase in evergreen heath shrub layers in oak forests (Monk, et al. 1985) are less likely to be appropriate in these mesophytic sites. However, the ability of trees, even shade-intolerant *Liriodendron,* to coexist with dense shrub layers is interesting and would warrant further investigation.

There is also a question of possible interplay between shrubs and herbs. Occasional forests may be found with trees of Rich Cove Forests but with a dense *Rhododendron* shrub layer and few herbs. It is unclear if these mixtures are stable, nor, if they represent a recent transition, what caused it. *Rhododendron maximum* litter acidifies the soil, and a feedback mechanism may promote its persistence once established. It is unclear how readily this effect would be reversed by loss of the shrubs, such as might occur if they were destroyed by fire. *Rhododendron maximum* patches are often present as minor components in Rich Cove Forests, just as small numbers of Rich Cove Forest herbs can be present in Acidic Cove Forests. Logging may potentially lead to proliferation of shrubs, expanding shrubby conditions into herbaceous areas. However, such sites that suggest a conversion between acidic and rich cove conditions are rare, and most examples appear to be stable in the long term.

Comments: Ulrey's (2002) analysis of mesophytic vegetation throughout the North Carolina mountains showed a distinct separation of Acidic Cove Forest and Rich Cove Forest in ordination space, with variables of soil fertility but not topography separating the two. The more mesic oak forests, also included in his analysis, were separated from both by variables related to topography and dryness but not by soil fertility. He noted, as has the author, that Acidic Cove Forests and Rich Cove Forests seldom grade into each other, but that each more often grades into oak forest. Ulrey (2002) also noted that the measures of soil chemistry that are generally termed "richness" or "fertility" in ecological studies and that correlate with community patterns are quite different from measures of fertility in agriculture. Ecological gradients are usually correlated with pH and a variety of nutrient cations, while agricultural productivity is most often determined by nitrogen and phosphorus.

KEY TO MOUNTAIN COVE FORESTS

1. Forest rich, containing significant amounts of trees and herbs of richer soils, such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Aesculus flava, Prunus serotina, Lindera benzoin, Actaea* spp., *Collinsonia canadensis, Sanguinaria canadensis, Asarum canadense, Osmorhiza* spp., *Laportea canadensis, Podophyllum peltatum, Phegopteris hexagonoptera, Phryma leptostachya*, *Hydrophyllum* spp., and a number of others. More broadly tolerant species listed below are also present and may dominate, but multiple rich-site species are present more than incidentally. *Rhododendron maximum* and *Leucothoe fontanesiana*, if present, are confined to patches in a minority of the area.

2. Forest additionally containing several species indicative of more extremely rich or calcareous soils, such as *Acer nigrum, Deparia acrostichoides, Diplaziopsis (Diplazium) pycnocarpa, Dryopteris goldieana,* and *Aquilegia canadensis*, and containing large amounts of species such as *Juglans nigra, Asarum canadense, Cryptotaenia canadensis*, and *Phryma leptostachya*. Sites are generally underlain by amphibolite, limestone, dolomite, or marble.

3. Community in the foothills or below 2000 feet in elevation; herb layer often only moderate in density.. **Rich Cove Forest (Foothills Rich Subtype)**

3. Community in the Blue Ridge, above 2000 feet in elevation; herb layer very dense and lush. .... **Rich Cove Forest (Montane Rich Subtype)**

2. Forest not additionally containing any more than stray individuals of species characteristic of more extremely rich soils. May be underlain by any common rock type but not associated with calcareous rock.

4. Community in a boulderfield; large boulders covering virtually all the ground, with open voids beneath many of them; canopy generally consisting of a smaller set of trees, usually predominantly *Betula alleghaniensis, Betula lenta*, and *Tilia americana* var. *heterophylla*; herb layer sparse or consisting mainly of moss and fern cover on rock but containing several of the species listed above.. **Rich Cove Forest (Boulderfield Subtype)**

4. Community not in a boulderfield; rock cover may be substantial but almost all plants are rooted in deep soil; the herb layer cover is not greatly reduced by rock.

5. Canopy with *Quercus rubra* dominant, though *Tilia americana* var. *heterophylla* and species of other Rich Cove Forests are codominant or abundant; community on a steep, though still concave, slope in the upper end of a cove, generally very rocky but not a boulderfield. .... **Rich Cove Forest (Red Oak Subtype)**

5. Canopy not dominated by *Quercus rubra* more than in small groves, at least not in coincidence with a steep, rocky, upper cove setting.

6. Community in the foothills or below 2000 feet elevation; herb layer often only moderate in density, though containing rich-soil species; *Fagus grandifolia* more likely to be present. .... **Rich Cove Forest (Foothills Intermediate Subtype)**

6. Community above 2000 feet elevation or within the interior of the Blue Ridge region and resembling communities at higher elevation; herb layer generally dense; *Fagus grandifolia* may be present but is less likely…………………………………………….. ………………………………………**Rich Cove Forest (Montane Intermediate Subtype)**

1. Forest lacking the above species of richer soils; trees and herbs consisting of a small suite of more broadly tolerant species such as *Liriodendron tulipifera, Betula lenta, Halesia tetraptera, Polystichum acrostichoides, Amauropelta* (*Parathelypteris*) *noveboracensis, Medeola virginiana*,

and *Viola rotundifolia*; often, but not always, with a dense shrub layer of *Rhododendron maximum* or *Leucothoe fontanesiana*.

7. Forest dominated by *Tsuga canadensis*, at least weakly. Communities formerly dominated by *Tsuga* that died recently because of hemlock woolly adelgid may be classified here but their future natural character is uncertain.

8. *Pinus strobus* codominant with *Tsuga canadensis*…………………………………………… ……………………………………………**Canada Hemlock Forest (White Pine Subtype)**

8. *Pinus strobus* not codominant, normally not present; other hardwood species may be abundant, or *Tsuga* may strongly dominate...........**Canada Hemlock Forest (Typic Subtype)**

7. Forest not dominated by *Tsuda canadensis*, though the species may be abundant; generally dominated by combinations of *Liriodendron tulipifera, Betula lenta, Betula alleghaniensis, Acer rubrum, Halesia tetraptera, Fagus grandifolia,* and *Quercus rubra*.

9. Forest dominated or codominated by *Betula alleghaniensis*, generally lacking *Liriodendron tulipifera*; generally at elevations above 3000 feet …………………………………………. …………………………………………..**Acidic Cove Forest (High Elevation Subtype)**

9. *Betula alleghaniensis* not dominant or codominant, generally absent; potentially at a broad range of elevations, including above 3000 feet.

10. Canopy dominated by *Halesia tetraptera*, often codominant with *Tsuga canadensis; Liriodendron tulipifera* generally absent .... **Acidic Cove Forest (Silverbell Subtype)**

10. Canopy not dominated by *Halesia*, though the species is often present; generally dominated by *Liriodendron* or with a mixed canopy of that species with *Betula lenta, Acer rubrum, Fagus grandifolia, Halesia tetraptera*, and *Quercus rubra*. ………………………… ....**Acidic Cove Forest (Typic Subtype)**

RICH COVE FOREST (MONTANE INTERMEDIATE SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The herb layer also is diverse and contains many species of richer soils. The Montane Intermediate Subtype covers the most common examples, occurring in the Mountains at all but the lowest elevations and lacking the species characteristic of the richest sites such as *Deparia acrostichoides*, *Diplaziopsis (Diplazium) pycnocarpa*, and *Dryopteris goldieana*.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils as well as more widely tolerant species. Trees common in Rich Cove Forest and scarce to absent in Acidic Cove Forest include *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla*, and *Magnolia acuminata*, along with less common species such as *Juglans nigra, Carya ovata*, and *Cladrastis kentukea (lutea).* Herbs present in Rich Cove Forest and absent or scarce in Acidic Cove Forest include *Actaea racemosa, Caulophyllum thalictroides, Prosartes lanuginosa, Aruncus dioicus, Adiantum pedatum, Collinsonia canadensis, Osmorhiza claytonii*, *Laportea canadensis*, and many others. Acidic Cove Forest canopy and herb species are a subset of those in Rich Cove Forest. Acidic Cove Forests also generally have a better developed shrub layer dominated by *Rhododendron maximum* or *Leucothoe fontanesiana*, species which are often present but not abundant in Rich Cove Forests. Most of the small number of herbaceous species of Acidic Cove Forest (e.g., *Polystichum acrostichoides, Medeola virginiana*, and *Viola canadensis*) may also occur in Rich Cove Forest.

The distinction between Rich Cove Forest and Northern Hardwood Forest can be especially subtle because Northern Hardwood Forests are often dominated by a subset of species found in Rich Cove Forest. However, Rich Cove Forests contain a number of species of lower elevation, which are absent or scarce in Northern Hardwood Forests. These include *Liriodendron tulipifera, Juglans nigra*, *Ulmus rubra*, and usually *Magnolia acuminata,* as well as many herbaceous species. A few species are more common in Northern Hardwood Forests, including *Viburnum lantanoides, Picea rubens*, and *Rhododendron catawbiense.*

Rich Cove Forests are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests, but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, while *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest.

Montane Alluvial Forest communities may share many species with Rich Cove Forests, but can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Montane Intermediate Subtype is distinguished from the Montane Rich Subtype by the absence or scarcity of the most calciphilic species, such as *Diplaziopsis pycnocarpa, Asplenium rhizophyllum, Dryopteris goldieana, Aquilegia canadensis*, and *Acer nigrum*. Additional species that are shared are more abundant in the Montane Rich Subtype, including *Asarum canadense*. *Cryptotaenia canadensis, and Phryma leptostachya*. The Montane Intermediate Subtype is distinguished from the Foothills subtypes by occurring in the central parts of the Blue Ridge rather than on the periphery or in the foothills, and generally at elevations above 2000 feet. The Foothills Intermediate Subtype may be distinguished from lower elevation examples of the Montane Intermediate Subtype by the presence of a few lower elevation species, such as *Liquidambar styraciflua*, and by a less dense and generally less diverse herb layer.

Crosswalks: *Liriodendron tulipifera - Fraxinus americana - (Aesculus flava) / Actaea racemosa - Laportea canadensis* Forest (CEGL007710).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Montane Intermediate Subtype usually occurs from 2000-4000 feet elevation, with a few examples higher and lower. The Montane Intermediate Subype may occur on any geologic substrate but is generally replaced by other subtypes on mafic or calcareous rocks.

Soils: The Montane Intermediate Subtype occurs on a wide range of soil map units, including Typic Dystrudepts (Ashe, Porters), Humic Dystrupepts (Tusquittee, Unaka), Typic Humadepts (Cullasaja, Tuckasegee), and Typic Hapludults (Chester, Watauga). Soils are acidic but are higher in pH, base saturation, and levels of nutritive cations than in most mountain communities, higher than in Acidic Cove Forests, but lower than in the Montane Rich Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence on concave slopes. Local small seepages may be present.

Vegetation: The Montane Intermediate Subtype canopy is dominated by a varying mix of mesophytic trees, which may locally have one or a couple of predominant species, but which usually contains many species within the stand. Canopy species in 50% or more of the numerous CVS plots, all sometimes dominant, are *Quercus rubra, Tilia americana* var. *heterophylla, Fraxinus americana, Aesculus flava, Liriodendron tulipifera, Acer saccharum, Betula lenta, Prunus serotina, Robinia pseudo-acacia, Magnolia acuminata, Tsuga canadensis*, and *Halesia tetraptera*. Also frequent are *Fagus grandifolia, Acer rubrum*, and *Carya glabra*. The understory consists primarily of canopy species but has *Acer pensylvanicum* as a constant component, frequently contains *Benthamidia* (*Cornus*) *florida, Swida* (*Cornus*) *alternifolia*, and sometimes contains *Magnolia fraseri, Ostrya virginiana*, or *Carpinus caroliniana*. The shrub layer usually is open, with no species constant. *Hamamelis virginiana, Rhododendron maximum*, and *Lindera benzoin* are most frequent, but *Rhododendron* does not dominate large areas. The herb layer is dense, often extremely lush, with multiple layers and with different species predominating in different seasons. A few species, such as *Polystichum acrostichoides, Laportea canadensis, Eurybia divaricata*, *Asarum canadense*, or *Amauropelta* (*Parathelypteris*) *noveboracensis* may dominate patches, but usually there is no strong dominant. Species occurring in 50% or more of CVS plots include, besides the above, *Prosartes lanuginosa, Maianthemum racemosum, Actaea racemosa, Solidago curtissii, Botrypus virginianus, Caulophyllum thalictroides, Galium triflorum, Dioscorea villosa, Collinsonia canadensis, Stellaria pubera, Tiarella cordifolia, Sanguinaria canadensis, Trillium erectum*, and *Osmorhiza claytonia*. Species only a bit less frequent (30-49%) include *Goodyera pubescens, Medeola virginiana, Dryopteris intermedia, Athyrium asplenioides, Amphicarpaea bracteata, Viola sororia, Adiantum pedatum, Polygonatum biflorum, Panax quinquefolius, Phegopteris hexagonoptera, Viola blanda, Viola canadensis, Eutrochium purpureum, Dryopteris marginalis, Polygonatum pubescens, Deparia acrostichoides, Hydrophyllum virginianum, Clintonia umbellula, Impatiens capensis/pallida*, and *Veratrum parviflorum*. A number of additional species are less frequent in plot data but are nevertheless characteristic of the community, including *Astilbe biternata, Uvularia grandiflora, Galium latifolium, Sanicula canadensis, Sanicula odorata, Podophyllum peltatum, Ranunculus recurvatus, Ageratina altissima, Phryma leptostachya, Cardamine diphylla, Hepatica acutiloba, Symphyotrichum cordifolium, Sedum ternatum, Actaea pachypoda, Osmorhiza longistylis, Arisaema triphyllum, Trillium grandiflorum, Dicentra canadensis, Dicentra cucullaria, Persicaria virginiana, Thaspium barbinode*, and several species of *Carex*. This community is rich in species at both the plot scale and the whole community scale. Plots averaged 71 species per 1/10 hectare. The species pool represented by the plots contains 490 species occurring in more than one plot, and 297 occurring in at least 5% of the plots.

Range and Abundance: Ranked G4. Rich Cove Forest (Montane Intermediate Subtype) is one of the most common communities in the Mountain region. It also occurs in Georgia, Tennessee, and Virginia, and the equivalent association has been questionably attributed to West Virginia.

Associations and Patterns: Rich Cove Forest (Montane Intermediate Subtype) is extensive and makes up a significant minority of the landscape mosaic in most places. It interfingers with various oak communities on the drier slopes. Ulrey (2002) indicated that he seldom saw Rich Cove Forests and Acidic Cove Forests co-occur, but such a pattern does sometimes occur. Rich Cove Forests fairly frequently contain embedded small patches of Montane Cliff, Rich Montane Seep, or Low Elevation Seep, and occasionally contain patches of Rich Cove Forest (Boulderfield Subtype).

Variation: With its large geographic and elevational range, the Montane Intermediate Subtype encompasses a tremendous range of variation. However, because of its large species pool and high local variability, it can be hard to sort out patterns suitable for recognition as variants. The large number of species with limited means for dispersal (Tessell 2017) leads to variability in composition that cannot be related to environmental variation. Ulrey (2002), in analysis focused on Rich Cove Forests, identified 5 groupings, four of which are tentatively recognized as variants here (the fifth is equated to the Red Oak Subtype). More testing is needed to determine how well these variants can be distinguished. Though apparently distinct in multivariate analysis, distinguishing features among them are not easily articulated. An additional variant is recognized based on the author's experience.

1. Typic Variant occurs in the lower elevation range and is most characteristic of the Montane Intermediate Subtype as a whole. *Acer saccharum, Aesculus flava*, and *Tilia americana* var. *heterophylla* usually dominate.

2. High Elevation North Variant occurs at elevations above 3600 feet in areas north of the Asheville Basin. It has *Betula alleghaniensis* and *Fagus grandifolia* dominant in addition to the species of the Typic Variant. *Ostrya virginiana* often occurs in the understory. Particular herb species may strongly dominate, including *Laportea canadensis, Stellaria pubera, Viola canadensis, Dryopteris intermedia*, and *Caulophyllum thalictroides*. This variant is transitional to Northern Hardwood Forest (Rich Subtype). Ulrey (2002) may not have placed the boundary in the same place the 4th Approximation does. *Liriodendron* and *Magnolia* both are present in his data for this group but at only low frequency.

3. High Elevation South Variant occurs above 3900 feet in areas south of the Asheville Basin. *Betula alleghaniensis* is a dominant canopy species, and *Betula lenta* is too. *Aesculus flava, Acer saccharum, Quercus rubra*, *Tilia americana* var. *heterophylla*, *Ageratina altissima* and *Actaea racemosa* often dominate the herb layer. Also characteristic, compared to other variants, is *Prunus pensylvanica*.

4. Rich Variant occurs at elevations below 3500 feet and contains richer soils and species indicative of them. Part of the set of plots defined as this group by Ulrey (2002) probably represents the Montane Rich Subtype. See the description of that subtype for more discussion. Because some portion of this rich group does not appear to fit within the Montane Rich Subtype, it is accommodated in this variant. *Liriodendron tulipifera* apparently is more constant and abundant in this variant than in any of the others, but this may be not be universally true compared to the Typic Variant. *Ulmus rubra*, *Astilbe biternata,* and *Cystopteris protrusa* are noted as characteristic of this group, and *Asarum canadense* is more abundant in it.

5. Acidic Transition Variant is less diverse and contains a smaller subset of characteristic Rich Cove Forest species. The canopy generally contains *Fraxinus americana, Magnolia acuminata,* or *Prunus serotina*, as well as species shared with Acidic Cove Forest, but lacks most of the other characteristic species. The herb layer generally contains *Amphicarpaea bracteata, Brachyelytrum erectum, Phegopteris hexagonoptera, Dichanthelium boscii,* or *Ageratina altissima*, along with the species shared with Acidic Cove Forest, but lacks many other characteristic Rich Cove Forest species. This variant should only be recognized where it covers a significant area without being transitional between another variant and an adjacent community. It is scattered throughout the Mountain Region but appears to be much less common than the Typic Variant. A comparable variant occurs in the Foothills Intermediate Subtype.

Dynamics: The Montane Intermediate Subtype has dynamics similar to the Mountain Cove Forests theme as a whole. The importance of dispersal limitation in Rich Cove Forests (Tessell 2017) may create some interesting dynamics, with herb layer composition changing in response to infrequent dispersal and metapopulation processes in a way different from many other communities.

Comments: Rich Cove Forests as a whole constitute one of the most recognized and well-loved communities in the Mountains. Though many early studies did not distinguish between Acidic Cove Forest and Rich Cove Forest (see discussion under Acidic Cove Forest (Typic Subtype), all described something recognizable as Rich Cove Forest. Where Rich Cove Forests were present. Acidic Cove Forests may have been ignored or viewed as a poorly developed versions.

Ulrey (2002) focused analysis on the distinction between Acidic Cove Forest and Rich Cove Forest, using plot data from across the North Carolina mountains and adjacent areas. His results are similar to what was recognized in the 3rd and 4th Approximation. He also analyzed variation within Rich Cove Forests, and his results are the basis for the variants described here. His results are not as definitive for the subtypes of Rich Cove Forest because he didn't include data from the foothills and because his results were apparently different from previous concepts for the Rich Subtype. However, the variants based on his descriptions may become the basis for recognition of additional subtypes in this complex set of communities. Newell (1997) also recognized multiple community groupings within the range, but these varied among her three study areas in a way that is difficult to interpret on a regional scale.

Ulrey demonstrated that even within the narrow range of moisture and soil nutrient status represented by Rich Cove Forests, soil chemistry as well as elevation play a recognizable role in structuring vegetation. He also noted that at least two of his groupings, adopted here as the High Elevation North and High Elevation South variants, did not have any recognizable environmental correlation. He suggested biogeography as a cause, though the possibility of unmeasured environmental variables remains a possibility. The Asheville Basin is a biogeographic break for many plant species, but the species that most strongly distinguish the variants occur on both sides of it. The biogeographic break between these variants is at a different geographic scale than the dispersal-related variation studied by Tessell (2017).

Both Whittaker (1956) and McLeod (1988) placed great emphasis on the broad transition between cove forests and drier oak forest communities. They noted that this transition zone is often more rich in species than the heart of the Rich Cove Forest. While this zone can sometimes be recognized in plots, it generally appears to be limited on the ground and too tightly tied to the Rich Cove Forest to classify as a separate community. The boundary between Rich Cove Forest and adjacent oak communities is placed where the diversity in the canopy and herb layer gives way to oak dominance and a sparser herb layer. Several of the characteristic Rich Cove Forest trees, especially *Magnolia acuminata, Prunus serotina*, and *Fraxinus americana*, can occur in oak forests as saplings or understory trees, while rarely being present in the canopy. This may be a recent phenomenon, the "mesophication" occurring as a result of removal of fire as a natural process. However, the observation of mixing and transition by Whittaker in 1956, not long after the beginning of effective fire suppression, suggests such gradation has long been present.

Rare species:
Vascular plants – *Aconitum reclinatum, Bromus ciliatus, Buckleya distichophylla, Cardamine clematitis, Carex pedunculata* var. *pedunculata, Caulophyllum giganteum, Chelone cuthbertii, Carex roanensis, Cypripedium parviflorum* var. *parviflorum, Dicentra eximia, Diervilla rivularis, Erigenia bulbosa, Frasera caroliniensis, Geum geniculatum, Hackelia virginiana, Hexastylis rhombiformis, Lilium grayi, Lonicera canadensis, Meehania cordata, Micranthes caroliniana, Polygala senega, Primula meadia, Scutellaria saxatilis, Silene ovata, Smilax hugeri, Spigelia marilandica, Stewartia ovata, Symphyotrichum shortii, Synandra hispidula, Trillium discolor, Trillium flexipes, Trillium simile, Viola appalachiensis,* and *Waldsteinia lobata.*

Nonvascular plants – *Brachythecium rotaeanum, Cirriphyllum piliferum, Cryphaea nervosa, Cyrto-hypnum pygmaeum, Entodon sullivantii, Metzgeria consanguinea, Rhabdoweisia crenulata, Sciuro-hypnum populeum,* and *Sticta limbata*.

Vertebrate animals – *Aneides aeneus, Dendroica cerulea,* and *Plethodon yonahlossee pop. 1*.

Invertebrate animals – *Appalachina chilhoweensis, Celastrina nigra, Discus bryanti,* Gastrocopta *corticaria, Glyphyalinia junaluskana, Glyphyalinia pentadelphia, Nesticus sheari, Pallifera ohioensis, Papaipema astuta, Papaipema cerina,* and *Paravitrea ternaria.*

RICH COVE FOREST (MONTANE RICH SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The herb layer also is diverse and contains many species of richer soils. The Montane Rich Subtype includes the less common examples occurring on the unusually rich substrates associated with mafic or calcareous rocks, in the Mountain region. They contain indicators of unusually rich soils, such as *Deparia acrostichoides*, *Diplaziopsis (Diplazium) pycnocarpa*, and *Dryopteris goldieana*.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. Trees common in Rich Cove Forest and scarce to absent in Acidic Cove Forest include *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla*, and *Magnolia acuminata*, along with less common species such as *Juglans nigra, Carya ovata*, and *Cladrastis kentukea* (*lutea*).

The Montane Rich Subtype is distinguished from the Montane Intermediate Subtype by differences in flora and vegetation that correlate with soil pH and fertility. The distinction can be subtle. Some members of a pool of calciphilic species such as *Cystopteris protrusa*, *Diplaziopsis (Diplazium) pycnocarpa, Asplenium rhizophyllum, Aquilegia canadensis, Dryopteris goldieana, Philadelphus hirsutus,* or *Acer nigrum* are generally present in a stand but may be sparse and not found in vegetation plots. Other species are more abundant in the Montane Rich Subtype but may still be found sometimes in other subtypes. These include *Carya cordiformis, Juglans nigra, Carpinus caroliniana, Toxicodendron radicans, Deparia acrostichoides, Asarum canadense, Astilbe biternata, Phryma leptostachya, Cryptotaenia canadensis,* and *Panax quinquefolius*. *Tsuga canadensis, Acer rubrum*, and *Oxydendrum arboreum* generally are absent in the Montane Rich Subtype.

The Montane Rich Subtype is distinguished from the Foothills Rich Subtype by occurring in the primary Blue Ridge region rather than in the foothills or low elevation periphery and generally at elevations above 2000 feet. The Foothills Rich Subtype may be distinguished from lower elevation examples of the Montane Rich Subtype by the presence of a few lower elevation species, such as *Liquidambar styraciflua*, and by an herb layer that is less dense even as it is generally highly diverse.

Crosswalks: *Aesculus flava - Acer saccharum - (Tilia americana* var. *heterophylla) / Hydrophyllum canadense - Solidago flexicaulis* Forest (CEGL007695).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Montane Rich Subtype occurs on rocks such as amphibolite, hornblende gneiss, calc-silicate, dolomite, and marble, that produce less acid, more fertile soils than typical. Many are on colluvial deposits. Most examples occur at 2000-4000 feet elevation, but a few examples are lower or higher.

Soils: The Montane Rich Subtype occurs on the same wide variety of Inceptisol and less common Ultisol soil map units as the Montane Intermediate Subtype. The Inceptisols are not classified by the chemical differences that distinguish the community subtypes, but it may be that some soils mapped as Ultisols are unrecognized Alfisols. The soils in the Montane Rich Subtype are acidic, but studies such as Ulrey (2002) and Newell (1997) find them less acidic than those in the other subtypes of Rich Cove Forest, and they are higher in base saturation and in most of the nutritive cations. They may be very rocky but do not have extreme boulder cover.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence. Local small seepages may be present.

Vegetation: The Montane Rich Subtype is dominated by a varying mix of mesophytic trees, which may locally have one or a couple of predominant species but which usually include many species within the stand. Canopy species in 50% or more of CVS plots are *Acer saccharum* (probably including some *Acer nigrum*), *Aesculus flava, Fraxinus americana, Tilia americana* var. *heterophylla, Carya cordiformis, Quercus rubra, Prunus serotina, Liriodendron tulipifera*, and *Betula alleghaniensis*. Also frequent are *Fagus grandifolia, Halesia tetraptera*, *Magnolia acuminata*, and *Betula lenta*. Less frequent, but notable, trees include *Juglans nigra*, *Ulmus rubra*, and *Cladrastis kentukea*. In addition to canopy species, the understory usually includes *Acer pensylvanicum* and *Ostrya virginiana*, and fairly frequently includes *Swida* (*Cornus*) *alternifolia*. The shrub layer usually is sparse, but moderate cover of *Hydrangea arborescens, Lindera benzoin*, or *Hamamelis virginiana* may be present. The vines *Isotrema macrophyllum, Parthenocissus quinquefolius*, and *Smilax rotundifolia* are highly constant or frequent, though their cover usually is limited. The herb layer generally is extremely dense and diverse, but patches may be strongly dominated by a single species and therefore be less diverse. High constancy species that sometimes dominate patches include *Caulophyllum thalictroides, Laportea canadensis*, *Hydrophyllum canadense*, *Asarum canadense*, and *Viola canadensis*. Other species occurring in 50% or more of CVS plots or of Ulrey's (2002) plots are *Arisaema triphyllum, Actaea racemosa, Prosartes lanuginosa, Dryopteris marginalis, Maianthemum racemosum, Osmorhiza claytonia, Deparia acrostichoides, Dryopteris intermedia, Botrypus virginianus, Galium triflorum, Stellaria pubera* (probably including *Stellaria corei*), *Trillium erectum, Solidago curtissii, Eurybia divaricata, Impatiens pallida, Sanguinaria canadensis*, and *Polygonatum pubescens*. Other frequent species in plots include *Adiantum pedatum, Uvularia grandiflora, Collinsonia canadensis, Solidago flexicaulis, Tiarella cordifolia, Astilbe biternata, Cystopteris protrusa, Thalictrum dioicum, Dioscorea villosa, Panax quinquefolius, Sanicula odorata, Podophyllum peltatum, Cryptotaenia canadensis, Lilium superbum, Veratrum parviflorum, Actaea podocarpa, Hepatica acutiloba, Athyrium asplenioides,* and *Arnoglossum reniforme*. Additional characteristic species, though less frequent in plots, include *Uvularia perfoliata, Ageratina altissima*, *Amphicarpaea bracteata, Allium tricoccum, Dryopteris goldieana, Galearis spectabilis, Persicaria virginiana, Phryma leptostachya, Thalictrum dioicum, Diplaziopsis pycnocarpa, Carex (Cymophilus) fraseriana, Carex plantaginea, Dicentra canadensis, Delphinium tricorne, Hydrophyllum macrophyllum, Aquilegia canadensis*, and several species of *Carex*. Many of these species that are less frequent in plot data are more frequently observed in surveys of whole stands. Compared to the Montane Intermediate Subtype, the greater number of species with high constancy in plots reflects the greater density and abundance of many species in stands.

Range and Abundance: Ranked G3G4, but probably appropriately G4. The overall abundance is somewhat uncertain because of difficulty and varying criteria used in distinguishing this subtype from others. Numerous occurrences are known, but the overall area of occurrence is much less than for the Montane Intermediate Subtype. The equivalent NVC association is attributed to Alabama, Georgia, Tennessee, and Virginia, as well as North Carolina. The association may be more broadly conceived than the subtype defined here.

Associations and Patterns: The Montane Rich Subtype generally occurs in small patches, occasionally large patches, corresponding to the distinctive underlying rock. It may grade to Montane Oak–Hickory Forest (Basic Subtype) on drier slopes and may contain embedded small patches of Montane Cliff (Mafic or Calcareous Subtype), Rich Montane Seep, or Rich Cove Forest (Boulderfield Subtype). The Montane Rich Subtype may sometimes grade to, or sharply border, the Montane Intermediate Subtype, and may occasionally grade to Northern Hardwood Forest (Rich Subtype) at higher elevations.

Variation: No variants are recognized, but further analysis may distinguish biogeographic or elevational variants analogous to those found by Ulrey (2002) for the Montane Intermediate Subtype.

Dynamics: The Montane Rich Subtype presumably has dynamics similar to the Mountain Cove Forest theme as a whole. As in the Montane Intermediate Subtype, the importance of dispersal limitation in Rich Cove Forests (Tessell 2017) may create some interesting dynamics, with herb layer composition changing in response to infrequent dispersal and metapopulation processes in a way different from many other communities.

Comments: Botanists have long highlighted sites with the Rich Subtype as unusually rich by several meanings of the term – in having long lists of species present on the site, having high abundance of species associated with rich soils, having a high potential for finding rare species, containing species absent even in less rich Rich Cove Forests, and, to use Ulrey's (2002) term, aesthetic lavishness. It is the presence of the most restricted "base-loving" species that is used to conceptually define the Rich Subtype here, but examples also differ in the quantitative abundance of many other species.

Nevertheless, the distinction between the Montane Rich and Montane Intermediate subtypes is subtle and somewhat confused. The majority of frequent and abundant species are shared among all Rich Cove Forest subtypes, though some tend to be more abundant in different subtypes. Though there is a substantial pool of species that distinguish the Montane Rich Subtype, many occur in only a minority of sites. Individual sites thus vary substantially in flora. The problem is magnified in plot data, because many of these species occur at low density or are patchy when they are present and may be missed in standard 1/10 hectare plots. Ulrey (2002) noted that most of the species suggested as indicative of the Rich Subtype at the time of his study were not found in any of the plots in his analysis. Nevertheless, those species can be found on whole-site species lists from the same locations, and the sites often were targeted for plot sampling on that basis. The plot studies have also generally been conducted in mid-summer and miss a substantial early spring flora.

It appears that different conceptual boundaries may have been used by different authors or that analysis of different sets of plots may have led to different impressions of which species are dominant or frequent. For example, Ulrey (2002) found *Liriodendron tulipifera, Carya cordiformis, Juglans nigra*, and *Ulmus rubra* to be characteristic species, present at high frequency in his rich grouping of plots and distinguishing it from other groups. Adding more recent CVS plot data attributed to this subtype suggests that all of these species but *Carya cordiformis* have low frequency in the Rich Subtype. The NVC description mentions only *Carya cordiformis* among these species, and Fleming and Patterson (2009) cited *Tilia* and *Aesculus* among the most diagnostic species. All of these analyses used large numbers of plots – numbers considered suitable for characterization of communities.

Rare species:
Vascular plants – *Aconitum reclinatum, Acer nigrum, Adlumia fungosa, Arabis patens, Cardamine clematitis, Carex careyana, Carex oligocarpa, Carex pedunculata* var. *pedunculata, Caulophyllum giganteum, Celastrus scandens, Corallorhiza maculata* var. *maculata, Diarrhena americana, Euphorbia purpurea, Frasera caroliniensis, Hackelia virginiana, Hydrastis canadensis, Jeffersonia diphylla, Lonicera canadensis, Meehania cordata, Micranthes caroliniana, Polygala senega, Primula meadia, Scutellaria saxatilis, Silene ovata, Stachys cordata, Synandra hispidula, Trillium discolor, Trillium simile, Viola appalachiensis,* and *Waldsteinia lobata.*

Nonvascular plants – *Brachythecium rotaeanum, Cirriphyllum piliferum, Cryphaea nervosa, Cyrto-hypnum pygmaeum, Encalypta procera, Entodon compressus, Entodon sullivantii, Leptodontium flexifolium, Rhabdoweisia crenulata, Sticta limbata, Taxiphyllum alternans,* and *Taxiphyllum cuspidifolium.*

Vertebrate animals – *Aneides aeneus* and *Plethodon yonahlossee pop. 1*.

Invertebrate animals – *Appalachina chilhoweensis, Celastrina nigra, Discus bryanti, Gastrocopta corticaria, Glyphyalinia junaluskana, Glyphyalinia pentadelphia, Nesticus sheari, Pallifera ohioensis, Papaipema astuta,* and *Papaipema cerina.*

RICH COVE FOREST (FOOTHILLS INTERMEDIATE SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees and herbs that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Foothills Intermediate Subtype covers examples in the foothills and periphery of the Blue Ridge, generally below 2000 feet, and lacking a significant component of high pH, rich-site flora. The herbaceous layer of this subtype is fairly diverse, much more diverse than that of Acidic Cove Forest, but is often not as dense or diverse as it is in the other subtypes.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. They are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, and *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest. Montane Alluvial Forest communities may share many species with Rich Cove Forests, but they can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Foothills Intermediate Subtype is distinguished from the Montane subtypes most easily by location and elevation. There are a few species largely confined to lower elevations, such as *Liquidambar styraciflua*, which distinguish the Foothills Subtype. Otherwise, it is distinguished by a generally lower diversity, with its flora being a subset of the characteristic species of the Montane Intermediate Subtype. The herb layer, though fairly diverse, is generally not dense as it is in the Montane Intermediate Subtype. The characteristic Rich Cove Forest herbs may be present only at low density. Species usually absent from the Foothills Intermediate Subtype include *Acer saccharum, Acer pensylvanicum, Impatiens pallida, Polygonatum pubescens, Clintonia umbellulata,* and *Maianthemum canadense.*

The Foothills Intermediate Subtype is distinguished from the Foothills Rich Subtype by the absence of strongly calciphilic species, such as *Aquilegia canadensis, Trillium simile, Asplenium rhizophyllum*, and *Cystopteris protrusa*. Some species shared by the Montane Intermediate and Foothills Rich subtypes, such as *Laportea canadensis*, are also absent or scarce.

Crosswalks: *Liriodendron tulipifera - Tilia americana* var. *heterophylla - (Aesculus flava) / Actaea racemosa* Forest (CEGL007291).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Foothills Intermediate Subtype can occur on any geologic substrate, though it rarely occurs over mafic rocks.

Soils: The Foothills Intermediate Subtype occurs on a wide variety of soils. Occurrences are most often mapped as Typic Hapludults (Fannin, Cowee, Evard, Brasstown, Junaluska, Rion, Pacolet, and others), while some are mapped as Typic Dystrudepts (Porters, Chestnut, Ashe) or Humic Dystrudepts (Tusquittee, Whiteoak). Soils are acidic but are presumed to be higher in pH, base saturation, and nutritive cations than those of Acidic Cove Forests and most drier forests, though lower than in the Foothills Rich Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering, low slope position, and flow convergence. Most examples of the Foothills Subtype are in areas with drier climate than most of the Mountain Region, apparently due to rain shadow effects.

Vegetation: The Foothills Intermediate Subtype forest is generally dominated by *Liriodendron tulipifera*, with a variety of other tree species abundant to scarce. *Fraxinus americana* and *Quercus rubra* are usually present. *Magnolia acuminata, Carya glabra, Prunus serotina, Carya cordiformis, Acer rubrum*, and even *Quercus montana* are frequent. *Tilia americana* var. *heterophylla* and *Aesculus flava* are frequent, but often sparse or only in the understory. *Fagus grandifolia* and *Magnolia acuminata* also often occur. The understory usually includes *Halesia tetraptera* and *Benthamidia* (*Cornus*) *florida*, as well as canopy species. The shrub layer is sparse to moderate. *Calycanthus floridus* and *Lindera benzoin* are usually present, and *Hydrangea arborescens* sometimes occurs. *Parthenocissus quinquefolius, Smilax rotundifolia*, and *Toxicodendron radicans* are usually present, along with small individuals of *Smilax glauca*. The herb layer is moderate to sparse in total cover and density. *Polystichum acrostichoides, Amauropelta* (*Parathelypteris*) *noveboracensis*, *Athyrium asplenioides, Eurybia divaricata*, or *Amphicarpaea bracteata* may dominate patches and be dense locally. Other high constancy species include *Actaea racemosa, Galium latifolium, Sanguinaria canadensis, Arisaema triphyllum, Botrypus virginianus, Dioscorea villosa, Maianthemum racemosum, Dichanthelium boscii, Endodeca serpentaria, Hylodesmum nudiflorum, Muhlenbergia tenuiflora, Phegopteris hexagonoptera, Prosartes lanuginosa, Tradescantia subaspera* and *Uvularia perfoliata*. Additional species frequent in plots and site descriptions include *Uvularia perfoliata, Adiantum pedatum, Caulophyllum thalictroides, Galium circaezans, Houstonia purpurea, Monarda clinopodia, Nabalus latissimus, Phryma leptostachya, Solidago curtisii, Stellaria pubera, Tiarella cordifolia, Trillium catesbaei, Viola canadensis, Viola sororia*, and *Galearis spectabilis*. Other characteristic species include *Arnoglossum reniforme, Circaea canadensis, Collinsonia canadensis, Galium triflorum, Iris cristata, Osmorhiza claytonia, Sanicula canadensis, Sanicula smallii*, and *Thalictrum dioicum*.

Range and Abundance: Ranked G4?, but perhaps better treated as G3G4 or even G3. In North Carolina, the Foothills Intermediate Subtype is uncommon, limited to the foothills ranges and a few low elevation valleys and gorges on the edges of the Blue Ridge itself. Rich Cove Forest occupies a much smaller part of the landscape in these areas than in the higher mountains. The equivalent association is attributed to South Carolina, Georgia, and uncertainly to Tennessee.

Because most of the acreage of low elevation fringe and foothills on the west and south are in other states, this association probably is more abundant outside of North Carolina.

Associations and Patterns: The Foothills Intermediate Subtype occurs as small to large patches. Patches generally are smaller than those of the Montane Intermediate Subtype, possibly because the drier low elevation conditions require more topographic sheltering to support it. Acidic Cove Forest also appears to also be more abundant in the foothills than Rich Cove Forest. Occurrences grade to various oak forests on drier slopes. They may grade to Acidic Cove Forest in other mesic areas. Small patches of Montane Cliff, Rich Montane Seep, or Low Elevation Seep may be embedded.

Variation: Two variants are recognized, based on the author's experience. Variation should also be sought between the eastern foothills and those occurrences on the west side of the Blue Ridge.

1. Typic Variant best fits the description above.

2. Acidic Transition Variant is less diverse and contains a smaller subset of characteristic Rich Cove Forest species. The canopy generally contains *Fraxinus americana, Magnolia acuminata,* or *Prunus serotina*, as well as species shared with Acidic Cove Forest, but it lacks most of the other characteristic species. The herb layer generally contains *Amphicarpaea bracteata, Brachyelytrum erectum, Phegopteris hexagonoptera, Dichanthelium boscii,* or *Ageratina altissima*, along with the species shared with Acidic Cove Forest, but lacks many other characteristic Rich Cove Forest species. This variant should only be recognized where it covers a significant area without being transitional between another variant and an adjacent community. It is scattered throughout the foothills but appears to be much less common than the Typic Variant. A comparable variant occurs in the Montane Intermediate Subtype.

Dynamics: Dynamics probably are similar to those of other Rich Cove Forests. Fire was more frequent at lower elevations, but, as in other cove forests, the sheltered moist sites where these communities occur presumably reduce fire effects.

Comments: The foothills have generally been less studied than the core of the Blue Ridge, at least in North Carolina. Ulrey (2002) did not include these lower elevation areas in his broad analysis of mesic forests. The NVC description notes that the equivalent association was first distinguished in analysis of plot data in the Chattooga River basin and lists several species that distinguish it from higher elevation cove forests.

The cause of the distinction between Acidic Cove Forest and Rich Cove Forest is not well known. Acidic Cove Forest predominates more in the foothills and Blue Ridge escarpment than in the higher mountains. Occurrences of Rich Cove Forest may partly depend on underlying rock type, even where the rock is not distinctive enough to support the Foothills Rich Subtype.

Rare species:
Vascular plants – *Adlumia fungosa, Botrychium angustisegmentum, Botrychium matricariifolium, Buckleya distichophylla, Collinsonia tuberosa, Collinsonia verticillata, Dicentra eximia, Gillenia*

stipulata, Monotropsis odorata, Sceptridium oneidense, Scutellaria saxatilis, Sisyrinchium dichotomum, Thermopsis fraxinifolia, Trillium discolor, and *Trillium simile.*
Nonvascular plants – *Brachythecium rotaeanum, Cryphaea nervosa, Cyrto-hypnum pygmaeum,* and *Entodon sullivantii*.

Vertebrate animals – *Aneides caryaensis* and *Plethodon yonahlossee pop. 1*.

Invertebrate animals – *Celastrina nigra* and *Stenotrema sp. 1*.

RICH COVE FOREST (FOOTHILLS RICH SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Foothills Rich Subtype covers examples in the foothills and periphery of the Blue Ridge, generally below 2000 feet, containing a significant component of flora of the richest, higher pH soils.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. They are distinguished from the Mesic Mixed Hardwood Forests and Basic Mesic Forests of the Piedmont by having a large component of montane flora; montane species may be present in Basic Mesic Forests, but generally only a few species at a given site and at low density. *Fagus grandifolia* is almost always a major component of the Piedmont communities, and *Tilia americana* var. *heterophylla, Aesculus flava, Magnolia acuminata, Betula alleghaniensis*, and *Betula lenta* are indicators of Rich Cove Forest. Montane Alluvial Forest communities may share many species with Rich Cove Forests, but can be distinguished by the presence of characteristic species of floodplains, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*. Montane Alluvial Forests also tend to have a different mix of species, often including more from a broad range of moisture tolerances.

The Foothills Rich Subtype is distinguished from the Foothills Intermediate Subtype by the presence of species associated with the highest pH, richest soils, such as *Asplenium rhizophyllum, Aquilegia canadensis, Cystopteris protrusa*, and *Trillium simile*. Some additional species common in both Montane subtypes are present in the Foothills Rich Subtype and absent or scarce in the Foothills Intermediate Subtype, including *Laportea canadensis, Asarum canadense*, and *Hydrophyllum canadense*. In addition, the Foothill Rich Subtype has greater abundance and local richness of most of the characteristic herbs of the Montane Intermediate Subtype.

The Foothills Rich Subtype is distinguished from the Montane subtypes most easily by location and elevation. Otherwise, it is distinguished by floristic differences. Its flora is a subset of the Montane Rich Subtype, generally less diverse. Most species generally absent from the Foothills Intermediate Subtype, *Acer saccharum, Acer pensylvanicum, Impatiens pallida, Polygonatum pubescens, Clintonia umbellulata,* and *Maianthemum canadense*, are also absent.

Crosswalks: *Tilia americana* var. *heterophylla - Fraxinus americana / Sanguinaria canadensis - (Aquilegia canadensis, Asplenium rhizophyllum)* Forest (CEGL007711).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Rich Cove Forests occur in sheltered mesic sites such as valley bottoms, ravines, lower slopes, and concave slopes. The Foothills Rich Subtype occurs on rocks such as amphibolite, hornblende gneiss, calc-silicate, dolomite, marble, or calcite-cemented siltstone that produce less acid, more fertile soils than typical. Most examples occur below 2000 feet elevation.

Soils: The Foothills Rich Subtype occurs on the same range of soil map units as the Foothills Intermediate Subtype. The Inceptisols are not classified by the chemical differences that distinguish the community subtypes, but it may be that some soils mapped as Ultisols are unrecognized Alfisols. The soils in the Montane Rich Subtype are acidic, but where tested, have been found to have higher pH, higher base saturation, and higher levels of nutritive cations than those in the Montane Intermediate Subtype.

Hydrology: Sites are well-drained but mesic due to topographic sheltering, low slope position, and flow convergence on concave slopes. Most examples of the Foothills Subtype are in areas with drier climate than most of the Mountain Region. The more clay-rich soils derived from mafic rocks may have higher moisture-holding capacity than those of the Foothills Intermediate Subtype.

Vegetation: The Foothills Rich Subtype canopy is generally dominated by *Liriodendron tulipifera*. In CVS plots, *Carya cordiformis* is uniformly present, and *Quercus rubra, Fraxinus americana, Carya glabra, Acer rubrum, Betula lenta, Prunus serotina, Robinia pseudo-acacia, Juglans nigra*, and *Ulmus rubra* occur in more than half of the plots. *Aesculus flava* and *Tilia americana* var. *heterophylla* are frequent in plots and are more constant in whole-site descriptions. Besides canopy species, the understory contains *Benthamidia* (*Cornus*) *florida* and *Halesia tetraptera* with high constancy, and frequently contains *Magnolia fraseri, Asimina triloba*, and *Carpinus caroliniana*. The shrub layer is open to sparse. *Lindera benzoin* occurs with high constancy and *Calycanthus floridus, Swida* (*Cornus*) *alternifolia, Sambucus canadensis*, *Hamamelis virginiana*, and *Philadelphus inodorus* are frequent. The herb layer is diverse and generally fairly dense. Species occurring in more than half the CVS plots are *Collinsonia canadensis, Sanguinaria canadensis, Prosartes lanuginosa, Polystichum acrostichoides, Arisaema triphyllum, Eurybia divaricata, Actaea racemosa, Maianthemum racemosum, Laportea canadensis, Caulophyllum thalictroides, Adiantum pedatum, Botrypus virginianus, Cryptotaenia canadensis, Dioscorea villosa, Ranunculus recurvatus, Solidago curtisii, Deparia acrostichoides, Stellaria pubera, Viola canadensis, Hydrophyllum canadense, Sanicula odorata, Ageratina altissima, Astilbe biternata, Galium circaezans, Osmorhiza claytonia, Persicaria virginiana, Phryma leptostachya,* and *Sanicula canadensis*. Other frequent species in CVS plot data include *Amphicarpaea bracteata, Cystopteris protrusa, Tiarella cordifolia, Hepatica acutiloba, Dryopteris marginalis, Lysimachia quadrifolia, Panax quinquefolius, Phacelia bipinnatifida, Podophyllum peltatum, Polygonatum biflorum, Tradescantia subaspera, Boechera laevigata, Asarum canadense*, and *Phegopteris hexagonoptera*. Less frequent but characteristic species include *Carex austro-caroliniana, Carex plantaginea, Actaea pachypoda, Symphyotrichum cordifolium, Asplenium rhizophyllum, Cubelium concolor, Hylodesmum glutinosum¸ Iris cristata, Trillium simile,* and *Aquilegia canadensis*. As in the Montane Rich Subtype, many of these distinctive characteristic species for this subtype occur at low density in stands and appear in few or no plots. Compared to the Foothills Intermediate Subtype, the number of species with high constancy in plots reflects the greater density and cover of these species within stands, but it also may reflect a smaller number of plots.

Range and Abundance: Ranked G2G3. In North Carolina, clusters of examples occur where mafic rocks are most abundant – in the Blue Ridge escarpment from Hickorynut Gorge to the Tryon Peak area, and in parts of the South Mountains, with examples sparsely scattered over the rest of the foothills and the western periphery of the Blue Ridge. The equivalent association also occurs in Georgia, South Carolina, and possibly Tennessee.

Associations and Patterns: The Foothills Rich Subtype occurs as small to large patches. Patches generally are smaller than those of the Montane subtypes, possibly because the drier low elevation conditions require more topographic sheltering to support it. Acidic Cove Forest appears to also be more abundant in the foothills than either Rich Cove Forest subtype. Occurrences grade to oak forests on drier slopes, generally to Montane Oak–Hickory Forest (Basic Subtype) if the underlying geology does not change. Small patches of Montane Cliff (Basic Subtype) or, rarely, Rich Montane Seep or Rich Cove Forest (Boulderfield Subtype) may be embedded.

Variation: No variants are recognized, but further analysis may distinguish biogeographic variants or variants for different degrees of richness.

Dynamics: Dynamics probably are similar to those of other Rich Cove Forests. Fire was more frequent at lower elevations, but as in other cove forests, the sheltered moist sites where these communities occur reduce fire effects.

Comments: The foothills have generally been less studied than the core of the Blue Ridge, at least in North Carolina. Ulrey (2002) did not include these lower elevation areas in his broad analysis of mesic forests. The NVC description notes that the broad scale regional analyses done for the Appalachian Trail corridor (Fleming and Patterson 2009), found only a handful of plots fitting the equivalent association. The CVS plot data used as the primary source for description of the vegetation are also limited, and the characterizations of species as highly constant, frequent, or less frequent may not be quite the same as the more numerous site-specific descriptions.

Rare species:
Vascular plants – *Cardamine dissecta, Carex pedunculata* var. *pedunculata, Carex radfordii, Collinsonia verticillata, Gillenia stipulata, Jeffersonia diphylla, Meehania cordata, Sceptridium jenmanii, Sisyrinchium dichotomum, Trillium discolor, Trillium simile.*

Nonvascular plants – *Brachythecium rotaeanum, Cryphaea nervosa, Cyrto-hypnum pygmaeum,* and *Entodon sullivantii.*

Vertebrate animals – *Aneides caryaensis* and *Plethodon yonahlossee pop. 1*.

Invertebrate animals – *Celastrina nigra*.

RICH COVE FOREST (RED OAK SUBTYPE)

Concept: Rich Cove Forests are low to mid elevation mesophytic mountain and foothill forests with a diverse mix of trees and herbs that includes species of richer soils such as *Fraxinus americana, Tilia americana* var. *heterophylla, Magnolia acuminata, Prunus serotina,* and *Aesculus flava*, along with more widely tolerant mesophytic species. The Red Oak Subtype covers uncommon forests of intermediate-elevation, steep, rocky upper coves, where *Quercus rubra* weakly dominates the canopy but the composition is otherwise similar to Rich Cove Forest. While the composition is intermediate between typical Rich Cove Forest and oak forests, these communities are tied to specialized rocky sites rather than simply being ecotonal communities.

Distinguishing Features: Rich Cove Forests are distinguished by having a diverse mix of mesophytic trees and a diverse mix of herbs, both of which include species of richer soils. The Red Oak Subtype has much in common with High Elevation Red Oak Forest (Rich Subtype) and Montane Oak–Hickory Forest (Basic Subtype). It is distinguished by occurring in more concave and sheltered sites (though more exposed than most Rich Cove Forests), in having only marginal dominance by *Quercus rubra* with more Rich Cove Forest trees, and by overall differences in dominant vegetation. The floristic distinctions need further clarification, but they appear to be real. While *Fraxinus americana*, *Acer saccharum*, and other species of Rich Cove Forests occur in the richer oak forest communities, Rich Cove Forest (Red Oak Subtype) is most often codominated by *Liriodendron tulipifera* or *Tilia americana* var. *heterophylla* and has a greater diversity of mesophytic hardwoods. The other strata show similar differences. The basic/rich oak forests share a number of herb species with Rich Cove Forest, but they lack many others, and the herb layer is more often dominated by *Solidago, Tradescantia*, or other species of drier sites. *Tilia americana* var. *heterophylla, Carya cordiformis, Astilbe biternata, Osmorhiza* spp., *Monarda didyma, Thalictrum clavatum*, and *Arnoglossum muehlenbergii* are some species characteristic of this subtype that are not typical of the rich oak forest communities.

The Red Oak Subtype is distinguished from other Rich Cove Forest subtypes by the abundance of *Quercus rubra* (though it is widespread and may be locally abundant in other subtypes), by occurrence in higher concave topography, by less diverse composition than the Montane Intermediate or Montane Rich Subtype, and by a less dense herb layer than in those subtypes. As in the Foothills subtypes, the herb layer is fairly diverse but cover is often sparse. The Boulderfield Subtype may occur in similar topographic settings but has near complete boulder cover and, though often rich in *Tilia*, has limited *Quercus rubra*.

Crosswalks: *Quercus rubra - Tilia americana* var. *heterophylla - (Halesia tetraptera var. monticola) / Collinsonia canadensis - Prosartes lanuginosa* Forest (CEGL007878).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: The Red Oak Subtype occurs on steep mid slopes at the heads of coves, generally with high cover of rock but not well-developed boulderfields. Most examples are at 3000-4000 feet, but they may occur somewhat lower or higher.

Soils: The Red Oak Subtype probably generally occurs as inclusions within soil map units. As with other Rich Cove Forests, soils are higher in pH, base saturation, and nutritive cation levels than most mountain communities. Within the range of Rich Cove Forests, Ulrey (2002) found them, on average, intermediate in these factors between the Montane Rich and Montane Intermediate Subtype but not statistically different from the latter.

Hydrology: Sites are well drained but are mesic due to topographic sheltering and flow convergence on concave slopes. With their higher topographic position, they probably are somewhat drier than other Rich Cove Forests at similar elevations.

Vegetation: The Red Oak Subtype canopy is dominated by *Quercus rubra,* in combination with *Tilia americana* var. *heterophylla, Liriodendron tulipifera*, *Betula lenta*, and *Acer rubrum*. In Ulrey (2002), the latter three species are the most abundant associates, while those seen by the author have been codominated by *Tilia*. Other frequent canopy species reported include *Acer saccharum, Carya glabra, Halesia tetraptera, Fraxinus americana, Magnolia acuminata, Tsuga canadensis, Prunus serotina, Robinia pseudo-acacia*, and *Aesculus flava*. The NVC notes that *Halesia* can be an important part of the canopy in the Great Smoky Mountains. The understory frequently includes *Acer pensylvanicum, Castanea dentata, Swida* (*Cornus*) *alternifolia*, and *Magnolia fraseri*, as well as canopy species. The shrub layer is low in density, with no species very constant. Frequent species include *Hamamelis virginiana, Hydrangea arborescens*, and *Rhododendron maximum*. The herb layer is moderate to low in density and is only moderately diverse. Widespread species such as *Amauropelta* (*Parathelypteris*) *noveboracensis, Polystichum acrostichoides*, and *Viola* spp. tend to dominate, but a variety of characteristic Rich Cove Forest species are present. Frequent species reported by Ulrey (2002) include *Arisaema triphyllum, Athyrium asplenioides, Prosartes lanuginosa, Botrypus virginianus, Maianthemum racemosum, Laportea canadensis, Medeola virginiana, Polygonatum biflorum, Dioscorea villosa, Nabalus* sp., *Caulophyllum thalictroides, Amphicarpaea bracteata, Eurybia divaricata, Collinsonia canadensis, Actaea racemosa, Sanguinaria canadensis, Solidago curtisii, Stellaria pubera, Goodyera pubescens, Galium triflorum, Ageratina altissima, Dryopteris marginalis*, and *Eupatorium purpureum.*

Range and Abundance: Ranked G3?, but perhaps G2. This subtype appears to be largely confined to the western part of the Mountain region south of Asheville, though it is not clear why this should be so. The overall abundance is confused by differing concepts and limited inventory, but it appears to be truly rare and tied to a very specialized habitat. The equivalent association also occurs in Tennessee and perhaps in Georgia.

Associations and Patterns: The Red Oak Subtype occurs as small patches. It may grade to other Rich Cove Forest subtypes in lower coves or on more concave slopes. It grades to various oak forests on drier slopes.

Variation: No recognized pattern of variation is known.

Dynamics: Dynamics presumably are similar to cove forests in general, but the location higher on slopes may lead to more frequent penetration by fire. However, the frequent abundance of rock may reduce fire spread and intensity.

Comments: The concept and circumscription of this subtype need further clarification, as does its distribution and abundance. It is accepted somewhat provisionally here, as a narrowly circumscribed community of specialized topographic sites. It should be applied where it represents a distinct patch of at least several acres, in a concave upper cove setting. It is not useful for conservation purposes to apply it either to groves of oak within the normal variation of cove forests or to narrow transition zones between typical cove forest and oak forest. The author has observed a few distinctive, well developed community patches, but further clarification is needed on whether other areas are similarly well developed. The number of plots attributed to the equivalent association, by Ulrey (2002), Fleming and Patterson (2009), and in the CVS database, is substantially larger than the number of sites that have been otherwise identified as this community, the reverse of the situation for most communities. It is unclear if this is because many well-developed occurrences have been overlooked or if many plots do not represent significant sized patches.

A red oak grouping was recognized in analysis by Ulrey (2002) and something like it was recognized by Fleming and Patterson (2009) in their analysis of Appalachian Trail corridor data. It was also recognized in analysis of plot data in the Great Smoky Mountains. In all cases, despite the abundance of oak, plots grouped more closely with cove forests than with oak forests.

Rare species: No rare species are specifically known to be associated with this community.

RICH COVE FOREST (BOULDERFIELD SUBTYPE)

Concept: Rich Cove Forest (Boulderfield Subtype) communities are forests of well-developed boulderfields, comparable to High Elevation Birch Boulderfield Forests, but occurring at lower elevations and having a more diverse canopy dominated by species of Rich Cove Forests in combination with *Betula alleghaniensis*.

Distinguishing Features: The Boulderfield Subtype of Rich Cove Forest, like the High Elevation Birch Boulderfield Forest community, is distinguished by occurring on well-developed boulderfields, with near complete cover by large rocks, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower strata substantially influenced by the rock cover. The Rich Cove Forest subtype is distinguished by lower elevation and a richer flora, which overall is very similar to other Rich Cove Forest subtypes. *Betula alleghaniensis* often is the most abundant tree in both, but the Boulderfield Subtype of Rich Cove Forest also contains significant numbers of other species, especially *Tilia americana* var. *heterophylla* or *Aesculus flava*. Several species of herbs characteristic of Rich Cove Forests are also present, though usually sparsely. Vine cover often is high. High Elevation Birch Boulderfield Forests generally occur at higher elevations; however, the Boulderfield Subtype can occur at higher elevations than other Rich Cove Forest subtypes and may be bordered by Northern Hardwood Forest on adjacent exposed slopes.

The Boulderfield Subtype of Rich Cove Forest is distinguished from the Boulderfield subtypes of Chestnut Oak Forest and Montane Oak—Hickory Forest by having canopy dominance or codominance by mesophytic species; oaks, particularly *Quercus rubra*, may be present but form a minority of the canopy.

This subtype should be used only for well-developed boulderfields. Many Rich Cove Forests of all subtypes occur on colluvial soils with abundant boulders, but most do not have enough boulder cover to affect community composition.

Crosswalks: *Betula alleghaniensis - Tilia americana* var. *heterophylla / Acer spicatum / Ribes cynosbati / Dryopteris marginalis* Forest (CEGL004982).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Rich Cove Forest (Boulderfield Subtype) occurs on coarse colluvial deposits. Large rocks cover virtually the entire ground surface and are piled on top of each other so that there is a substantial amount of void space beneath them. Boulderfields may be relict Pleistocene periglacial features on concave north-facing slopes, or they may be talus on steep slopes below rock outcrops. Most examples occur at 2500-4500 feet, but a few occur at substantially higher or lower altitudes.

Soils: Soil consists of accumulations of organic matter on and among the boulders (Lithic Dystrochrepts), but patches are generally small and are inclusions in soil map units.

Hydrology: Conditions are generally mesic due to topographic sheltering, but moisture may vary drastically at very fine scale. Shallow soil pockets maybe become dry very quickly. Some boulderfields have seepage that creates moist conditions locally. In some, water may be heard flowing rapidly beneath the rocks, and some of this may be accessible to plant roots.

Vegetation: The Boulderfield Subtype canopy may be closed or somewhat open. It is generally dominated by varying combinations of *Betula alleghaniensis, Tilia americana* var. *heterophylla*, *Aesculus flava*, and *Betula lenta*. Other species of Rich Cove Forests may be present, usually in much smaller numbers but occasionally abundant, including *Acer saccharum, Fraxinus americana, Tsuga canadensis, Fagus grandifolia, Halesia tetraptera, Quercus rubra,* and *Liriodendron tulipifera*. The understory generally is dominated by *Acer pensylvanicum* or *Acer spicatum*. Shrubs are often sparse, but *Hydrangea arborescens, Ribes cynosbati*, *Euonymus obovatus*, or rarely other species may have substantial cover. Vines, most often *Isotrema macrophyllum* or *Parthenocissus quinquefolia*, often have significant cover. The herb layer often includes substantial cover of *Dryopteris intermedia, Dryopteris marginalis, Polypodium appalachianum*, *Heuchera villosa*, *Cystopteris protrusa*, or other species that can root on rocks, as well as substantial bryophyte cover. Where there is seepage through the rocks but near the surface, patches may be dominated by dense *Laportea canadensis*, *Impatiens pallida*, or *Impatiens capensis*. Usually several other species typical of Rich Cove Forests are present with low cover. Frequent species include *Polystichum acrostichoides, Arisaema triphyllum, Actaea racemosa, Tiarella cordifolia, Galium triflorum, Prosartes lanuginosa, Solidago curtisii, Trillium erectum, Eurybia chlorolepis, Caulophyllum thalictroides, Stellaria pubera, Veratrum parviflorum, Allium tricoccum*, *Clintonia umbellulata, Collinsonia canadensis*, and *Osmorhiza claytonia*.

Range and Abundance: Ranked G2G3. The Boulderfield Subtype is scattered throughout the Mountain region, but only very rarely in the foothills. The equivalent association also occurs in Georgia, Tennessee, and possibly Virginia and Kentucky.

Associations and Patterns: The Boulderfield Subtype occurs as small patches, often associated with other subtypes of Rich Cove Forest. Higher elevation examples may be surrounded by Northern Hardwood Forest. Examples often grade to oak forests on adjacent slopes. A few examples may have cliffs or other rock outcrops at their upper end.

Variation: This subtype is not divided by elevation into montane and foothills groups and indeed can extend up to elevations more typical of Northern Hardwood Forest. Division by elevation may prove warranted in the future, but it appears that the extreme environment of boulderfields overrides elevational effects in this subtype. Other variations, such as an odd example in Madison County dominated by *Tsuga canadensis* but otherwise rich, may warrant recognition as variants.

Dynamics: While stand dynamics presumably are similar to other cove forests, canopy gaps last longer because of the difficulty of tree establishment. Chafin and Jones (1989) found windthrow to be more common and canopy gaps more abundant in Boulderfield Forests than in nearby Rich Cove Forests. The ability of *Betula alleghaniensi*s to germinate and establish on top of logs and rocks, with its roots wrapping around these features and continuing downward until they reach soil, allows it to dominate in this unique environment. It is not clear what aspect of the lower elevation makes it possible for other tree species to be more abundant than they are in the High Elevation Birch Boulderfield Forest. The greater dryness of lower elevation might be expected to make establishment of seedings on rocks more difficult. It may be that periglacial processes were less intense at lower elevations or that chemical weathering is more intense, either possibility leading to more soil being associated with the rocks.

Comments: The Boulderfield Subtype appears to be less distinct from typical Rich Cove Forests than the High Elevation Birch Boulderfield Forest type is from Northern Hardwood Forests; thus it is treated as a subtype rather than as a full type. Though it has affinities with both Rich Cove Forests and High Elevation Birch Boulderfield Forest, its flora is closer to the former. The group placement of the NVC association is in conflict with this interpretation.

Rare species:
Vascular plants – *Aconitum reclinatum, Cardamine clematitis, Caulophyllum giganteum, Geum geniculatum, Lilium grayi, Lonicera canadensis, Meehania cordata, Scutellaria ovata* var. *rugosa*, and *Scutellaria saxatilis.*

Nonvascular plants – *Lejeunea blomquistii*.

Vertebrate animals – *Aneides aeneus, Aneides caryaensis, Plethodon ventralis. Plethodon yonahlossee pop. 1,* and *Sorex dispar blitchi.*

Invertebrate animals – *Discus bryanti* and *Nesticus nasicus*.

ACIDIC COVE FOREST (TYPIC SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees, primarily *Liriodendron tulipifera, Betula lenta, Tsuga canadensis, Acer rubrum*, *Halesia tetraptera*, and sometimes *Betula alleghaniensis,* with acid-tolerant undergrowth lacking most of the species typical of Rich Cove Forests. The Typic Subtype covers the common examples in most of the Blue Ridge of North Carolina, where neither *Halesia tetraptera* nor *Betula alleghaniensis* is codominant or dominant.

Distinguishing Features: Acidic Cove Forests are distinguished from the closely related Canada Hemlock Forest type by having a mixed canopy in which *Tsuga canadensis* may be present but does not dominate. They are distinguished from Rich Cove Forests by the absence or near absence of plants that require richer or less acidic soils. Trees such as *Aesculus flava, Tilia americana* var. *heterophylla, Acer saccharum*, *Fraxinus americana*, *Magnolia acuminata*, and *Prunus serotina* are present only as stray individuals, if at all. Likewise, herbs of rich soils, such as *Actaea racemosa, Caulophyllum thalictroides, Actaea pachypoda*, and *Adiantum pedatum* are absent or nearly so. All species of Acidic Cove Forests also occur in Rich Forests, though generally not as abundantly. Acidic Cove Forests are distinguished from Northern Hardwood Forests by the presence of low elevation species such as *Liriodendron tulipifera, Betula lenta*, *Rhododendron maximum*, and generally by a less well developed and less diverse herb layer.

Acidic Cove Forests share many canopy, understory, and shrub species with Montane Alluvial Forest and Swamp Forest–Bog Complex. They are distinguished from the latter by lacking boggy openings with *Sphagnum* and lacking appreciable numbers of wetland species such as *Osmundastrum cinnamomeum*. They are distinguished from Montane Alluvial Forest by lacking alluvial species such as *Platanus occidentalis* and *Carpinus caroliniana*. The distinction from Montane Alluvial Forest (Small River Subtype) may be subtle, as both may occur on flats along streams, and characteristic alluvial species may be present only as minority components. Acidic Cove Forests usually have some oaks present in the canopy but are distinguished from oak forests by not having these species dominant.

The Typic Subtype is distinguished from the Silverbell Subtype by having *Halesia tetraptera* only in limited numbers, not codominant in the canopy. It is distinguished from the High Elevation Subtype by elevation and by having a canopy with a mix of species that does not include *Betula alleghaniensis* as dominant or codominant.

Crosswalks: *Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest (CEGL007543).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Acidic Cove Forests occur in sheltered, mesic, low to mid elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves. Local slopes may be concave or convex. Most examples are at 4000 feet or lower, but a few range higher. A few disjunct Piedmont occurrences are below 1000 feet.

Soils: Acidic Cove Forests occur on a wide range of typical mountain soils, most often Typic Dystrudepts (Ashe, Chestnut, Edneyville, Greenlee) or Typic Hapludults (Cowee, Evard, Tate), sometimes Lithic Dystrudepts (Cleveland), Typic Humadepts (Cullasaja), or other types. Soils are generally very acidic and low in base saturation and in levels of nutritive cations.

Hydrology: Sites are well-drained but mesic due to topographic sheltering and low slope position.

Vegetation: Acidic Cove Forest (Typic Subtype) is dominated by a varying mix of mesophytic plants tolerant of acidic conditions. Highly constant species in CVS plot data are *Betula lenta, Liriodendron tulipifera, Quercus rubra,* and *Acer rubrum*, and *Quercus montana*. Also frequent are *Halesia tetraptera, Pinus strobus, Carya glabra, Fagus grandifolia*, and *Quercus alba*. *Tsuga canadensis* has high constancy and often is in the canopy but more often has high cover in the understory. Other high constancy or frequent understory species in addition to canopy species are *Magnolia fraseri, Oxydendrum arboreum, Acer pensylvanicum, Nyssa sylvatica, Benthamidia* (*Cornus*) *florida*, and *Ilex opaca*. The shrub layer usually is dense, with *Rhododendron maximum* strongly dominant. Less often, *Leucothoe fontanesiana* forms a dense shorter thicket, or shrubs are sparse. Other frequent shrubs include *Kalmia latifolia, Hamamelis virginiana*, and *Euonymus americana*. *Smilax rotundifolia, Smilax glauca*, and *Parthenocissus quinquefolius* also are frequent and occasionally form tangles. The herb layer is sparse beneath dense shrub cover and consists primarily of scattered individuals of the most acid-tolerant species, such as *Galax urceolata, Goodyera pubescens, Chimaphila maculata*, *Mitchella repens*, and *Viola hastata*. Where shrub cover is less dense, extensive cover of *Polystichum acrostichoides, Amauropelta* (*Parathelypteris*) *noveboracensis, Athyrium asplenioides*, or *Eurybia divaricata* may be present. Other frequent herbs in CVS plot data are *Arisaema triphyllum* and *Medeola virginica*. Small numbers of plants shared with Rich Cove Forest may be present locally.

Range and Abundance: Ranked G5. The Typic Subtype is widespread throughout the Mountain region and foothills. The equivalent association also occurs in South Carolina, Georgia, Tennessee, Virginia, and in West Virginia.

Associations and Patterns: Acidic Cove Forest (Typic Subtype) is one of the communities making up the typical landscape mosaic in most low to mid elevation areas. It generally grades into Chestnut Oak Forest, Montane Oak–Hickory Forest, or other Mountain Oak Forests uphill and in drier settings. It may grade to Rich Cove Forest downhill or on more concave slopes, though more often the two are in separate coves and not adjacent. Sometimes Acidic Cove Forest is on spur ridges within larger coves filled with Rich Cove Forest. In other places, it may be on slopes of sharp ravines, with Rich Cove Forest on gentler and more concave slopes uphill of it. If variable geology is present, Acidic Cove Forest may also transition abruptly to Rich Cove Forest on less acidic substrates with similar topography. Acidic Cove Forest may also be associated with Canada Hemlock Forest. Less frequently, it may be associated with Swamp Forest—Bog Complex, Southern Appalachian Bog, Montane Alluvial Forest, or small patches of rock outcrop or seep communities.

Variation: Distinct variation is recognizable in the dominants of the lower strata. Three variants are defined based on lower strata. A fourth variant is recognized based on a division described by Ulrey (2002), and a fifth is recognized to parallel units accepted for related communities.

1. Rhododendron Variant has a dense shrub layer dominated by *Rhododendron maximum*. This is the most common and widespread variant.

2. Dog Hobble Variant has a dense shrub layer dominated by *Leucothoe fontanesiana*. It is uncommon in many parts of the region but is fairly common in parts of the northern Blue Ridge escarpment and crest and appears to be widespread in the Great Smoky Mountains. This variant often occurs on flatter valley bottoms.

3. Herb Variant has limited shrub cover and usually has a well-developed herb layer, most often dominated by ferns. It usually occurs on flatter valley bottoms. Widely scattered throughout the range of Acidic Cove Forest, it is less common than the Rhododendron Variant.

4. Submesic Variant has more oak present, somewhat less *Rhododendron maximum*, and more of several understory and shrub species such as *Ilex opaca* and *Gaylussacia ursina*. This variant was found distinct in Ulrey's (2002) regionwide analysis of Acidic Cove Forest plot data, at a level comparable to the Silverbell and High Elevation subtypes. It appears to be transitional to drier oak communities, but it is unclear if it occurs as extensive patches or only as a narrow ecotonal zone. It is recognized as a variant rather than a subtype until its ecological significance can be clarified. Its plots were lower in elevation on average. Given the wide elevational range of Acidic Cove Forests, it should be investigated as a possible lower elevation subtype.

5. White Pine Variant contains appreciable amounts of *Pinus strobus* in the canopy. This variant is parallel to the White Pine Subtype recognized for Canada Hemlock Forest. Investigation is needed into whether it is distinctive enough to recognize as a subtype.

Dynamics: Most of the dynamics of Acidic Cove Forests likely are similar to those of Rich Cove Forests, including natural occurrence primarily as old-growth multi-aged forests, tree regeneration primarily in small canopy gaps, and limited influence of fire. As with Rich Cove Forests, the widespread and fairly frequent occurrence of fire in oak forests implies an ability of fire to cross the Acidic Cove Forest bands that often dissect them, but the low intensity of fire in these locations probably limits its ecological effects. However, if more intense fire occurs, it may be a significant natural disturbance. *Rhododendron maximum* is easily top-killed by fire and is slow to sprout. The mesophytic tree species also are not adapted to surviving appreciable fire, though their ability to sprout would limit the likelihood that infrequent more severe fires would change the forest composition.

Carter, et al. (2000) described successional patterns in the high rainfall southern escarpment area, including in mid elevation mesic sites that appear to be Acidic Cove Forest (Typic Subtype). They described early successional sites dominated by *Liriodendron tulipifera, Robinia pseudo-acacia*, and *Quercus rubra*; mid successional sites dominated by *Quercus alba, Nyssa sylvatica*, and *Robinia pseudo-acacia*, and later successional sites by *Quercus rubra*, *Tsuga canadensis*, and *Betula lenta*. It is not clear how general this pattern is, even in that region. Some other biologists regard *Betula lenta* as an early successional species. But mature stands with abundant *Liriodendron* can be readily observed, and *Betula lenta* can be observed to be abundant in combination with all of these species in both young and old stands.

Comments: The name Acidic Cove Forest apparently was new with the First Approximation. Earlier literature referred simply to cove forests or mixed mesophytic forests and appears to have meant either both Rich and Acidic Cove Forest or only Rich Cove Forest (e.g. Cooper and Hardin 1970, Dumond 1969). Something recognizable as Acidic Cove Forest is described by Wentworth (1980), who noted the absence of more typical Rich Cove Forest species in the mesophytic forests of the Thompson River gorge, and by Callaway, et al. (1987) in the western Great Smoky Mountains. Whittaker (1956) described only a rich cove forest and a hemlock forest. However, he described the hemlock forests of the Smokies as merging with cove forests below 2500 feet and becoming mixed with hardwoods. Given the abundance of both kinds of communities and the striking difference in appearance, diversity, and composition in all strata, the lack of early recognition is surprising. McLeod (1988) distinguished cove forests with hemlock and oaks from those without, as well as recognizing a hemlock forest. Other literature that used Whittaker (1956) as a primary reference tended to name communities as hemlock forests even when they appear to be mixed forests more like Acidic Cove Forests. Later studies are much more likely to recognize something analogous to Acidic Cove Forest. Newell (1997) had such communities in all three of her study areas (Linville Gorge, Shining Rock Wilderness, and Joyce Kilmer-Slickrock Wilderness).

Ulrey (2002) focused analysis on the distinction between Acidic Cove Forest and Rich Cove Forest, using plot data from across the North Carolina mountains and adjacent areas. He also analyzed variation within Acidic Cove Forest, and his work, along with Newell (1997), is the basis for the three subtypes. He showed significant correlations of vegetation with elevation and soil richness even within the narrow range of conditions represented by Acidic Cove Forests.

The relationship of Acidic Cove Forest to Canada Hemlock Forest may benefit from further investigation, though this may be difficult after the widespread recent hemlock mortality. In North Carolina, Canada Hemlock Forest and Acidic Cove Forest appear to occupy very similar sites. Whittaker (1956) emphasized the strong effect of *Tsuga canadensis* dominance, acting as what would now be called a keystone role, modifying the environment with its heavy shade and acidic litter. He believed the species itself excluded many species of his (rich) cove forest. However, such effects would present less contrast with typical Acidic Cove Forest, where moderate amounts of *Tsuga canadensis* may be present and where *Rhododendron maximum* similarly produces dense shade and acidic litter even without *Tsuga*. The two communities share most of their species and may differ only in dominance. *Tsuga* appears to dominate larger areas in the Great Smoky Mountains than elsewhere, though it is also abundant on the Highlands Plateau and is present as a minority species in forests throughout the region.

Tsuga is often regarded as a later successional tree in the north, coming to dominate only after years free of disturbance. A similar impression can be gotten in North Carolina from the dense *Tsuga* understory that develops in some hardwood communities. However, in North Carolina, mixed Acidic Cove Forests are more abundant than Canada Hemlock Forest even in virgin forest areas. The two community types appear similar enough that it may be as appropriate to treat Canada Hemlock Forest as a subtype of Acidic Cove Forest.

Acer rubrum - Betula (alleghaniensis, lenta) - Magnolia fraseri / (Rhododendron maximum, Kalmia latifolia) Forest (CEGL008558) is an association that appears to represent heavily disturbed versions of all three subtypes of Acidic Cove Forest.

Rare species:
Vascular plants – *Adlumia fungosa, Buckleya distichophylla, Cardamine rotundifolia, Corallorhiza maculata* var. *maculata, Dactylorhiza viridis, Dicentra eximia, Dendrolycopodium hickeyi, Didymoglossum* (*Trichomanes*) *petersii, Geum geniculatum, Hexastylis contracta, Hexastylis naniflora, Hexastylis rhombiformis, Hexastylis rosei, Hymenophyllum tayloriae, Liparis loeselii, Lysimachia fraseri, Meehania cordata, Shortia brevistyla, Shortia galacifolia, Smilax hugeri, Stewartia ovata, Trientalis* (*Lysimachia*) *borealis,* and *Vandenboschia boschiana.*

Nonvascular plants – *Brachythecium rotaeanum, Bryocrumia vivicolor, Bryoxiphium norvegicum, Cirriphyllum piliferum, Cryphaea nervosa, Drepanolejeunea appalachiana, Entodon sullivantii, Herzogiella turfacea, Lejeunea blomquistii, Leptostomopsis (Brachymenium) systylia, Lophocolea muricata, Macrocoma sullivantii, Neckera complanata, Pilosium chlorophyllum, Plagiochila austinii, Plagiochila caduciloba, Plagiochila echinata, Plagiochila raddiana, Plagiochila virginica var. caroliniana, Plagiomnium* (*Mnium*) *carolinianum, Pohlia lescuriana, Racomitrium aciculare, Radula sullivantii, Rhabdoweisia crenulata, Rosulabryum andersonii, Scopelophila cataractae,* and *Schlotheimia lancifolia*.

Vertebrate animals – *Aneides aeneus, Aneides caryaensis,* and *Plethodon yonahlossee pop. 1*.

ACIDIC COVE FOREST (HIGH ELEVATION SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees. The High Elevation Subtype occurs at the higher elevations of the range and has *Betula alleghaniensis* as an important component. This subtype extends up into the elevational range of Northern Hardwood Forest and is intermediate between them and Acidic Cove Forest.

Distinguishing Features: The High Elevation Subtype is distinguished from other subtypes by the significant presence of *Betula alleghaniensis* in the canopy. Though it occurs at higher elevations on average, it may occur as low as 3000 feet, occasionally lower, and thus substantially overlaps in elevation with the Typic Subtype as well as the Silverbell Subtype. The High Elevation Subtype is distinguished from Northern Hardwood Forest and High Elevation Birch Boulderfield Forest, which also may be dominated by *Betula alleghaniensis*, by having a shrub layer dominated by *Rhododendron maximum* or *Leucothoe fontanesiana*. It also generally contains some trees of lower elevations, such as *Liriodendron tulipifera* and *Magnolia fraseri*. The High Elevation Subtype may be distinguished from the occasional Swamp Forest–Bog Complex that has abundant *Betula alleghaniensis* by lacking open patches with wetland species.

Crosswalks: *Betula alleghaniensis - (Tsuga canadensis) / Rhododendron maximum / (Leucothoe fontanesiana)* Forest (CEGL007861).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).
Montane Type (*Tsuga canadensis - Betula alleghaniensis / Rhododendron maximum - Acer pensylvanicum / Dryopteris intermedia - Huperzia lucidula*) (Ulrey 2002).

Sites: The High Elevation Subtype occurs in sheltered, mesic sites such as narrow rocky gorges, steep ravines, and low gentle ridges within coves. Ulrey (2002) reported an elevation range of about 3000-4100 feet, but a few examples have been found much higher, up to around 5000 feet. This elevational range substantially overlaps that of the Silverbell Subtype, overlaps a little of the Typic Subtype's range, and extends well into the range of Northern Hardwood Forest. Lower elevation occurrences may be associated with cold air drainage from higher elevations.

Soils: Examples occur on a wide range of mapped soil series, primarily Typic Dystrudepts, Humic Dystrudepts, and Typic Humadepts. Soils are generally very acidic and low in base saturation and in levels of nutritive cations but are slightly less extreme than in the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position. They probably are more moist than the Typic Subtype because of the higher elevation.

Vegetation: The High Elevation Subtype is dominated by *Tsuga canadensis* and *Betula alleghaniensis*, sometimes in combination with *Liriodendron tulipifera*. Other frequent canopy trees include *Betula lenta, Acer rubrum, Quercus rubra*, *Fagus grandifolia*, and occasional *Tilia americana* var. *heterophylla*, *Acer saccharum*, and *Halesia tetraptera*. The understory includes *Acer pensylvanicum* and *Magnolia fraseri*, as well as canopy species. The shrub layer is generally a dense thicket of *Rhododendron maximum*. The herb layer is sparse to moderate. *Dryopteris* *intermedia* is the most constant and abundant species reported by Ulrey (2002), and *Huperzia lucidula, Mitchella repens*, and *Arisaema triphyllum* are highly constant. Other frequent species include *Eurybia divaricata, Goodyera pubescens, Medeola virginica, Polystichum acrostichoides, Tiarella cordifolia*, *Trillium undulatum*, and *Viola rotundifolia*.

Range and Abundance: Ranked G3. The classification is no more uncertain than that of many communities, and this community appears to be much less common than the Typic Subtype. The High Elevation Subtype ranges throughout the higher mountains of North Carolina. The synonymized association also occurs in Tennessee, Virginia, and West Virginia. Though not reported, it could also be found in Georgia.

Associations and Patterns: The High Elevation Subtype occurs as small to large patches. It may grade to other subtypes of Acidic Cove Forest and potentially to Northern Hardwood Forest. It grades to various oak forests on drier slopes.

Variation: Two variants are recognized, but additional clarification is needed.

1. Rhododendron Variant has *Rhododendron maximum* dominant in the shrub layer.

2. Dog Hobble Variant has *Leucothoe fontanesiana* dominant in the shrub layer. Large areas are said to occur around Mount LeConte in the Great Smoky Mountains. It is unclear where, or even if, it occurs in North Carolina.

Dynamics: The dynamics of the High Elevation Subtype are presumably similar to those of Acidic Cove Forests and Mountain Cove Forests in general. As with the Silverbell Subtype, this subtype has had particularly severe impacts from the hemlock woolly adelgid because of its large component of *Tsuga canadensis*.

Comments: The High Elevation Subtype was defined by Ulrey (2002), who showed that it differs in its combination of soil fertility and elevation from other Acidic Cove Forests as well as being distinct in numerical classification and ordination. An association recognizable as the High Elevation Subtype was also described by Newell (1997) in her analysis of vegetation of Joyce Kilmer-Slickrock Wilderness. It was not recognized in her similar analysis of Shining Rock Wilderness, despite similar elevations. It is not recognized in other local studies, which tend to classify communities more coarsely. The relationship between the High Elevation Subtype and Silverbell Subtype warrants further investigation, as the environmental and elevational differences are relatively subtle. Both have more abundant *Tsuga canadensis* and both share a tendency to contain some species more typical of richer sites.

Acer rubrum - Betula lenta - Magnolia fraseri / (Rhododendron maximum, Kalmia latifolia) Forest (CEGL008558) is an association that appears to represent heavily disturbed versions of all three subtypes of Acidic Cove Forest.

Rare species: No rare species are specifically known to be associated with this community.

ACIDIC COVE FOREST (SILVERBELL SUBTYPE)

Concept: Acidic Cove Forests are low to mid elevation mesophytic mountain and foothill forests dominated by combinations of acid-tolerant trees. The Silverbell Subtype covers examples of the southwestern ranges of the Blue Ridge, in which *Halesia tetraptera* is codominant in the canopy, often along with *Tsuga canadensis*. It is known from the Tennessee side of the Great Smoky Mountains and from Joyce Kilmer-Slickrock Wilderness but may be found elsewhere in southwestern North Carolina.

Distinguishing Features: Acidic Cove Forests are distinguished by a canopy dominated by *Liriodendron tulipifera, Betula lenta, Acer rubrum*, *Tsuga canadensis*, and other species tolerant of highly acidic conditions. The Silverbell Subtype is distinguished from the other subtypes by canopy dominance by *Halesia tetraptera* and *Tsuga canadensis*, while generally lacking *Liriodendron tulipifera*. It occurs at somewhat higher elevations than the Typic Subtype but lacks the abundant *Betula alleghaniensis* of the High Elevation Subtype. It has a somewhat more diverse flora than other Acidic Cove Forest subtypes and may be somewhat transitional to Rich Cove Forest. The Silverbell Subtype is similar to Canada Hemlock Forest but has only weak dominance or codominance by *Tsuga canadensis*.

Crosswalks: *Tsuga canadensis - Halesia tetraptera - Magnolia fraseri / Rhododendron maximum / Dryopteris intermedia* Forest (CEGL007693).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: The Silverbell Subtype occurs in sheltered, mesic sites such as narrow rocky gorges, steep ravines, and low gentle ridges within coves. The Silverbell Subtype is known from 2700-3800 feet in elevation (Ulrey 2002), higher on average than the Typic Subtype and lower than the High Elevation Subtype but overlapping both.

Soils: Despite its limited range, the Silverbell Subtype occurs on a wide range of soil map units, all Inceptisols, including Typic Dystrudepts (Ditney, Cataska, Soco, Stecoah), Humic Dystrudepts (Jeffrey, Sylva, Whiteoak), Lithic Dystrudepts (Unicoi), Typic Humadepts (Spivey, Santeetlah), and Humic Endoaquepts (Sylco). Soils are generally very acidic and low in base saturation and in levels of nutritive cations, but they are slightly less extreme than in the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: The Silverbell Subtype typically is dominated by *Tsuga canadensis* and *Halesia tetraptera*. Surprisingly for Acidic Cove Forests, *Acer saccharum* may also codominate or be abundant. Other frequent canopy species include *Liriodendron tulipifera, Fagus grandifolia*, *Betula lenta*, *Acer rubrum*, and *Quercus rubra*. Understory trees, in addition to the canopy species, frequently include *Acer pensylvanicum* and *Magnolia fraseri*. A surprising number of CVS plots have small numbers of *Tilia americana* var. *heterophylla* and *Magnolia acuminata*. The shrub layer tends to be less dense than in the other subtypes, but *Rhododendron maximum* is the dominant species. The herb layer is well developed. In Ulrey's (2002) constancy tables, *Dryopteris intermedia* has the highest average cover and constancy. Other constant herbs include *Eurybia* *divaricata, Solidago curtissii, Laportea canadensis, Tiarella cordifolia, Polystichum acrostichoides, Viola rotundifolia, Stellaria pubera, Mitchella repens, Polygonatum biflorum, Arisaema triphyllum, Medeola virginica, Viola hastata, Nabalus* sp., *Athyrium asplenioides*, *Amauropelta* (*Parathelypteris*) *noveboracensis*, and again surprisingly, small amounts of *Caulophyllum thalictroides* and *Prosartes lanuginosa*.

Range and Abundance: Ranked G2. The Silverbell Subtype appears to be limited to the southwestern part of the Mountain Region and adjacent Tennessee. It is definitively known only in the Great Smoky Mountains and the Joyce Kilmer-Slickrock Wilderness.

Associations and Patterns: The Silverbell Subtype occurs as large patches where it is present. It can occur in close proximity to both the High Elevation and Typic Subtype. It grades to various oak forests on drier slopes and may potentially grade to Rich Cove Forest on richer soils.

Variation: Variation is not well known. The Silverbell Subtype is narrowly defined.

Dynamics: The dynamics of the Silverbell Subtype are presumably similar to those of Acidic Cove Forests and Mountain Cove Forests in general. This subtype has had particularly severe impacts from the hemlock woolly adelgid, given its large component of *Tsuga canadensis* and occurrence in remote wilderness areas where treatment is difficult.

Comments: The Silverbell Subtype was defined by Ulrey (2002), who showed that it differs in its combination of soil fertility and elevation from other Acidic Cove Forests as well as being distinct in numerical classification and ordination. An association recognizable as this subtype was also described by Newell (1997) in her analysis of vegetation of Joyce Kilmer-Slickrock Wilderness but was not found in Shining Rock Wilderness. It was not recognized in other local studies, which tend to classify communities more coarsely. It appears to be transitional to Rich Cove Forest, with several characteristic species commonly present, while at the same time being transitional to Canada Hemlock Forest. However, this subtype remains little studied beyond its initial recognition. The coexistence of heavy *Tsuga* cover with species of rich soils warrants investigation. The limited range of this association is also curious, given that all the component species range widely in the Mountain region.

Rare species: No rare species are specifically known to be associated with this community.

CANADA HEMLOCK FOREST (TYPIC SUBTYPE)

Concept: Canada Hemlock Forests are mesophytic mountain and foothill forests naturally dominated by *Tsuga canadensis*, with acid-tolerant undergrowth and low species richness. These communities share many species with Acidic Cove Forest and occur in similar settings of coves, gorges, and sheltered slopes. Much of the *Tsuga canadensis* in the Southern Appalachians has been killed by an introduced insect, the hemlock woolly adelgid (*Adelges tsugae*). The future of this community type is highly uncertain.

The Typic Subtype lacks appreciable *Pinus strobus* in the canopy.

Distinguishing Features: Canada Hemlock Forest (Typic Subtype) is distinguished by having *Tsuga canadensis* constituting more than 60 percent of the canopy, at least before recent mortality, in a mesic but not wet environment. The long-term future of *Tsuga canadensis* in the region is uncertain. Canada Hemlock Forests may lose their distinctive character if a solution to the hemlock woolly adelgid is not found, but recognition of this community is retained for the present and may be based on the evidence of recently dead trees.

Acidic Cove Forests, especially the Silverbell Subtype and High Elevation Subtype, usually have abundant *Tsuga canadensis* in the canopy and often have a *Tsuga* understory but have a predominance of hardwoods. *Tsuga canadensis* may also be abundant in Swamp Forest–Bog Complex, but that community has wetland conditions and wetland plants at least in a series of boggy patches dispersed through the forest. *Pinus rigida, Nyssa sylvatica*, and a variety of wetland herbs occur in Swamp Forest–Bog Complex but rarely in Canada Hemlock Forest. Montane Alluvial Forest, especially the Small River Subtype, may have abundant *Tsuga canadensis* but also contains species indicative of periodic flooding and alluvial deposition, such as *Platanus occidentalis*. It also tends to have higher species richness. Rich Cove Forest, Acidic Cove Forest, and Northern Hardwood Forest sometimes have small groves where *Tsuga canadensis* is locally dominant but have hardwoods dominant in the stand as a whole. Carolina Hemlock Forest (Mesic Subtype) may occur in similar environments and look similar but is dominated or codominated by *Tsuga caroliniana*.

The Typic Subtype is distinguished from the White Pine subtype by lacking appreciable natural occurrence of *Pinus strobus*. This may be difficult to distinguish, as planting or logging of pines may have affected their presence without being obvious.

Crosswalks: *Tsuga canadensis / Rhododendron maximum - (Clethra acuminata, Leucothoe fontanesiana)* Forest (CEGL007136).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: Canada Hemlock Forests occur in sheltered, mesic, low- to mid-elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves. Local slopes may be concave or convex. In a few places, such as the area around Highlands and parts of the Great Smoky Mountains, Canada Hemlock Forests occupy or occupied larger expanses of the landscape. A few examples occur as disjunct patches on north-facing river bluffs in the western Piedmont, as well as in more typical mountainous terrain in the foothills. Elevations range from below 1000 feet to 5000 feet or somewhat higher.

Soils: Canada Hemlock Forests occur on the same wide range of Typic Dystrudepts, Typic Hapludults, Lithic Dystrudepts, Typic Humadepts, or other types as Acidic Cove Forests do. Soils are extremely acidic because the hemlock litter adds organic acids.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: Canada Hemlock Forests generally had a dense canopy before the widespread recent mortality caused by the non-native pest hemlock wooly adelgid, with *Tsuga canadensis* dominant. *Betula lenta* and *Liriodendron tulipifera* have high constancy in CVS plots, and *Acer rubrum, Quercus rubra*, and *Halesia tetraptera* are frequent. *Betula alleghaniensis, Quercus alba*, and other species occur occasionally. The understory often is dominated by *Tsuga canadensis* as well, but *Magnolia fraseri, Nyssa sylvatica, Oxydendrum arboreum*, and *Acer pensylvanicum* are highly constant or frequent, along with the other species in the canopy. *Ilex opaca, Amelanchier* laevis, or *Sassafras albidum* sometimes are abundant. The shrub layer may be dense or open. *Rhododendron maximum* is universally present and often forms dense thickets comparable to those in many Acidic Cove Forests. *Kalmia latifolia* also is highly constant and may have fairly high cover. Occasionally, *Leucothoe fontanesiana* may form a dense thicket. Other shrubs, generally not dense, include *Clethra acuminata*, *Hamamelis virginiana*, and less frequently, *Symplocos tinctoria, Ilex montana*, and *Pyrularia pubera*. *Smilax rotundifolia* is highly constant and *Smilax glauca* frequent. The herb layer is usually sparse, though *Galax urceolata* may occasionally have high cover. Other frequent herb layer species include *Mitchella repens, Goodyera pubescens, Chimaphila maculata,* and *Medeola virginica*. Other characteristic species include *Monotropa uniflora, Arisaema triphyllum, Polystichum acrostichoides*, and *Viola rotundifolia*. Overall diversity is low, with an average of only 25 species per 1/10 hectare. A large majority of the constant and frequent species are woody.

Range and Abundance: Ranked G3G4. Occurrences are scattered throughout the Mountain region, more heavily concentrated south of the Asheville basin. Sparser occurrences are present in the foothills and a few disjunct examples occur on river bluffs in the upper Piedmont as far east as Stokes County. The equivalent association is attributed to South Carolina, Georgia, Tennessee, and Kentucky.

Associations and Patterns: Canada Hemlock Forest occurs in large or small patches. It often grades to Acidic Cove Forest in mesic areas. It grades to various oak forests on drier slopes and may occasionally grade to Northern Hardwood Forest or Red Spruce–Fraser Fir Forest. The boundary of occurrences sometimes is a typical gradual transition but sometimes is abrupt.

Variation: Whittaker (1956) and others have described two different kinds of hemlock forest. One has a dense heath shrub layer, the other has more open and herb-dominated undergrowth. These may be worthy of recognition as variants if they are a result of different environments.

Dynamics: In most ways the natural dynamics of Canada Hemlock Forests have been similar to other cove forests. *Tsuga canadensis* is considered very intolerant of fire, but this community, like other mesic forests, could potentially allow low intensity fire to spread through it without being greatly affected. This may be less likely in Canada Hemlock Forest, given the likelihood of even higher humidities than in the other cove forests because of the dense evergreen canopy and understory.

The spread of the hemlock woolly adelgid (*Adelges tsugae*) through North Carolina from 1995-2005 has severely disrupted almost all Canada Hemlock Forests and leaves the future of these communities and their dominant tree species in doubt. This introduced insect kills both adult and juvenile trees. Except where protected by systemic insecticides or occasionally successful biological controls, the hemlock trees in most examples are dead or dying. Living infested or uninfested trees may still be observed in some places, but it is unclear if these represent natural resistance or merely not yet complete spread of the aldegid. All examples of Canada Hemlock Forest therefore are now in a heavily disturbed state, with only a sparse canopy of whatever hardwoods were present. It remains to be seen if natural resistance may develop or if an effective lasting control measure may be found. In the absence of a resurgence of hemlock, it is likely that mesophytic hardwoods will come to be dominant, and that Canada Hemlock Forests will become indistinguishable from Acidic Cove Forests.

The natural relationship of Canada Hemlock Forests to Acidic Cove Forests is unclear. Hemlock is often regarded as a late successional or climax tree, coming to dominate in forests that are long undisturbed. Oosting and Billings (1939) suggest that the marked acidity of the soil caused by the hemlocks may exclude other species. Whittaker (1956) emphasized the competitiveness of the species, noting that hemlock forests often corresponded to a gap in distributions of other tree species along environmental gradients. He suggested that, once established, hemlock excludes other species through its dense shade and acidified soil.

Hemlock is extremely shade-tolerant, and the understory of saplings that often is present suggests it could capture all canopy gaps that form above it. The presence of such a hemlock understory in many Acidic Cove Forests might suggest that they too are succeeding to Canada Hemlock Forest. Yet, both Canada Hemlock Forests and Acidic Cove Forests with varying amounts of hemlock exist as old-growth forests that were never logged and which seem to be old-growth. Hemlock widely coexists with other tree species, including ones such as *Liriodendron* that are not considered tolerant of shade. Whittaker's study area on the Tennessee side of the Great Smoky Mountains apparently had much Canada Hemlock Forest, but in North Carolina hemlock more often occurs in mixed stands of Acidic Cove Forests than as a strong dominant. As in other cove forests, the fall of one or a few large old-growth trees may open a gap large enough to allow shade-intolerant species to reproduce.

In the more widespread second growth forests, land use history may further confuse interpretation. Hemlock was not a desirable wood, and the species often was left when other trees were cut. Some sites may be seen to have old hemlocks embedded in younger hardwood forests, suggesting that hemlock was mixed with more desired species at the time of selective logging. Given the abundance of hemlock saplings and seedlings, logging might be expected to increase rather than decrease the species. However, slash fires may have eliminated hemlock from some second growth forests and may even have destroyed some unlogged forests. At a later time, hemlock bark was desired for tanneries, and so hemlock was selectively removed at some locations.

The varying abundance of Canada Hemlock Forests may offer clues to its ecological drivers, but it is not yet clear how to interpret these clues. Hemlock is abundant at higher elevations in parts of the Smokies, more so than elsewhere. The Highlands plateau is an area of high rainfall and relatively gentle slopes at moderate elevation, but other areas of high rainfall do not have extensive Canada Hemlock Forest.

It is possible that rare penetration of fire could determine the difference between Canada Hemlock Forest and Acidic Cove Forest, with the former developing only in sites that are more sheltered from fire, or in longer fire-free intervals. This would warrant investigation.

Comments: Canada Hemlock Forests appear to have been recognized in many local studies, e.g., Oosting and Bordeau (1955), Valentine (1983), Feil (1988), and McLeod (1988). They were found in Whittaker's (1956) study in the Smokies and in Newell's (1997) analysis of Linville Gorge and Joyce Kilmer but not Shining Rock. Because of the lack of the concept of Acidic Cove Forest in earlier years, it can be hard in qualitative site descriptions to tell if what was identified would be classified as Canada Hemlock Forest here.

Rare species:
Vascular plants – *Buckleya distichophylla, Hexastylis contracta, Hexastylis rhombiformis, Meehania cordata,* and *Shortia brevistyla.*

Nonvascular plants – *Entodon sullivantii, Herzogiella turfacea, Schlotheimia lancifolia,* and *Rosulabryum andersonii*.

Vertebrate animals – *Aneides aeneus, Aneides caryaensis,* and *Plethodon yonahlossee pop. 1*.

CANADA HEMLOCK FOREST (WHITE PINE SUBTYPE)

Concept: Canada Hemlock Forests are mesophytic mountain and foothill forests dominated by *Tsuga canadensis*, with acid-tolerant undergrowth and low species richness. Much of the *Tsuga canadensis* in the Southern Appalachians has been killed by an introduced insect, the hemlock woolly adelgid (*Adelges tsugae*). The future of this community type is highly uncertain.

The White Pine Subtype has *Pinus strobus* as a significant component, sometimes codominant.

Distinguishing Features: Canada Hemlock Forest (White Pine Subtype) is distinguished from all other communities by having *Pinus strobus* as a significant component in a forest, at least until recently, dominated or codominated by *Tsuga canadensis*. Associated canopy species and undergrowth are generally the same as in Canada Hemlock Forest (Typic Subtype) but are somewhat different from in White Pine Forest. This subtype should be applied only for mixtures that are apparently of natural origin. Forests in which white pine was planted, where it is not believed to have previously been a component, should be regarded as altered examples of the Typic Subtype.

Crosswalks: *Pinus strobus - Tsuga canadensis / Rhododendron maximum - (Leucothoe fontanesiana)* Forest (CEGL007102).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern and Central Appalachian Cove Forest Ecological System (CES202.373).

Sites: The White Pine Subtype occurs in sites similar to those of the Typic Subtype and of Acidic Cove Forest: sheltered, mesic, low- to mid-elevation sites, primarily in narrow rocky gorges, steep ravines, and low gentle ridges within coves.

Soils: Soils of the White Pine Subtype are similar to those of the Typic Subtype.

Hydrology: Sites are well drained but mesic due to topographic sheltering and low slope position.

Vegetation: The White Pine Subtype is dominated by a combination of *Tsuga canadensis* and *Pinus strobus*. *Tsuga* is always at least codominant, and *Pinus* may be codominant or present in smaller but appreciable amounts. Other highly constant canopy species include *Acer rubrum, Betula lenta, Liriodendron tulipifera*, *Quercus alba*, *Quercus montana, Quercus rubra, Halesia tetraptera*, and *Carya glabra*. The understory may be dominated by the canopy species, and usually contains *Oxydendrum arboreum, Ilex opaca, Nyssa sylvatica,* and *Magnolia fraseri*. Also frequent are *Benthamidia* (*Cornus) florida* and *Sassafras albidum*. *Rhododendron maximum* is generally present and usually forms a dense thicket. *Kalmia latifolia* also is highly constant and may have high cover. Other highly constant or frequent shrubs include *Hamamelis virginiana, Leucothoe fontanesiana,* and *Gaylussacia ursina*; less frequent ones include *Symplocos tinctoria, Calycanthus floridus, Pyrularia pubera,* and *Clethra acuminata*. *Smilax rotundifolia* is usually present and may be abundant. The herb layer is generally sparse, but *Galax urceolata* may occasionally have high cover. Other frequent herb layer species include *Chimaphila maculata, Mitchella repens, Goodyera pubescens, Polystichum acrostichoides,* and *Medeola virginiana*. Less frequent species include *Amauropelta* (*Parathelypteris) noveboracensis, Hexastylis* *shuttleworthii*, *Viola hastata, Eurybia divaricata*, and *Arisaema triphyllum*. As in the Typic Subtype, species richness is low, averaging 27 species per 1/10 hectare. Woody species substantially outnumber herbaceous.

Range and Abundance: Ranked G4. The abundance of this community is uncertain. Very few sites are recorded, but many may be overlooked since earlier site descriptions may not emphasize the pine. Recorded occurrences are concentrated in the southern mountains, especially in the high rainfall area and south-facing Blue Ridge escarpment. Many plots are attributed to this subtype, possibly suggesting it is more abundant than occurrence records indicate. However, most plots are from a few locations, with more than a third from the heavily sampled Ellicott Rock Wilderness alone. It is not entirely clear that all plots are good examples of this community, since successional pine forests with an understory of hemlock might look similar in plot cover data. The equivalent association is attributed to South Carolina, Georgia, Tennessee, Kentucky, and possibly Virginia.

Associations and Patterns: The White Pine Subtype appears to occur primarily as large patches. It may grade to the Typic Subtype or to Acidic Cove Forest. It grades to various oak forests on drier slopes.

Variation: Little is known about natural variation in this subtype.

Dynamics: The dynamics of the White Pine Subtype are generally similar to those in the Typic Subtype. However, the coexistence of two conifer species believed to have rather different life histories warrants further study. Understanding their interaction will be particularly complex given the effects of logging and other land use on populations of white pine.

Where appreciable white pine is present, the death of the hemlock may lead this subtype to develop into White Pine Forest rather than Acidic Cove Forest.

Comments: This subtype is one of the least well supported communities in the Fourth Approximation, and it is accepted only provisionally. Though an equivalent association is recognized in the NVC, it is not clear that this particular mixture of canopy trees is ecologically more distinct and important than other combinations. It is also less sure than for most associations that it occurs naturally. However, with the widespread mortality of hemlock, this subtype retains a more evergreen structure than the Typic Subtype, a characteristic that may prove important for animal populations and perhaps for ecological dynamics.

It also is ambiguous whether this community should be treated as a subtype of Canada Hemlock Forest or of White Pine Forest. The NVC description emphasizes the pine, and in fact suggests hemlock is not necessarily even present, which would make it indistinguishable from White Pine Forest. A somewhat different circumscription is used here, emphasizing the hemlock component and treating white pine as an indicator that may be present in smaller amounts.

Rare species:
Vascular plants – *Buckleya distichophylla* and *Hexastylis contracta*.

Nonvascular plants – *Entodon sullivantii, Lophocolea muricata, Schlotheimia lancifolia,* and *Rosulabryum andersonii*.

Vertebrate animals – *Aneides aeneus, Aneides caryaensis,* and *Plethodon yonahlossee pop. 1*.

PIEDMONT AND COASTAL PLAIN MESIC FORESTS THEME

Concept: Piedmont and Coastal Plain Mesic Forests occur on slopes or flats that are moist but well drained, not affected by flooding, and with only brief or very local saturated soil. Their canopy is dominated or codominated by mesophytic deciduous hardwoods such as *Fagus grandifolia*, *Quercus rubra*, *Liriodendron tulipifera*, and *Quercus nigra*.

Distinguishing Features: Most of these forests are distinguished from others in the Piedmont and Coastal Plain by dominance by *Fagus grandifolia*, *Quercus rubra*, and *Liriodendron tulipifera* in upland sites. If *Quercus alba*, *Quercus nigra*, or other oaks are abundant, it is in combination with *Fagus* or other mesophytic species. These mesic forests are distinguished from Piedmont and Mountain Floodplain communities, which may contain the same tree species, by lacking any appreciable presence of alluvial species (e.g., *Fraxinus pennsylvanica, Platanus occidentalis, Betula nigra*) and lacking evidence of regular flooding. In the upper Piedmont, where Mountain Cove Forests may be present, Piedmont and Coastal Plain Mesic Forests are distinguished by the absence of the more diverse set of Mountain Cove Forest species (e.g., *Tilia americana* var. *heterophylla*, *Betula lenta, Aesculus flava, Magnolia acuminata*), and by an association with other Piedmont rather than Mountain communities. One rare Coastal Plain community in this theme lacks all of these species and is dominated by an uncharacteristic combination of other upland oaks (*Quercus alba, Quercus nigra*) with wetland species such as *Chamaecyparis thyoides* on steep bluffs.

Low Elevation Cliffs and Rock Outcrops and Piedmont and Mountain Glades and Barrens are distinguished from Piedmont and Coastal Plain Mesic Forests by having more open vegetation. They have less tree cover than a typical forest canopy, with openness caused by rock cover, shallow soil, or long term slope instability.

Within Piedmont and Coastal Plain Mesic Forests, the most common communities are distinguished by the floristic differences associated with Piedmont and Coastal Plain locations, and by soil nutrient levels that are indicated by flora and vegetation.

Sites: Piedmont and Coastal Plain Mesic Forests occur on well drained but moist areas. Most occur on steep slopes, bluffs, or in ravines in dissected uplands, where slope aspect or topographic sheltering create a cool microclimate and limit spread of fire. They may also occur on relict river terraces in areas that no longer flood. In the Coastal Plain, they may occur on moist but well-drained flats or low ridges surrounded by extensive Coastal Plain Nonalluvial Wetland Forests.

Soils: Most Piedmont and Coastal Plain Mesic Forests occur on moist Ultisols. A few on steep slopes have Inceptisols, and a few occur on Alfisols. Soils may occasionally have substantial amounts of rock or be punctuated by rock outcrops, but rock cover is not enough to change the vegetation cover and structure from that typical of forests.

Hydrology: Sites are moist most of the time but are not saturated other than locally or briefly. In most examples, water can move into the site from adjacent higher areas but drains away and does not accumulate.

Vegetation: Piedmont and Coastal Plain Mesic Forests generally have well-developed canopies that are usually dominated by a mix of several tree species, including *Fagus grandifolia*, *Quercus rubra*, and *Liriodendron tulipifera*. A variety of other species may be present, including *Acer floridanum, Quercus nigra*, *Carya spp., Quercus alba*, and *Pinus taeda* or *Pinus echinata*. Rarely, primarily in the Coastal Plain, a few wetland trees such as *Quercus michauxii, Quercus pagoda*, or *Chamaecyparis thyoides* may be present. A few communities have dense shrub layers, but most are open beneath the understory and have dense or sparse herb layers.

Dynamics: Piedmont and Coastal Plain Mesic Forests, like most of North Carolina's hardwood forests, naturally occur primarily as old-growth, uneven-aged stands. Trees up to several centuries old are common in uncut forests. Most tree reproduction is in small, less often medium size, canopy gaps created by the death of one or a few trees, resulting in a fine-scale mosaic of tree ages across the forest and relative stability of the forest cover over large areas. Wind, lightning, and ice damage are important sources of mortality. Lightning creates gaps at a relatively steady rate but probably is less frequent in the sheltered settings of bluffs and ravines than it is on ridges. Large wind storms may create numerous gaps at once, while leaving the majority of canopy cover intact. Wind disturbance may be more severe nearer the coast, where hurricanes are more intense. Gap formation rates have not been studied in as much detail as they have for Mountain Cove Forests but probably are similar.

Mesic forests occur in landscapes that were naturally subject to fire at least fairly frequently. The moist conditions, limited flammability of mesophytic tree litter (Kreye, et al. 2013, Kreye, et al. 2018), and occurrence in dissected and sloping topography where fire would usually be spreading downhill all contribute to limiting fire penetration and to reducing its intensity when it did occur. The process recently termed "mesophication" (Nowacki and Abrams 2008), which is believed to be altering upland oak forests, is a natural characteristic of the mesic forest communities. The thin bark of most of the dominant species also suggests that fire was not an important natural influence, though any intense fire that did occur would be a significant natural disturbance.

Fire may have been an important natural determinant of the boundaries of mesic forests. With the removal of fire from the landscape, individuals of mesophytic species are able to establish in drier, more fire-prone locations. This may eventually lead to a shift in the community boundary. Caution is needed in interpreting the extent of this phenomenon, however. Seedlings and saplings of mesophytic trees may be present in dry areas but fail to mature due to stress or because of periodic drought-caused mortality.

Mesic forests often contain a mix of trees that have very different tolerances of shade, from the very shade-tolerant *Fagus* to the intolerant *Liriodendron*. Occasional fire penetration might be a disturbance that would favor such coexistence but may not be necessary. Skeen, Carter, and Ragsdale (1980) argue that the canopy gaps produced by the death of one or several large old-growth trees would have been sufficient to allow regeneration of *Liriodendron* in the past.

Nutrient levels and soil chemistry vary among the different mesophytic forest communities, but the moist conditions favor decomposition of litter. In addition to transport of nutrients into these communities from uphill, rapid recycling of litter may promote more fertile conditions than in drier communities with comparable geologic substrate.

Comments: Mesic forests are one of the few community themes that are shared between the Piedmont and Coastal Plain, where differences in fire frequency, hydrology, and substrates generally create substantial differences among most communities. The limited role of fire and the lack of extremes in moisture levels lead to more similarities than differences in mesic forests, despite the differences in geology. It may be said that the mesic forests are the most Piedmont-like of Coastal Plain communities. Nevertheless, mesic hardwood forests in the Coastal Plain occur in small patches in unusual topography, while in those in the Piedmont are a regular and extensive part of the typical landscape mosaic.

In the Piedmont, mesic forests were treated by Peet and Christensen (1980) as part of their study of typical forest patterns. In the Coastal Plain, the relationship of our mesic hardwood forests to the concept of southern mixed forest or beech-magnolia forest has been a subject of discussion (Nesom and Treiber 1977, Ware 1978).

KEY TO PIEDMONT AND COASTAL PLAIN MESIC FORESTS

1. Community with a dense shrub layer, either a low-diversity layer dominated by *Kalmia latifolia, Rhododendron catawbiense,* or occasionally *Symplocos tinctoria*, or a high-diversity layer containing a mix of wetland and upland species.

  2. Shrub layer low in diversity, dominated by *Kalmia latifolia, Rhododendron catawbiense,* or occasionally *Symplocos tinctoria*; canopy generally of *Fagus grandifolia, Quercus* spp., and *Liriodendron tulipifera;* occurring in either the Piedmont or Coastal Plain.. **Piedmont/Coastal Plain Heath Bluff**

  2. Shrub layer high in diversity, containing multiple wetland species such as *Cyrilla racemiflora, Clethra alnifolia*, and *Lyonia lucida* as well as upland species such as *Kalmia latifolia* and *Hamamelis virginiana*; canopy generally a mix of upland and wetland species, such *Quercus nigra, Quercus alba*, and *Chamaecyparis thyoides*; occurring in the Sandhills Region along the Little River or similar deeply entrenched streams draining to the Cape Fear River ……………….. **Cape Fear Valley Mixed Bluff Forest**

1. Community with low to moderate shrub cover, with most of the above species sparse or absent.

  3. Community with flora indicating higher soil pH and base saturation than is typical, with several species such as *Actaea racemosa, Sanguinaria canadensis, Asarum canadense, Adiantum pedatum, Collinsonia canadensis, Botrypus virginianus, Elymus hystrix, Lindera benzoin, Aesculus sylvatica, Cercis canadensis, Fraxinus americana,* and *Juglans nigra.* (Some of these species are common in floodplains but indicate more basic conditions when occurring in uplands).

    4. Community in the Piedmont, underlain by substrate of mafic rock or older calcium-rich sedimentary rock; lacking species typical of the Coastal Plain; potentially containing species confined to more inland areas, such as *Dicentra cucullaria, Cubelium concolor, Collinsonia canadensis, Cardamine concatenata,* and *Staphylea trifoliata* .... …………………………………………………….... **Basic Mesic Forest (Piedmont Subtype)**

    4. Community in the Coastal Plain, underlain by Tertiary limestone, alluvial terrace deposits, or other base-rich unconsolidated sediments; containing species typical of the Coastal Plain such as *Stewartia malacodendron, Quercus michauxii*, and often small numbers of wetland species such as *Persea palustris, Ilex glabra, Arundinaria tecta, Osmundastrum cinnamomeum,* and *Lorinseria areolata*, while lacking the above inland species .... ………………………………………………… **Basic Mesic Forest (Coastal Plain Subtype)**

  3. Community lacking multiple species indicating higher soil pH and base saturation such as those listed above; flora consists of more widely tolerant mesophytic species such as *Polystichum acrostichoides, Hexastylis* spp., *Hamamelis virginiana,* and *Fagus grandifolia*

    5. Community in the Piedmont, underlain by felsic igneous or metamorphic rocks or by older sedimentary rocks; generally lacking species more typical of the Coastal Plain. .... **Mesic Mixed Hardwood Forest (Piedmont Subtype)**

    5. Community in the Coastal Plain, underlain by acidic unconsolidated sediments or younger acidic sedimentary rocks; generally containing species typical of the Coastal Plain and scarce in the Piedmont, such as *Persea palustris, Stewartia malacodendron, Quercus nigra, Ilex glabra, Gaylussacia frondosa, Arundinaria tecta, Osmundastrum cinnamomeum*, and *Lorinseria areolata*. .... **Mesic Mixed Hardwood Forest (Coastal Plain Subtype)**

MESIC MIXED HARDWOOD FOREST (PIEDMONT SUBTYPE)

Concept: Mesic Mixed Hardwood Forests are forests of moist but not wet sites lacking indicators of unusually high pH or base-rich soils. They are characterized by vegetation dominated or codominated by *Fagus grandifolia* but lacking the more diverse flora of Basic Mesic Forests or Montane Cove Forests. The Piedmont Subtype covers examples on Piedmont substrates, where *Quercus rubra* and other characteristic Piedmont species are present and characteristic Coastal Plain species are absent or scarce.

Distinguishing Features: Mesic Mixed Hardwood Forests are distinguished from Basic Mesic Forests by lower species richness and by lacking the species that in Piedmont and Coastal Plain uplands are indicators of higher pH soils (e.g, *Actaea racemosa, Asarum canadense, Adiantum pedatum, Sanguinaria canadensis, Andersonglossum* (*Cynoglossum*) *virginianum, Cubelium (Hybanthus) concolor*, and *Actaea pachypoda*). Other species tend to be common in Basic Mesic Forest and scarce in Mesic Mixed Hardwood Forest, including *Ostrya virginiana, Carpinus caroliniana, Fraxinus americana, Lindera benzoin,* and *Aesculus sylvatica*. Rich Cove Forests may have most of these species but will also contain a number of additional montane species, including the additional trees *Aesculus flava, Tilia americana* var. *heterophylla, Halesia tetraptera*, and *Betula lenta*. A smaller set of mountain species distinguishes Mesic Mixed Hardwood Forests from Acidic Cove Forests. These include *Betula lenta, Tsuga canadensis, Rhododendron maximum*, and *Leucothoe fontanesiana*.

Mesic Mixed Hardwood Forest is distinguished from Piedmont Levee Forest (Beech Subtype), Piedmont Headwater Stream Forest, Piedmont Alluvial Forest, and other floodplain communities, which may contain similar tree species, by the absence of evidence of flooding and by the lack of characteristic floodplain plant species such as *Platanus occidentalis, Fraxinus pennsylvanica, Betula nigra*, *Lindera benzoin, Xanthorhiza simplicissima, Elymus virginicus,* and *Elymus hystrix*.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by a number of species that occur primarily in the Coastal Plain, at least in mesic uplands. Coastal Plain species include *Quercus nigra, Stewartia malacodendron, Symplocos tinctoria, Gaylussacia frondosa, Ilex glabra*, and *Clethra alnifolia*. *Quercus rubra* is generally a good indicator of Piedmont flora, except in the far northern Coastal Plain. However, a number of species considered typical of the Piedmont occur as disjunct populations in the Coastal Plain in Mesic Mixed Hardwood Forests, including *Podophyllum peltatum*, *Epifagus virginiana*, and *Hamamelis virginiana*. Some of the indicators occur at low density, and standard plot samples may capture few of them, making classification based on data from individual plots difficult.

Crosswalks: *Fagus grandifolia - Quercus rubra / Cornus florida / Polystichum acrostichoides - Hexastylis virginica* Forest (CEGL008465).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern Piedmont Mesic Forest Ecological System (CES202.342).

Sites: Most examples occur on steep slopes, bluffs, or in ravines in dissected uplands along streams, where slope aspect or topographic sheltering create a cool microclimate and limit spread of fire. They may also occur on relict river terraces in areas that no longer flood.

Soils: Examples occur on a wide range of soils, most of which are Typic Kanhapludults or Typic Hapludults. The most frequent series mapped in known occurrences are Pacolet, Cecil, Tatum, and Georgeville, among the most extensive soils in the Piedmont. A few are mapped as Wilkes (Typic Hapludalf) or Goldston (Typic Dystrudept). More occurrences may be on inclusions within their map units.

Hydrology: Sites are moist but well drained.

Vegetation: Mesic Mixed Hardwood Forests generally are dominated by *Fagus grandifolia*. *Quercus alba* and *Liriodendron tulipifera* are often abundant and sometimes codominant. Less frequent canopy species include *Quercus rubra*, *Carya tomentosa*, and *Quercus velutina*. CVS data show the most abundant understory tree species to be *Benthamidia* (*Cornus*) *florida, Acer rubrum, Oxydendrum arboreum, Liquidambar styraciflua*, and *Nyssa sylvatica*. *Acer floridanum, Ulmus alata*, *Ostrya virginiana*, and other species are less frequent. Shrubs generally are sparse. *Euonymus americana* is the only frequent species, though *Viburnum prunifolium, Viburnum rafinesqueanum*, *Viburnum acerifolium*, or *Vaccinium pallidum* occur in some examples. A few vine species are frequent, especially *Muscadinia rotundifolia* and small individuals of *Smilax glauca* and *Parthenocissus quinquefolia*. Herbs may be sparse to dense. Some examples have large beds of *Polystichum acrostichoides*, while other don't. Other herbs with high constancy in CVS data, though low cover, include *Galium circaezans*, *Maianthemum racemosum, Hexastylis arifolia, Chimaphila maculata, Goodyera pubescens, Uvularia perfoliata*, and *Hylodesmum nudiflorum*.

Range and Abundance: The equivalent association is ranked G3G4, but G4 likely is appropriate. These communities occur throughout the Piedmont and are one of the most frequently recorded communities in the state. Many examples were protected by steep topography from past agricultural clearing and more recent development, and some are steep enough to be unlikely to be logged. However, many examples are of limited size because of the dissected terrain and many are bordered by more altered sites. This community ranges southward to Georgia; a different, related community is recognized in Virginia.

Associations and Patterns: Mesic Mixed Hardwood Forests may be regarded as matrix-forming communities; they make up a significant minority of the landscape mosaic in most Piedmont landscapes, though individual patches may be small. Mesic Mixed Hardwood Forests grade to Dry-Mesic Oak–Hickory Forest uphill and to floodplain communities downhill. Piedmont/Coastal Plain Heath Bluff, Basic Mesic Forest, or Piedmont Cliff communities may be associated with them along slopes.

Variation: Examples vary with the transition to adjacent communities and with biogeography. Examples farther west in the Piedmont may have more montane species, though a few disjunct montane species are known even in the eastern Piedmont. Examples also seem to vary significantly in species richness, with some moderately rich and some with only a few strongly dominant species. Harry LeGrand, in several Natural Heritage Program reports, proposed recognition of a distinct subtype on steeper bluffs. This initially does not appear consistently distinguishable but is recognized as a variant to allow use of the concept and to seek further evidence.

1. Typic Variant most closely fits the description of the subtype. Its canopy may be strongly dominated by *Fagus* or may be more mixed. Plants of deep soils generally are present, especially *Polystichum acrostichoides,* but also *Podophyllum peltatum, Tiarella cordifolia, Cardamine angustata, Geranium maculatum*, and *Erythronium umbilicatum*.

2. Bluff Variant occurs on steeper slopes. *Fagus* typically is strongly dominant, and several species typical of shallow soil and greater drainage are present. These include *Hydrangea arborescens, Cunila origanoides, Epigaea repens, Solidago arguta, Hexastylis minor*, and *Silene virginica*.

Dynamics: Dynamics are similar to the theme in general.

Comments: Mesic Mixed Hardwood Forests have consistently been distinguished in local analyses of vegetation data in the Piedmont (Peet and Christensen 1980, Oosting 1942). Numerous CVS plots exist for this subtype.

A few Mesic Mixed Hardwood Forests in the Coastal Plain may fit this subtype better than the Coastal Plain Subtype. The NVC association synonymized with this subtype is recognized as extending into the Coastal Plain in northern Virginia.

Rare species:
Vascular plants – *Callitriche terrestris, Cardamine dissecta, Cardamine douglassii, Cardamine micranthera, Carex impressinervia, Carex superata, Eurybia mirabilis, Euphorbia mercurialina, Fothergilla major, Gillenia stipulata, Hexastylis naniflora, Magnolia macrophylla, Schisandra glabra, Scrophularia lanceolata, Thermopsis mollis,* and *Viola walteri.*

Nonvascular plants – *Hygrohypnum closteri*.

MESIC MIXED HARDWOOD FOREST (COASTAL PLAIN SUBTYPE)

Concept: Mesic Mixed Hardwood Forests are forests of moist but not wet sites lacking indicators of unusually high pH or base-rich soils. They are characterized by vegetation dominated or codominated by *Fagus grandifolia* or other mesophytic hardwoods. The Coastal Plain Subtype covers the examples on Coastal Plain substrates, where a distinct component of Coastal Plain flora occurs. They may occur on steep north-facing bluffs, on moist upland flats associated with nonriverine wetlands, or on mesic ridges within river floodplains.

Distinguishing Features: Mesic Mixed Hardwood Forests are distinguished from Basic Mesic Forests by lower species richness and by lacking the species that in the Piedmont and Coastal Plain are indicators of higher pH soils (e.g, *Actaea racemosa, Asarum canadense, Adiantum pedatum, Sanguinaria canadensis, Andersonglossum* (*Cynoglossum*) *virginianum, Cubelium (Hybanthus) concolor*, and *Actaea pachypoda*). Other species tend to be common in Basic Mesic Forest and scarce in Mesic Mixed Hardwood Forest, including *Ostrya virginiana, Carpinus caroliniana, Fraxinus americana, Lindera benzoin,* and *Aesculus pavia*.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by occurrence in the Coastal Plain and by accompanying floristic differences. Distinctive species of the Coastal Plain Subtype include *Quercus nigra, Stewartia malacodendron, Symplocos tinctoria, Gaylussacia frondosa*, and a variety of shrubs and herbs that more typically occur in wetlands, such as *Arundinaria tecta, Ilex glabra, Persea palustris*, *Lorinseria areolata*, and *Osmundastrum cinnamomeum*. A few Coastal Plain Small Stream Swamp communities may share some of the mesophytic hardwoods, but generally will have a substantial component of wetland species or floodplain species. *Nyssa biflora* is usually present in floodplains and never in mesic forests. However, a few bottomland species such as *Quercus michauxii* may frequently occur in Mesic Mixed Harwood Forest.

Crosswalks: *Fagus grandifolia - Quercus (alba, nigra) / Symplocos tinctoria* – (*Stewartia malacodendron*) Forest (CEGL007211).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Atlantic Coastal Plain Mesic Hardwood Forest Ecological System (CES203.242).

Sites: Mesic Mixed Hardwood Forests occur on upland areas protected from fire. They are primarily on north-facing river bluffs and ravine slopes, less commonly on upland flats or islands surrounded by peatland or swamp communities.

Soils: These communities occur on a great variety of soils, with 30 different series map units recorded with occurrences. Among the more frequently mapped soils are Craven (Aquic Hapludult), Winton (Aquic Hapludult), Norfolk (Typic Kandiudult), Roanoke (Typic Endoaquult), Wagram (Arenic Kandiudult), Conetoe (Arenic Hapludult), and Wickham (Typic Hapludult). Less frequently recorded series include Spodic Paleudults, Aquic Quartzipsamments, Typic Humaquepts, Udipsamments, and Dystrochrepts.

Hydrology: Moisture levels are mesic overall, though small areas with seepage are common in the Coastal Plain Subtype. These communities may be on the best-drained sites in the vicinity, located between wet floodplains or swamps below and wetlands of upland flats above. However, they also often are associated with drier upland communities.

Vegetation: The Coastal Plain Subtype is dominated by *Fagus grandifolia*, sometimes codominant with *Quercus alba* or *Quercus nigra*, *Liquidambar styraciflua, Liriodendron tulipifera,* or *Pinus taeda*. Other canopy species sometimes abundant in CVS plots include *Quercus michauxii, Quercus laurifolia* (possibly including *Quercus hemisphaerica*), *Quercus pagoda, Carya tomentosa, Carya glabra, Carya pallida,* and *Quercus shumardii*. The understory is often well developed and may be dominated by *Ilex opaca, Carpinus caroliniana, Nyssa sylvatica, Acer rubrum*, or *Benthamidia* (*Cornus*) *florida*. *Stewartia malacodendron, Acer floridanum*, *Oxydendrum arboreum,* or *Magnolia tripetala* may be abundant in some examples. The shrub layer is generally open and may include *Hamamelis virginiana*, *Symplocos tinctoria, Euonymus americana*, *Clethra alnifolia, Asimina parviflora, Callicarpa americana*, *Vaccinium* spp., *Gaylussacia frondosa*, *Arundinaria tecta*, and a wide variety of other occasional species. Vines may be abundant, particularly *Muscadinia rotundifolia* or *Smilax rotundifolia*. *Parthenocissus quinquefolia*, *Smilax glauca*, and *Bignonia capreolata* are also frequent. The herb layer may be sparse to dense. *Polystichum acrostichoides* sometimes forms dense beds, and *Athyrium asplenioides*, *Amauropelta* (*Parathelypteris*) *noveboracensis*, or *Mitchella repens* are extensive in some plots. A variety of other species may occur in the herb layer, including *Chimaphila maculata, Asplenium platyneuron, Lorinseria areolata, Chasmanthium laxum, Galium circaezans, Galium uniflorum, Hexastylis arifolia* var. *arifolia, Dichanthelium commutatum,* and *Sanicula canadensis*.

Range and Abundance: Ranked G4, but this may not make sense given the rank of G3G4 for the Piedmont Subtype. At least in North Carolina, the Piedmont Subtype is much more abundant than the Coastal Plain Subtype. Examples occur irregularly throughout the Coastal Plain of the state; they are largely limited to narrow bands of dissected lands along stream systems, but a few examples also occur on “swamp islands” in the flat lands of the outer Coastal Plain in the northeastern part of the state. The equivalent association ranges from southern Virginia to South Carolina, but most of its range is in North Carolina.

Associations and Patterns: This subtype occurs as small patches, though some may aggregate into larger occurrences in bluff systems. It usually grades downhill to a Coastal Plain floodplain community, but a few may be surrounded by or occur on edges of Nonriverine Wet Hardwood Forest or Nonriverine Swamp Forest. Examples on bluffs usually grade uphill to Dry-Mesic Oak–Hickory Forest or Dry Oak–Hickory Forest. Enough are now bordered by altered vegetation on flatter uplands that other natural transitions may not be known.

Variation: Three variants are distinguished, corresponding to different landscape settings, which are believed to have effects on hydrology and fire dynamics. Vegetation differences among them are not known but have not been sought. Further study may show them to warrant treatment as subtypes, but the boundaries between them may not be well marked and the floristic differences are not as strong as between the recognized subtypes.

1. Bluff/Slope Variant occurs on locally relatively steep or dissected lands near streams. Examples are well drained but may have local seepage. They grade to drier communities above and probably were naturally subject to more frequent fire than the other subtypes.

2. Swamp Island Variant occurs on isolated ridges surrounded by wetter communities, generally nonriverine wetlands. Examples are usually small and remote from other examples. They must have limited gene flow for plants and sessile animals and may be depauperate (nevertheless, examples have the surprising presence of large-seeded species not shared with the surrounding communities). Surrounding vegetation generally is not flammable, and this variant must rarely if ever burn naturally.

3. Upland Flat Variant occurs on very gentle rises on wet upland flats of the outer Coastal Plain or of relict high river terraces without flooding. Examples are often in a mosaic with marginal wetlands such as Nonriverine Wet Hardwood Forest, with which they can share some species, but they generally are not associated with drier communities. They may be more subject to high water tables than the other variants. Surrounding vegetation generally is not very flammable, but fire is more likely to occur occasionally than in the Swamp Island Variant.

Dynamics: Dynamics are generally similar to other Piedmont and Coastal Plain Mesic Forests. However, at least some examples of the Bluff/Slope Variant have greater exposure to fire because of their association with drier, more flammable upland vegetation such as Dry Longleaf Pine Communities. This subtype also is more subject to disturbance by hurricanes than the Piedmont Subtype, because it occurs closer to the coast and because soils are less dense.

Comments: Several other associations in the NVC are closely related to this community, leading to potential confusion. *Fagus grandifolia - Quercus alba - Quercus laurifolia / Galax urceolata* Forest (CEGL007863) was described for Virginia but has since been dropped. *Fagus grandifolia - Liquidambar styraciflua - Quercus (michauxii, nigra)* Forest (CEGL007866) is a Coastal Plain small stream bottom association of South Carolina and Georgia, which has at times been attributed to plots in North Carolina. *Fagus grandifolia - Quercus (alba, rubra) - Liriodendron tulipifera / (Ilex opaca* var. *opaca) / Polystichum acrostichoides* Forest (CEGL006075) is a Coastal Plain mesic forest of northern Virginia and northward but is not expected to occur in North Carolina.

Rare species:
Vascular plants – *Chasmanthium nitidum, Ponthieva racemosa,* and *Schisandra glabra*.

Nonvascular plants – *Acanthothecis paucispora. Lejeunea bermudiana,* and *Plagiochila raddiana.*

BASIC MESIC FOREST (PIEDMONT SUBTYPE)

Concept: Basic Mesic Forests are forests of moist but not wet sites, containing species indicating unusually high pH or base-rich soils. They are characterized by vegetation dominated or codominated by *Fagus grandifolia, Liriodendron tulipifera*, or *Quercus rubra* but lacking the more diverse montane flora of Montane Cove Forests. The Piedmont Subtype covers examples on Piedmont substrates, where *Quercus rubra* and other characteristic Piedmont species are present and characteristic Coastal Plain species are absent or scarce.

Distinguishing Features: Basic Mesic Forests are distinguished from Mesic Mixed Hardwood Forests by higher species richness and by the presence of multiple species that in Piedmont and Coastal Plain uplands are indicators of higher pH soils (e.g, *Actaea racemosa, Asarum canadense, Adiantum pedatum, Sanguinaria canadensis, Andersonglossum (Cynoglossum) virginianum, Cubelium (Hybanthus) concolor*, *Actaea pachypoda*, *Carpinus caroliniana, Fraxinus americana, Lindera benzoin,* and *Aesculus sylvatica*. Additional species are more widespread but tend to be more abundant in Basic Mesic Forest, such as *Cercis canadensis*, *Ostrya virginiana*, and *Acer floridanum*. Because many of the indicator species are herbs, it can be difficult to distinguish Basic Mesic Forests from Mesic Mixed Hardwood Forests in the winter. In addition, because many of them are present at low density, few may appear in plot data.

Rich Cove Forests share most of the species that indicate Basic Mesic Forests, but they contain a number of additional montane species that are lacking from Basic Mesic Forest. These include the trees *Aesculus flava, Tilia americana* var. *heterophylla, Halesia tetraptera*, and *Betula lenta*, and a number of additional herbs such as *Caulophyllum thalictroides*.

Basic Mesic Forests are distinguished from Piedmont Levee Forest (Beech Subtype), Piedmont Headwater Stream Forest, Piedmont Alluvial Forest, and other floodplain communities, which may contain similar tree species, by the absence of evidence of flooding and by the lack of characteristic floodplain plant species such as *Platanus occidentalis, Fraxinus pennsylvanica, Betula nigra,* and *Xanthorhiza simplicissima*. However, a number of species typical of floodplains are present on slopes in Basic Mesic Forest but not in Mesic Mixed Hardwood Forest (e.g., *Lindera benzoin, Elymus hystrix, Elymus virginicus,* and *Chasmanthium latifolium*).

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by substrate and by a number of species that occur primarily in the Coastal Plain, at least in mesic uplands. Coastal Plain species include *Quercus nigra, Stewartia malacodendron, Aesculus pavia, Symplocos tinctoria, Gaylussacia frondosa, Ilex glabra*, and *Clethra alnifolia*. *Quercus rubra* is generally a good indicator of Piedmont flora, except in the far northern Coastal Plain. However, a number of species considered typical of the Piedmont occur as disjunct populations in the Coastal Plain in Mesic Mixed Hardwood Forests, including *Podophyllum peltatum*, *Epifagus virginiana*, and *Hamamelis virginiana*.

Crosswalks: *Fagus grandifolia - Quercus rubra / Aesculus sylvatica / Actaea racemosa - Adiantum pedatum* Forest (CEGL008466).
G020 Southern Appalachian-Interior Mesic Forest Group.
Southern Piedmont Mesic Forest Ecological System (CES202.342).

Sites: Most examples occur on steep slopes, bluffs, or ravines in dissected uplands along streams, where slope aspect or topographic sheltering create a cool microclimate and limit the spread of fire. They are underlain by diabase, amphibolite, gabbro, or other mafic rocks, or by some metasedimentary formations.

Soils: Soils in these communities are called "basic," reflecting long usage of the term by North Carolina's botanists. The species distinctly associated with them are widely recognized as indicating higher base status. However, the pH measured for CVS plots, as in most studies, is well below neutral, and the difference from Mesic Mixed Hardwood Forests is not as much as often implied (averaging 5.3 and 4.8 respectively in surface soils, 5.2 and 4.7 deeper). Average base saturation in surface soils similarly is 59% versus 43%. Calcium abundance, however, is much greater: 1327 ppm versus 455 ppm. Additional causes of this geologically-driven distinction may remain to be discovered.

Examples are mapped with a wide diversity of soils. Most frequent is Wilkes (Typic Hapludalf). Poindexter is also frequent, and there are several other Typic Hapludalfs mapped. A number of examples are mapped as Goldston (Typic Dystrudept) and some as other Alfisols. Those mapped as Pacolet (Typic Kanhapludult) presumably represent inclusions; those mapped as Chewacla (Fluvaquentic Dystrudept) may also represent inclusions or may indicate mesic river terraces.

Hydrology: Sites are well drained but moist due to topographic sheltering, cool slope aspects, and low slope position.

Vegetation: Forests generally are dominated by *Fagus grandifolia*, but sometimes by *Liriodendron tulipifera, Acer floridanum*, or *Quercus rubra*. Other canopy trees may include *Quercus alba, Fraxinus americana, Carya glabra, Carya ovata, Pinus taeda, Carya tomentosa*, and less often *Quercus velutina, Quercus shumardii, Juglans nigra*, and *Carya cordiformis*. The understory may be dominated by *Fagus grandifolia, Acer floridanum, Ostrya virginiana, Carpinus caroliniana, Asimina triloba, Magnolia tripetala*, or *Benthamidia* (*Cornus*) *florida*. Other understory species frequent in CVS plots include *Cercis canadensis, Prunus serotina, Morus rubra, Ulmus alata*, *Oxydendrum arboreum,* and *Nyssa sylvatica*. Shrubs generally are not dense. Frequent species are *Lindera benzoin, Euonymus americana,* and *Viburnum* spp. Other shrub and understory species indicative of Basic Mesic Forest include *Tilia americana* var. *caroliniana, Chionanthus virginiana*, *Celtis* sp., *Staphylea trifoliata, Hydrangea arborescens,* and *Styrax grandifolia*. The herb layer may be dense to sparse but is fairly diverse and includes a number of species indicative of basic soil conditions. The most constant species include *Maianthemum racemosum, Galium circaezans, Botrypus virginianus, Arisaema triphyllum, Uvularia perfoliata, Polygonatum biflorum, Sanguinaria canadensis, Actaea racemosa*, and *Phryma leptostachya*. Additional species that sometimes are abundant include *Podophyllum peltatum, Phegopteris hexagonoptera, Amphicarpaea bracteata, Andersonglossum virginianum, Geranium maculatum, Elymus hystrix, Asarum canadense, Piptochaetium avenaceum*, and *Elymus virginicus*. Other species indicative of Basic Mesic Forest include *Cubelium concolor*, *Aquilegia canadensis*, *Agrimonia pubescens, Collinsonia canadensis, Iris cristata, Osmorhiza longistylis, Oxalis violacea, Thaspium barbinode*, and *Actaea pachypoda*. Additional fairly frequent species shared with acidic communities include *Tiarella cordifolia, Stellaria pubera, Eurybia divaricata, Nabalus altissima*, and *Epifagus virginiana*.

Range and Abundance: Ranked G3G4, but probably more appropriately G4. This community has numerous examples widely distributed throughout the Piedmont, though most are small patches confined to the intersection of mesic topographic settings with unusual rock types. The equivalent association ranges from Georgia to Virginia, with its northern range limit at the Nottoway River. A related association replaces it farther north.

Associations and Patterns: Basic Mesic Forests usually occur as small patch communities, occasionally as large patches. Many small examples are associated with diabase dikes, which produce narrow surface expressions of mafic rock. Basic Mesic Forests usually grade to Dry-Mesic Basic Oak—Hickory Forest or Dry Basic Oak—Hickory Forest above, and to floodplain communities below. Mesic Mixed Hardwood Forest may border them along slopes, often with sharp boundaries marking geologic contacts.

Variation: Examples vary greatly in their dominant species and in their overall composition. Harry LeGrand, in several Natural Heritage Program reports, proposed recognition of subtypes with stronger and weaker basic character. Preliminary analysis of CVS plot data did not show consistent differences corresponding to proposed examples of the groups. Though not recognized here as subtypes, they are recognized as variants to allow use of the concepts and to encourage further investigation. The idea of a gradient in basic influence appears reasonable, but may be difficult to apply. The pool of indicator species, especially of the more basic variant, includes many species that have low constancy among sites. Many occur only sparsely within sites, and others are visible only early in the spring, making them unlikely to be detected in plots and often missed in whole-site species lists. Indeed, they appear in almost no CVS plots, even those sampled in places reported to have them.

1. Intermediate Variant is the common variant, containing only the more widespread and broadly tolerant circumneutral plant species such as *Adiantum pedatum, Sanguinaria canadensis, Cardamine concatenata*, and *Actaea racemosa*.

2. Basic Variant contains the more narrowly tolerant base-loving plant species such as *Cubelium (Hybanthus) concolor, Enemion biternatum, Trillium cuneatum, Dicentra cucullaria,* and *Aquilegia canadensis*. These sites presumably have soils with higher pH and base status, but no difference has been recognized in geologic substrates.

Dynamics: Dynamics are similar to the theme in general.

Comments: Peet and Christensen (1980) demonstrated the distinctness of Basic Mesic Forest vegetation in their analysis of Piedmont communities, calling them mesic eutrophic forests.

Quercus rubra / Magnolia tripetala - Cercis canadensis / Actaea racemosa - Tiarella cordifolia Forest (CEGL003949) was another basic mesic association that overlapped this subtype, but it has been lumped.

Rare species:

Vascular plants – *Cardamine dissecta, Cardamine douglassii, Carex impressinervia, Carex jamesii, Celastrus scandens, Chasmanthium sessilifolium, Collinsonia tuberosa, Collinsonia verticillata, Corallorhiza wisteriana, Dichanthelium annulum, Enemion biternatum, Euphorbia mercurialina, Eurybia mirabilis, Hackelia virginiana, Hexalectris spicata, Hydrastis canadensis, Magnolia macrophylla, Pachysandra procumbens, Phacelia covillei, Polemonium reptans* var. *reptans*, *Primula meadia, Quercus austrina*, *Quercus prinoides, Ranunculus micranthus, Schisandra glabra, Sedum glaucophyllum, Smilax hugeri,* and *Tradescantia virginiana*.

BASIC MESIC FOREST (COASTAL PLAIN SUBTYPE)

Concept: Basic Mesic Forests are forests of moist but not wet sites, with indicators of unusually high pH or base-rich soils. They are characterized by vegetation dominated or codominated by *Fagus grandifolia*, usually along with *Liriodendron tulipifera* or *Quercus alba*. The Coastal Plain Subtype covers examples on Coastal Plain soils on bluffs or terraces, containing characteristic Coastal Plain species though often also having species more typical of inland areas.

Distinguishing Features: Basic Mesic Forests are distinguished from Mesic Mixed Hardwood Forests by higher species richness and by the presence of multiple species that in the Piedmont and Coastal Plain uplands are indicators of higher pH soils (e.g., *Actaea racemosa, Adiantum pedatum, Sanguinaria canadensis, Carpinus caroliniana, Fraxinus americana, Ulmus rubra, Asimina triloba, Lindera benzoin,* and *Aesculus pavia)*. Additional species are more widespread but tend to be more abundant in Basic Mesic Forest, such as *Ostrya virginiana* and *Acer floridanum*. A Basic Mesic Forest should have several members of this suite present in the site, dispersed through the community. Because many of the indicator species are herbs, it can be difficult to distinguish Basic Mesic Forests in the winter. In addition, because many of them are present at low density, few may appear in plot data.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by occurring on Coastal Plain sediments and by floristic differences. Substrates may be rich alluvium on well-drained terrace slopes, soils influenced by limestone, or sandy soils with abundant shells. The interpretation of floristic differences is complex because these communities often harbor disjunct populations of plant species typical of the Piedmont. Plants frequently present in the Coastal Plain Subtype and scarce or lacking in the Piedmont Subtype include *Quercus shumardii*, *Quercus michauxii*, *Stewartia malacodendron*, and *Chasmanthium sessiliflorum*, along with the species listed above the distinguish the Coastal Plain Subtype of Mesic Mixed Hardwood Forest. Plants found in the Piedmont Subtype but scarcely or never in the Coastal Plain Subtype include *Cubelium (Hybanthus) concolor*, *Iris cristata, Hydrangea arborescens, Actaea pachypoda, Dicentra cucullaria, Collinsonia canadensis, Cardamine concatenata, Viburnum rafinesqueanum, Staphylea trifolia, Dirca palustris*, *Quercus muhlenbergii*, and *Carya carolinae-septentrionalis*, among others.

Basic Mesic Forests may share some species with Brownwater Levee Forest, but lack characteristic alluvial species such as *Platanus occidentalis*, *Acer negundo*, and generally *Celtis laevigata*.

Coastal Plain Marl Outcrop communities may be embedded in Basic Mesic Forest. They are distinguished by substantial cover of limestone ("marl"), with most vascular plants limited to rooting in crevices and soil pockets. Coastal Plain Marl Outcrops tend to be small, and often are shaded by trees of the adjacent Basic Mesic Forest.

Crosswalks: *Fagus grandifolia - Quercus alba - (Acer floridanum)* / Mixed Herbs Forest (CEGL007206).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Atlantic Coastal Plain Mesic Hardwood Forest Ecological System (CES203.242).

Sites: Basic Mesic Forests occur on upland areas protected from fire. The Coastal Plain Subtype is primarily on north-facing river bluffs and ravine slopes with limestone close to the surface, occasionally on slopes of alluvial terraces that are now above flood levels.

Soils: As in the Piedmont Subtype, soils are higher in pH, base saturation, and content of calcium and other nutritive cations, but do not generally exceed neutral pH. Soil series mapped are quite variable. Recorded occurrences for which soils were noted included 11 series, of which none were in more than two sites. Most are Hapludults or Paleudults, a few are Endoaquults, and some are simply mapped as Dystrochrepts. Many of these examples may actually be on inclusions in the soil map unit.

Hydrology: Moisture levels are mesic overall, though local small areas with seepage are common in the Coastal Plain Subtype.

Vegetation: Basic Mesic Forests are dominated by combinations of species that usually include *Fagus grandifolia* and often include *Quercus alba, Liriodendron tulipifera*, and *Carya tomentosa*. The Coastal Plain Subtype sometimes includes *Quercus shumardii, Quercus michauxii, Quercus nigra, Pinus taeda, Fraxinus americana, Acer floridanum*, and *Ulmus rubra*. Understory species typically frequent and abundant in CVS data are *Carpinus caroliniana*, *Acer floridanum, Benthamidia* (*Cornus*) *florida, Acer rubrum*, and *Ilex opaca*. Fairly frequent species include *Asimina triloba, Stewartia malacodendron, Magnolia tripetala*, and *Oxydendrum arboreum*. Shrubs tend to be few, but may include *Hamamelis virginiana, Lindera benzoin, Symplocos tinctoria, Euonymus americana, Styrax grandifolia, Callicarpa americana*, and *Persea palustris*. Widespread vines of the Coastal Plain are frequent, including *Parthenocissus quinquefolia, Smilax rotundifolia*, *Muscadinia rotundifolia, Smilax glauca*, and *Toxicodendron radicans*. The herb layer is dense to moderate. *Polystichum acrostichoides, Podophyllum peltatum*, or *Mitchella repens* may form large patches. Other species that sometimes are abundant in plots include *Podophyllum peltatum, Adiantum pedatum, Amphicarpaea bracteata, Amauropelta* (*Parthelypteris*) *noveboracensis*, *Geranium maculatum*, and *Brachyelytrum erectum*. Herbs that are less frequent but are indicative of basic conditions include *Sanguinaria canadensis, Solidago caesia, Endodeca serpentaria, Phryma leptostachya, Dichanthelium boscii, Actaea racemosa, Melica mutica*, and *Aquilegia canadensis*.

Range and Abundance: The equivalent association is ranked G4 but should perhaps be G3. At least in North Carolina, it is much less abundant than the Piedmont Subtype, which is ranked G3G4. This community is rare in North Carolina, and almost all examples are small. The equivalent association ranges through South Carolina, and possibly into Georgia.

Associations and Patterns: This subtype occurs as small patches, associated with rare, specialized site conditions. It may grade or abruptly transition to Mesic Mixed Hardwood Forest at the edge of the calcareous substrate. It may grade to Dry-Mesic Basic Oak—Hickory Forest on drier sites, and usually is bordered by a floodplain community below. Coastal Plain Marl Outcrop communities are embedded in a few examples.

Variation: There are two distinct variants of this subtype. These may warrant separate associations, but the floristic differences have not been adequately clarified.

1. Marl Outcrop Variant occurs on soils derived from or influenced by limestone.

2. Terrace Slope Variant occurs on slopes mantled with rich alluvial material on the edges of floodplain terraces.

Dynamics: Dynamics are generally similar to other Piedmont and Coastal Plain Mesic Forests. If examples are associated with longleaf pine communities, they may be more exposed to fire, but slopes, dissected terrain, and association with floodplain communities limit fire spread for most. This subtype is more subject to disturbance by hurricanes than in the Piedmont Subtype, because they are closer to the coast and because soils are less dense.

Comments: Few studies have been published that include the Coastal Plain Subtype. Sears (1966) addressed those along Island Creek.

Rare species:
Vascular plants – *Camassia scilloides, Carex basiantha, Carex emmonsii, Carex jamesii, Enemion biternatum, Hackelia virginiana, Malaxis spicata, Ponthieva racemosa, Quercus austrina, Schisandra glabra, Scutellaria nervosa, Trillium sessile, Urtica chamaedryoides*, likely others.

Nonvascular plants – *Brachythecium rotaeanum* and *Lejeunea bermudiana*.

PIEDMONT/COASTAL PLAIN HEATH BLUFF

Concept: Piedmont/Coastal Plain Heath Bluff is a community of cool microsites in the Piedmont and Coastal Plain, generally on north-facing bluffs, with a dense shrub layer dominated by *Kalmia latifolia, Rhododendron catawbiense*, or occasionally *Symplocos tinctoria*, generally under a mesic canopy.

Distinguishing Features: Piedmont/Coastal Plain Heath Bluffs are distinguished from Mesic Mixed Hardwood Forests by having a dense shrub layer dominated by *Kalmia latifolia, Rhododendron* sp., or *Symplocos tinctoria*. The first two shrub species generally occur as disjunct populations; however, individuals of them may be found at lower density in the adjacent mesic and dry-mesic forests.

Heath Bluffs grade conceptually into Acidic Cove Forests in the upper Piedmont, with *Rhododendron maximum* becoming a more prominent component and additional montane species being present. Significant presence of *Tsuga canadensis, Betula lenta, Halesia tetraptera*, or *Liriodendron tulipifera*, predominating over *Quercus montana, Quercus alba*, or *Fagus grandifolia*, indicates Acidic Cove Forest.

The Heath Subtype of Piedmont Monadnock Forest also has a dense shrub layer of *Kalmia*, but may be distinguished by occurring on higher, more exposed rocky slopes, and by having a canopy dominated by *Quercus montana* and lacking more mesophytic trees.

Crosswalks: *Fagus grandifolia - Quercus alba / Kalmia latifolia - (Rhododendron catawbiense) / Galax urceolata* Forest (CEGL004539).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Piedmont Mesic Forest Ecological System (CES202.342).

Sites: Heath Bluffs usually occur on steep north-facing slopes, often on stream bluffs, but they may occasionally occur in sheltered ravines.

Soils: Soils may be any of those associated with Mesic Mixed Hardwood Forest, either Piedmont or Coastal Plain Subtype. Piedmont examples sometimes have small bedrock outcrops.

Hydrology: Sites are moist but well drained. They presumably stay moister than other mesic communities because of the cool slope aspect.

Vegetation: Vegetation usually has a forest structure but occasionally is a more open woodland. The canopy generally is dominated by *Fagus grandifolia*, alone or in combinations with *Quercus alba* or *Quercus montana*, less often with *Carya tomentosa, Carya glabra*, *Liriodendron tulipifera*, and a variety of other species. Predominant understory species are *Oxydendrum arboreum, Ilex opaca*, *Nyssa sylvatica*, *Acer rubrum*, and *Benthamidia* (*Cornus*) *florida*, with *Liquidambar styraciflua* often present. The shrub layer is dense. *Kalmia latifolia* strongly dominates in most examples, but a few examples are dominated or codominated by *Rhododendron catawbiense, Rhododendron maximum*, or *Symplocos tinctoria*. *Hamamelis virginiana* often is present. Various shrubs shared with adjacent communities are common, especially *Euonymus americana* and

Vaccinium pallidum. Herbs are sparse beneath the dense shrubs. *Galax urceolata* is most frequent, *Polystichum acrostichoides* and *Mitchella repens* are frequent, and *Epigaea repens, Hexastylis minor*, and a variety of other species may occur.

Range and Abundance: The equivalent association is ranked G2G3, but G3 likely is appropriate. This community is uncommon in the Piedmont but is scattered throughout most of the region. It is rarer in the Coastal Plain but is scattered over a large area, including a few examples overlooking tidal creeks. This community ranges to Virginia and southward to Alabama.

Associations and Patterns: Piedmont/Coastal Plain Heath Bluffs occur as small patch communities. They generally are bordered by a floodplain community below, and by Dry–Mesic Oak–Hickory Forest or Mesic Mixed Hardwood Forest above and along the bluff. Occasional examples are associated with basic communities or with cliff communities.

Variation: At least three variants can be recognized, based on the dominant shrub.

1. Mountain Laurel Variant is the most common variant, throughout the Piedmont and Coastal Plain. Its shrub layer is dominated by *Kalmia latifolia*.

2. Catawba Rhododendron Variant is dominated by *Rhododendron catawbiense*, with or without *Kalmia*. It apparently is limited to a cluster of sites in Orange and Durham counties. The disjunction is particularly notable because this species of *Rhododendron* is associated with higher elevations in the mountains.

3. Horse Sugar Variant is dominated by *Symplocos tinctoria*, usually with *Kalmia* but occasionally without it. It is confined to a few sites in the Coastal Plain.

Dynamics: Most aspects of dynamics are similar to other mesic forests. The distinctive characteristic of this community is the occurrence of disjunct populations of plants more typical of the Mountains, sometimes of animals as well. These populations are presumed to be relict since the Pleistocene, when they were more widespread in the Piedmont and Coastal Plain. They persist because of the cool microclimate of north-facing bluffs. However, it is notable that the disjunct species often are present beyond the cool bluff, in the adjacent upland forest. They presumably have spread there from the bluff, and this suggests that the confinement of these species to disjunct locations may be at least partly a result of factors other than the current climate. It is likely they were confined to the coolest bluffs at least partly by fire rather than by temperature alone. Not all cool bluffs support Heath Bluff communities, and it is likely that the warmer and drier Hypsithermal period eliminated their characteristic species from all but the most protected sites.

Comments: This community type barely ranges into Virginia. In much of the Virginia Piedmont, *Kalmia latifolia* is widespread in oak-heath forests and is not confined to cool microsites. Heath Bluff communities therefore grade into more widespread oak-heath forests, recognized in the NVC as *Quercus prinus - (Quercus coccinea, Quercus rubra) / Kalmia latifolia / Vaccinium pallidum* Forest (CEGL006299) and *Quercus alba - Quercus (coccinea, velutina, prinus) / Gaylussacia baccata* Forest (CEGL008521). A similar but less drastic blurring occurs in the Uwharrie Mountains, where *Kalmia* is more widespread in the landscape and occurs in other community types, but distinct occurrences of Piedmont/Coastal Plain Heath Bluff are still recognizable there. In the rest of the North Carolina Piedmont and Coastal Plain, *Kalmia latifolia* is scarce and is largely confined to this community type.

Fagus grandifolia - (Liquidambar styraciflua) / Oxydendrum arboreum / Kalmia latifolia Forest (CEGL004636) is a nonstandard entity in the NVC, based on results of the Roanoke River study by Rice,and Peet 1997) It is not clear that Roanoke River examples or most Coastal Plain examples are distinct from those in the Piedmont. However, some Coastal Plain examples contain a larger component of characteristic Coastal Plain species, usually including some wetland species that apparently are associated with seepage from the steep bluffs.

Pinus echinata - Pinus virginiana / Rhododendron minus - Kalmia latifolia Woodland (CEGL003563) was named as a slate slope community, based on a single site for which there is no community documentation. There is not enough evidence to support recognition of slate slopes as a distinctive type or subtype. This association, or the site on which it was based, may be best classified as a Piedmont/Coastal Plain Heath Bluff.

Rare species:
Vascular plants – *Fothergilla major, Gaylussacia brachycera, Monotropsis odorata,* and *Stewartia ovata*.

CAPE FEAR VALLEY MIXED BLUFF FOREST

Concept: Cape Fear Valley Mixed Bluff Forests are rare shrubby forests or woodlands with a distinctive mixed composition of wetland and upland species and of Piedmont and Coastal Plain species, occurring on steep bluffs with a combination of seepage and good drainage, ameliorated microclimate, and natural sheltering from fire. These communities are associated with the unusual, deeply entrenched major tributaries on the west side of the Cape Fear River in the Sandhills Region: Little River, Rockfish Creek, and Willis Creek.

Distinguishing Features: Cape Fear Valley Mixed Bluff Forest is distinguished by its distinctive mixed dominance of upland and wetland trees, generally including *Quercus alba* or *Quercus nigra* along with *Chamaecyparis thyoides*, and comparably mixed dominance of shrubs, generally including *Kalmia latifolia*, mesophytic species such as *Hamamelis virginiana*, and wetland species such as *Cyrilla racemiflora*, *Lyonia lucida*, *Clethra alnifolia*, or *Arundinaria tecta*.

Crosswalks: *Pinus taeda - Quercus alba - Chamaecyparis thyoides / Kalmia latifolia - Lyonia lucida* Forest (CEGL004304).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Atlantic Coastal Plain Mesic Hardwood Forest Ecological System (CES203.242).

Sites: Cape Fear Valley Mixed Bluff Forests occur on steep slopes of clay and sand, along deeply entrenched valleys of small rivers. The geologic processes that created their distinctive setting have not been well studied but must represent subtle regional uplift or a fall in base level. The Cape Fear River in the vicinity of Fayetteville has cut deeply below its older floodplain terraces. This has induced several of the larger tributaries in the Sandhills region to cut deep gorge-like valleys into the underlying Cretaceous sediments, leaving relict floodplain terraces far above the stream.

Soils: Soils in this community are usually mapped as Gilead (Arenic Hapludult) and are a heterogeneous mix of sand and clay.

Hydrology: Moisture levels in this community are generally mesic but may be heterogeneous on a very fine scale. The vegetation is a mix of upland and wetland species. The sandy cover at the top of the bluffs, and possibly interbedded sand layers within them, provide a source of seepage. The dense clay layers limit water penetration and may force seepage water to flow along the surface.

Vegetation: The canopy is usually dense but may be somewhat open. It has a mix of trees that is more diverse than most Coastal Plain forests, with *Chamaecyparis thyoides, Acer rubrum, Pinus taeda, Liquidambar styraciflua, Quercus alba*, and *Quercus nigra* usually present. Other species may include *Quercus falcata* and *Pinus palustris* in the upper parts and *Nyssa biflora* and *Fraxinus caroliniana* near the base. The understory usually includes *Magnolia virginiana, Ilex opaca*, and *Benthamidia* (*Cornus*) *florida*, and often also has *Oxydendrum arboreum, Persea palustris*, and sometimes *Hamamelis virginiana*, as well as canopy species. The shrub layer is dense. *Kalmia latifolia, Clethra alnifolia*, and *Lyonia lucida* are usually present. Also frequent and sometimes abundant are *Alnus serrulata, Vaccinium elliottii, Arundinaria tecta, Vaccinium arboreum*, *Ilex* *coriacea*, and *Symplocos tinctoria*. Additional species sometimes present include *Leucothoe axillaris, Gaylussacia frondosa, Vaccinium tenellum, Rhododendron periclymenoides, Rhododendron viscosum, Rhododendron arborescens, Rhododendron atlanticum, Nestronia umbellula*, *Itea virginica*, and, in one example, *Kalmia* (*Leiophyllum*) *buxifolia*. Vines are not usually prominent, but *Bignonia capreolata*, *Smilax rotundifolia*, and *Smilax glauca* may be present. The herb layer is sparse. *Mitchella repens* is the most constant species, and *Viola primulifolia* and *Agrostis perennans* are frequent. Other herb species include *Erigeron vernus, Pteridium aquilinum, Hexastylis minor* (possibly *Hexastylis sorrei*), *Epigaea repens, Galax urceolata, Lygodium palmatum, Osmundastrum cinnamomeum, Lorinseria* (*Woodwardia*) *areolata*, and *Anchistea* (*Woodwardia) virginica*. Other species unusual to the region that have been reported in this community include *Trillium catesbaei, Maianthemum racemosum, Chionanthus virginicus, Gaultheria procumbens*, and *Amsonia tabernaemontana*.

Range and Abundance: Ranked G1G2, but likely G1. This community is endemic to small parts of four counties and to three small stream systems. The distinctive geologic setting that supports it is unlikely to be found elsewhere, at least in North Carolina.

Associations and Patterns: Cape Fear Valley Mixed Bluff Forests occur as narrow bands or series of small patches along stream bluff systems. Above the bluffs they give way to longleaf pine communities, usually Pine/Scrub Oak Sandhill. The bluffs may plunge directly into the stream, or they may be bordered by Cypress–Gum Swamp or other floodplain communities below. Coastal Plain Seepage Bank communities are sometimes associated.

Variation: Examples are heterogeneous and variable from one patch to another. No pattern of variation has been identified.

Dynamics: The dynamics of this community are particularly little known. As with Piedmont/Coastal Plain Heath Bluffs, the presence of *Kalmia latifolia* and some other disjunct species probably is relict from the Pleistocene. The heterogeneous distribution of seepage is presumably an important factor in the coexistence of so many species characteristic of different conditions. Though slumps are not readily apparent, it is possible that slumping or slope movement is a periodic natural disturbance.

The role of fire in the Mixed Bluff Forest is not known. They probably are excluded from present controlled burning, and examples do not show evidence of fire. Natural fires would burn the upper edges, and might occasionally penetrate the community, but as in other mesic forests, the steep slope and nonflammable vegetation below presumably limit fire intensity and frequency.

Comments: This is one of the most enigmatic of communities in North Carolina, and it appears not to have been reported before systematic natural heritage surveys of Fort Liberty in the 1990s. Its placement with mesic forests is marginal and somewhat problematic, but its odd mix of flora makes it a poor fit in any theme. It shares the most characteristics with, and is conceptually intermediate between, Piedmont/Coastal Plain Heath Bluff, Coastal Plain Seepage Bank, Low Elevation Seep, and Sandhill Seep.

Rare species: No rare species are believed to be specifically associated with this community.

MOUNTAIN DRY CONIFEROUS WOODLANDS THEME

Concept: Mountain Dry Coniferous Woodlands are communities dominated or codominated by various species of *Pinus* or by *Tsuga caroliniana*, in upland settings. They may range from closed forests to open woodlands or savannas in natural condition, but many are believed to be more open than typical hardwood forests under natural conditions.

Distinguishing Features: Mountain Dry Coniferous Woodlands are distinguished by being dominated by *Pinus* spp. or *Tsuga caroliniana* under natural conditions, occurring in dry to mesic upland sites. A few examples of Montane Alluvial Forest, and of Swamp Forest–Bog Complex or other Mountain Bogs and Fens may be codominated by some of the same conifer species but occur on floodplain terraces or in wetlands and have flora more like other communities in those themes.

Distinguishing natural communities of this theme from successional pine forests can sometimes be difficult. Any of the pine species are capable of taking advantage of severe human disturbances such as logging and clearing and dominating stands in what would otherwise be hardwood forest sites. For *Pinus pungens* and *Pinus rigida*, this is uncommon, but *Pinus virginiana* and *Pinus strobus* dominance more often indicates an artificial community than a natural one. In addition, *Pinus strobus* has been widely planted. Successional and planted stands can often be recognized because they are floristically depauperate or occur in sites not characteristic of Mountain Dry Coniferous Woodland communities. Pine-dominated stands on flat ground or in easily accessible areas should generally be regarded as successional unless their history is known.

Sites: Most Mountain Dry Coniferous Woodland communities occur on ridge tops and upper slopes, often with southerly or westerly aspect. Most slopes are convex in shape, generally the sharpest or most convex topography in the local area. Some may be on more planar slopes of dry aspect, and a few may be in more mesic settings such as valley bottoms.

Soils: Most Mountain Dry Coniferous Woodlands occur on shallow or rocky soils, typically classified as Typic Dystrochrepts or Lithic Dystrochrepts. Fewer occur on Ultisols or on other kinds of soil. Some may be inclusions in the soil map unit.

Hydrology: Mountain Dry Coniferous Woodland sites are typically the driest, most well-drained sites in the mountain landscape. However, high rainfall or cool temperatures at higher elevations may make them less xeric than similar topographic positions elsewhere.

Vegetation: Mountain Dry Coniferous Woodlands are dominated or codominated by various combinations of *Pinus rigida, Pinus pungens, Pinus virginiana, Pinus echinata, Pinus strobus*, and *Tsuga caroliniana* under natural conditions and when not recently disturbed. Codominant hardwoods are most often *Quercus montana, Quercus coccinea*, or at lower elevations, *Quercus alba, Quercus falcata,* or *Quercus stellata*. Given the present widespread alteration of fire regimes and impacts of southern pine beetles, *Acer rubrum* and typical understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum* often are abundant in the canopy. *Castanea dentata* was probably an important component of some of these communities in the past, but the role of *C. dentata* is less well understood than it is in oak forests. The canopy in most examples of most of the communities probably was naturally at least somewhat open, though some probably had dense canopies. Most examples at present have dense shrub layers, usually dominated by *Kalmia latifolia* but potentially including several other species, such as *Gaylussacia baccata, Rhododendron* spp., *Clethra acuminata*, *Eubotrys recurvus*, *Lyonia ligustrina* var. *ligustrina*, and *Vaccinium* spp. In the past, with more frequent fire, Mountain Dry Coniferous Woodlands are thought to have had less shrub cover and to have had well-developed grassy herb layers.

Dynamics: The dynamics of Mountain Dry Coniferous Woodlands, especially the yellow pine communities, have been of great research interest for several decades, with an acceleration of interest in the last 20 years. The more recent focus coincides with an increased interest in the historical role of fire and in prescribed burning in the Central and Southern Appalachians in general. Several dendrochronological and fire-scar studies have given evidence of past fire regimes (e.g., Aldrich et al. 2009; Cohen et al. 2007; Lafon et al. 2017), while widespread presence of charcoal in the soil also attests to the occurrence of fire (Welch 1999). Trees old enough to give evidence about these communities in pre-European times are sparse, making the picture of that time much less clear than in the time of heavy later human influence.

Nevertheless, it is clear that fire has long been the major ecological process in pine communities. These communities occur on the parts of the landscape most prone to lightning, most prone to ignition if exposed to fire, and most likely to burn intensely. Serotinous cones in *Pinus pungens* provide evidence that it is highly adapted to regeneration after fire. Epicormic sprouting in *Pinus rigida* and seedling morphology in *Pinus echinata*, in addition to thick bark in all these species, suggest adaptation to surviving fire. *Pinus virginiana* is generally known to be intolerant of fire, but it successfully seeds into disturbed areas. Multiple field observations, demographic studies, and experimental prescribed burns have given information on the effects of fire in the present day. However, the specific role of fire in maintaining these communities remains unclear in several ways, with contradictory results in the literature suggesting that important aspects of fire ecology are not yet understood.

A primary question related to understanding the dynamics of Mountain Dry Coniferous Woodlands is the mechanism of pine regeneration. Racine (1966) was one of several early authors who thought that pine communities were physiographic or edaphic climaxes, not dependent on widespread disturbance for their maintenance in the landscape, and Barden (2000) noted that pines were reproducing in the absence of fire, though drought changed the ability of seedlings to survive across the time span of his study. There seems to be a widespread belief that pine communities must be regenerated by catastrophic disturbance, a belief perhaps partially fueled by the occurrence of even-aged stands that regenerated after logging or field abandonment, which may or may not reflect natural conditions. However, Williams and Johnson (1992), Williams (1998), and Barden (2000) are among those who have noted that older natural pine communities are multi-aged, suggesting periodic recruitment without stand destruction, though perhaps still in response to fire. Barden (2000) noted that pines had successfully regenerated every decade from 1877-1976 in his study site.

There is a widespread belief that pines cannot reproduce without bare mineral soil, and that fire is crucial for providing a suitable seedbed. Williams (1998) indicated that ice storms, producing canopy opening but not removing litter, favored oaks rather than pines. Pine stands killed by southern pine beetles and not burned often have little or no pine regeneration. However, Williams et al. (1990), in experiments, found that pine seedlings did best with pine litter and that survival was low without daily watering in treatments with no litter, though oak litter was also harmful to seedling success. Williams and Johnson (1992) noted seedlings growing in up to 3 inches of duff and concluded that severe fire was not needed for reproduction. Reduction of competition, generally implied to be competition for light, is also suggested as important for pine regeneration. Williams (1998) indicated that regeneration was best after severe fire, such as that following insect-mediated mortality or occurring during drought, even though he acknowledged that presettlement fire was frequent and of low intensity. Waldrop et al. (2000) noted that experimental burns at three different intensities all failed to allow pines to regenerate because of dense hardwood sprouts, and that the most intense fire was the least successful. They suggested multiple low-intensity fires as a better approach to regeneration.

These apparently contradictory conclusions may be explainable by differences in the examples and circumstances under study. Canopy opening may be important where the canopy is dense but not in the driest sites or where the canopy is kept open by rockiness. Given the dense shrub layer in so many pine forests at present, fire may be more essential for reducing competition in that stratum than in the canopy. Canopy opening may be needed for pine regeneration, but, as in many other kinds of forest, small single-tree gaps may be sufficient, or may have been sufficient in the more open canopies that prevailed when fire occurred more regularly. Reduction of litter and duff by fire may be crucial in some circumstances, when the accumulation is very thick or where it contains too much oak or evergreen ericaceous litter, but not otherwise. Vigorous hardwood resprouting may be an important limitation on pine recruitment where pine was a minority of the previous stand or where hardwoods were dense in either the canopy or the understory. In some places, pines may fail to persist because they were playing a successional role following logging or clearing, on sites where pine would not dominate naturally. In other cases, the effects of fire suppression may have gone too far to be reversed quickly. White (1987) offered a state-transition model for pine communities of the Great Smoky Mountains and suggested that oak dominance could form an alternative stable state on the same sites. With enough hardwood dominance, it is reasonable to expect that multiple fires at greater frequency may be needed, rather than a single fire, to bring the hardwoods under control. However, most pine seedlings are not likely to survive fires, so successful replacement of canopy pines may never occur if fire remains too frequent. In addition, since multiple fires and multiple seeding events may be needed to establish a new pine cohort, loss of too many of the canopy pines due to intense fire, insect mortality, or logging can make regeneration of pines unlikely. If hardwoods other than oaks, including understory species, are well established, catastrophic disturbance may lead to dominance by their sprouts rather than to successful regeneration of either pines or oaks. It should also be noted that, if there is no catastrophic disturbance, sporadic regeneration in smaller canopy gaps, if successful, is all that is needed to perpetuate pine dominance. However, pine communities appear to be more prone to catastrophic disturbance than most of our natural communities, so natural dynamics likely include a combination of disturbance intensities.

Besides the dominant role of fire, the dynamics of yellow pine-dominated communities are potentially strongly affected by the southern pine beetle (*Dendroctonus frontalis*) and potentially by other insects. This species is native to the area and at normal endemic levels it is confined to preying on weakened and dying trees. In times of drought, and potentially other stresses, insect populations can build up to levels that can overwhelm and kill even healthy trees. While this is presumably a natural phenomenon in the region, it is possible that the increased extent of dense even-aged successional pine stands, with many trees reaching high susceptibility at the same time, has exacerbated the intensity of outbreaks. Southern pine beetle attacks during outbreaks act as catastrophic disturbances to yellow pine communities, killing all or most of the mature trees.

The intense research interest in the dynamics of yellow pines is not paralleled for the other conifers in this theme, particularly for *Tsuga caroliniana*. What is known is discussed within the descriptions of White Pine Forest and Carolina Hemlock Forest communities.

KEY TO MOUNTAIN DRY CONIFEROUS WOODLANDS

1. Canopy dominated or codominated by *Tsuga caroliniana*, or dominated by it until recent hemlock wooly adelgid mortality.

2. *Tsuga caroliniana* codominant with *Pinus rigida, Pinus pungens*, or *Pinus virginiana*..**Carolina Hemlock Forest (Pine Subtype)**

2. Pines a minor component or absent; *Tsuga caroliniana* solely dominant or codominant with *Tsuga canadensis* or other species.

3. Community in a mesic site, generally on a lower slope or valley bottom; *Tsuga canadensis* or mesophytic hardwoods often codominant; shrub layer often dominated by *Rhododendron maximum*. ....**Carolina Hemlock Forest (Mesic Subtype)**

3. Community in a dry site, generally on upper slopes or ridge tops; shrub layer generally dominated by *Kalmia latifolia*. ....**Carolina Hemlock Forest (Typic Subtype)**

1. Canopy dominated by *Pinus* spp., or codominated by *Pinus* with *Quercus* spp. or species other than *Tsuga*.

4. Canopy naturally dominated by *Pinus strobus*...**White Pine Forest**

4. Canopy naturally dominated by *Pinus virginiana, rigida, pungens*, or *echinata*, or codominated by these species along with *Quercus* spp.; if *Pinus strobus* is present, it is in small to moderate amounts or represents altered composition.

5. Canopy dominated by *Pinus echinata*, at least weakly...**Low Mountain Pine Forest (Shortleaf Pine Subtype)**

5. Canopy not dominated by *Pinus echinata*, though the species may be present in small to moderate amounts.

6. Canopy a relatively even mix of pines and oaks; canopy contains species indicative of low elevation dry conditions (*Pinus echinata, Quercus falcata, Quercus stellata, Quercus marilandica, Carya pallida*) or there is evidence that it did in the past.

7. Canopy naturally very open and persistently small in stature. ....**Southern Mountain Xeric Pine–Oak Woodland**

7. Canopy closed or somewhat open, normal in stature for its maturity. ....**Southern Mountain Pine–Oak Forest**

6. Canopy dominated by *Pinus rigida, virginiana*, or *pungens*, with few oaks or with only *Quercus montana* and *Quercus coccinea* abundant; species indicative of low elevation dry conditions present or not.

8. Canopy containing species indicative of low elevation dry conditions (*Pinus echinata, Quercus falcata, Quercus stellata, Quercus marilandica, Carya pallida*), at least in small numbers, though dominated by *Pinus virginiana, rigida*, or *pungens*; community occurring at low elevations, generally below 2500 feet ....**Low Mountain Pine Forest (Montane Pine Subtype)**

8. Canopy containing no species indicative of low elevation dry conditions, even in small numbers; canopy dominated by *Pinus virginiana, rigida*, or *pungens*; community generally occurring above 2000 feet but potentially lower in appropriate sites.

9. Community occurring at higher elevations, above 3500 feet; shrub layer containing appreciable *Rhododendron catawbiense*, which is often codominant with *Kalmia latifolia*; *Eubotrys recurvus* often fairly abundant ....**Pine–Oak/Heath (High Elevation Subtype)**

9. Community occurring at elevations below 3500 feet; *Rhododendron catawbiense* absent, or, if rarely present, low in abundant; *Eubotrys recurvus* abundant or not.

10. Community occurring in Linville Gorge or potentially in similar gorges with extremely acidic substrates; *Rhododendron carolinianum* generally abundant; *Eubotrys recurvus* and other species shared with the High Elevation Subtype (excluding *Rhododendron catawbiense*) often abundant ……………………….. ....**Pine–Oak/Heath (Linville Gorge Subtype)**

10. Community not occurring in Linville Gorge, but potentially anywhere else in the Mountains or foothills; shrub layer not as above, generally lacking *Rhododendron carolinianum* and having little or no *Eubotrys recurvus*. …………………………………………………… **Pine–Oak/Heath (Typic Subtype)**

PINE–OAK / HEATH (TYPIC SUBTYPE)

Concept: Pine–Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate or higher elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The Typic Subtype covers the common examples at lower to mid elevations, lacking high elevation species such as *Rhododendron catawbiense*.

Distinguishing Features: Pine–Oak/Heaths are distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Beetle-killed stands generally are dominated by understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum*, with oaks less abundant than in typical oak forests. Stands that have seen increases in oaks because of fire suppression or logging often have more abundant *Quercus coccinea* than *Quercus montana*, and they tend to have abundant *Acer rubrum*. However, it may not be possible to know if a *Quercus montana* forest with a minority component of pine might be pine-dominated under a more natural fire regime.

Carolina Hemlock Forest (Pine Subtype) is distinguished from Pine–Oak/Heath by a dominance or codominance of *Tsuga caroliniana*. If hemlock woolly adelgids have killed the hemlocks, the community may closely resemble Pine-Oak Heath, and it is unclear whether Carolina Hemlock Forest (Pine Subtype) may ever recover.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit, Low Elevation Granitic Dome, or High Elevation Granitic Dome communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

The distinction between Pine–Oak/Heath and Low Mountain Pine Forest (Montane Pine Subtype) can be particularly subtle. Low Mountain Pine Forests always occur below 2000-2500 feet in elevation and are indicated by the presence of species confined to low elevations, such as *Pinus echinata, Quercus falcata, Quercus stellata*, and *Quercus marilandica*. *Pinus virginiana* is more likely to be abundant, at least under current conditions. They also tend to have a greater diversity of shade-intolerant herbs, which are more abundant in burned examples. *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Lysimachia quadrifolia, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens, Symphyotrichum patens*, and *Scleria triglomerata/nitida* are species that are generally more frequent and abundant in Low Mountain Pine Forest, though many can also occur in Pine–Oak/Heath (Wentworth et al. in prep). *Quercus velutina, Carya pallida, Carya glabra, Carya tomentosa, Ilex montana, Castanea pumila, Vaccinium stamineum, Rhus copallinum*, and *Magnolia fraseri* are also more frequent in Low Mountain Pine Forest. A few species are more typical of Pine–Oak/Heath, including *Rhododendron catawbiense*, *Eubotrys recurvus*, and *Clethra acuminata*. Nevertheless, many stands at low elevation have none of the definitive indicator species and appear indistinguishable from Pine–Oak/Heath communities at higher elevation. See the discussion in the Comments section below about this ambiguity. A careful search of the vicinity, including roadsides and forest edges, may reveal indicator species that have been lost from the interior of the stand. However, some stands cannot be definitively classified with our current level of understanding.

The Typic Subtype is distinguished from the High Elevation Subtype by the absence or near absence of higher elevation species, especially *Rhododendron catawbiense*. Additional species occur in all subtypes but are less frequent and abundant in the Typic Subtype, including *Eubotrys recurvus, Vaccinium simulatum,* and *Clethra acuminata*. Species shared with Low Mountain Pine Forest are generally completely absent in the High Elevation Subtype.

The Typic Subtype is easily distinguished from the Linville Gorge Subtype by location. That subtype is not known outside of Linville Gorge, and the Typic Subtype is not known within it. Vegetational distinctions of the Linville Gorge Subtype include abundant *Rhododendron carolinianum,* frequent *Eubotrys recurvus* at elevations below that of the High Elevation Subtype, and frequent *Symplocos tinctoria* at elevations above that of Low Mountain Pine Forest.

Crosswalks: *Pinus pungens - Pinus rigida - (Quercus montana) / Kalmia latifolia - Vaccinium pallidum* Woodland (CEGL007097).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).

Sites: Pine–Oak/Heath communities occur on ridge tops, spur ridges, and convex upper slopes. Their topography often is notably sharper than that of nearby ridges. Small rock outcrops may be present but are not extensive. The Typic Subtype generally occurs below 3500 feet elevation, though it may range higher in more southerly areas. It generally occurs above 2000 feet in elevation, but occasional examples are lower. See the discussion below on the uncertain identity of some lower elevation stands.

Soils: Soils of the Typic Subtype are generally rocky and often shallow. Mapped series are widely variable. Many are mapped as Typic Dystrudepts (Ashe, Chestnut, Buladean, Soco, Edneyville) or Lithic Dystrudepts (Cleveland), but many are mapped as Typic Hapludults (Evard, Cowee, Tate, Brasstown, Junaluska, Sauratown).

Hydrology: Pine–Oak/Heaths are dry to xeric because of rapid drainage caused by their topography. They occur in the driest parts of the landscape.

Vegetation: The Typic Subtype usually has an open canopy. Canopies are thought to have typically less than 60 percent cover but may sometimes be denser, particularly if fire has not occurred for a long time. The canopy is dominated by varying combinations of *Pinus rigida* and *Pinus pungens*, sometimes with abundant *Pinus virginiana*. Other tree species that are highly constant in CVS plot data (Wentworth et al. in prep) and field observations, in either the canopy or understory, include *Quercus montana, Quercus coccinea, Oxydendrum arboreum, Nyssa sylvatica*, and *Acer rubrum*. Also frequent are *Pinus strobus, Tsuga caroliniana, Tsuga canadensis, Quercus alba, Quercus velutina*, *Castanea dentata, Amelanchier* sp., and *Magnolia fraseri*. These species likely have increased significantly as a result of fire suppression, and it is possible that only the most fire-tolerant — *Quercus montana* and *Oxydendrum arboretum* —

would be frequent under a natural fire regime. Virtually all examples have a dense shrub layer dominated by *Kalmia latifolia*. *Vaccinium pallidum* is highly constant but not nearly as abundant. Other frequent shrubs include *Gaylussacia baccata, Symplocos tinctoria, Lyonia ligustrina, Eubotrys recurvus, Castanea pumila*, and, in the southern part of the state, *Gaylussacia ursina* and *Vaccinium hirsutum*. *Smilax glauca* and *Smilax rotundifolia* are frequent. The shrub layer likely would be less dense and probably less strongly dominated by *Kalmia* with more frequent fire. The herb layer is generally sparse in existing examples, with the only frequent species being *Galax urceolata, Chimaphila maculata, Pteridium latiusculum, Epigaea repens*, and *Iris verna*. Additional herbaceous species would likely be more abundant with more frequent fire, including *Danthonia spicata, Xerophyllum asphodeloides, Schizachyrium scoparium, Coreopsis major, Baptisia tinctoria*, and perhaps others considered more typical of lower elevation communities.

Range and Abundance: Ranked G3. The Typic Subtype is distributed across the interior of the Blue Ridge, throughout the Blue Ridge escarpment, and is present in the foothills. A few disjunct occurrences are present farther east, such as in the Sauratown Mountains. The NVC association is attributed to all of North Carolina's neighboring states and to Kentucky.

Associations and Patterns: All subtypes of Pine–Oak/Heath are treated as small patch communities. Occurrences are fairly small and are not predictable. All may once have occurred more regularly in mountain landscapes and have behaved as a matrix community in appropriate landscapes. The Typic Subtype most often grades to Chestnut Oak Forest (Dry Heath Subtype), but it may be associated with other subtypes of Chestnut Oak Forest, Montane Oak–Hickory Forest, or other oak communities. Rock outcrop or glade communities may be embedded in it or occur nearby. Carolina Hemlock Forests, both the Typic and Pine Subtype, often occur in similar topographic settings and may be associated. In areas with a substantial range in elevation, the Typic Subtype may give way to the High Elevation Subtype or to Low Mountain Pine Forest.

Variation: The Typic Subtype is highly heterogeneous, within and among stands. Preliminary data analysis by Wentworth et al. (in prep.) found a strong signal of geographic variation, but one that was too irregular to use as a basis for classification. The dominant pine species are often patchy within stands, with portions dominated by two or all three of the species. Variations in combinations of the dominant species do not appear to be a good basis for finer classification. There is also substantial variation in the shrub layer, which may be more useful for finer distinctions. Density or cover of shrubs may be modified by fire history, but the dominant species is more likely to endure. Variants are tentatively recognized on this basis, to encourage further investigation of their stability and usefulness.

1. Evergreen Heath Variant is the most typical vegetation, with Kalmia latifolia dominating the shrub layer. Examples dominated by Rhododendron minus or Rhododendron smokianum, if found, may also be included here, but may warrant their own variants.

2. Typic Deciduous Heath Variant has limited Kalmia and has a shrub layer dominated by Vaccinium pallidum or Gaylussacia baccata. It may represent a geographic variant primarily north of Asheville, but this is uncertain. It may be widespread farther south.

3. Southern Deciduous Heath Variant has a shrub layer dominated by species confined to south of Asheville, usually Gaylussacia ursina but potentially Vaccinium hirsutum. This variant may be transitional to Low Mountain Pine Forest.

Dynamics: Dynamics for the Typic Subtype are likely similar to the general patterns described for the theme. Because Pine–Oak/Heath communities occur on sharp ridge tops, they are targets for lightning and may be naturally ignited more often than any other montane community. Fire ignited may or may not spread far downhill, resulting in a fire frequency greater than the surrounding landscape, although this is not an established fact.

There is widespread consensus that mountain pine communities have been changed as a result of fire suppression, though there is less consensus on precisely what they looked with a natural fire regime. More open canopies with less hardwood, especially lower density and cover of fire-intolerant trees such as *Acer rubrum* and *Quercus coccinea*, seem certain. How much the more fire-tolerant *Quercus montana* was reduced is less clear. Presumably the amount of *Pinus strobus* was less. However, established *Pinus strobus* can tolerate significant levels of fire, and this species may have been a persistent component.

Despite acceptance of the importance and past frequency of fire in Pine–Oak/Heath, the environmental and dynamic factors that determine the boundary between Pine–Oak/Heath and Chestnut Oak Forest are not entirely understood. Predictive models often suggest Pine–Oak/Heath should cover all ridge tops but as is readily observed and was noted by Racine (1966), its present occurrence can often be observed to be tied to particularly sharp ridges, a distinction not generally obvious in the digital elevation models used for terrain analysis. Pine–Oak/Heath often is confined to the sharpest ridges even where these occur below the main ridge line and would presumably be less exposed to lightning. However, in other places, patches can be found on broader ridge tops.

The extent of intact Pine–Oak/Heath has greatly declined in recent decades, and areas dominated by *Quercus coccinea* and understory tree species often indicate places where it recently occurred. Evidence of replacement of Pine–Oak/Heath by mature *Quercus montana* stands is not clear. *Quercus montana* is a long-lived, fire-tolerant species; once established, it would likely survive fire frequencies nearly as great as those that support Pine–Oak/Heath. It is unclear if these communities existed as a shifting mosaic or as long-term patches stabilized by site characteristics and vegetation feedbacks.

Comments: Pine–Oak/Heath and Low Mountain Pine Forests collectively are very distinctive and are recognized by most local vegetation studies such as Whittaker (1954), Dumond (1969), Cooper and Hardin (1970), McCurdy (1975), McLeod (1988), and Newell (1997).

Some literature has suggested subdivisions of the pine communities, particularly along a gradient from dominance by *Pinus virginiana* at lower elevations to *Pinus rigida* at intermediate elevations to *Pinus pungens* at the highest elevations (Whittaker 1954). This roughly corresponds to the gradient from Low Mountain Pine Forest to the Typic Subtype to the High Elevation Subtype. However, the pine species do not sort as well as suggested. *Pinus rigida* is abundant at all elevations and in all communities. *Pinus pungens* is more abundant in the High Elevation Subtype, but it occurs across the full range of elevation and can dominate at low elevations. *Pinus virginiana* is generally absent in the High Elevation Subtype and is more abundant in Low Mountain Pine Forest but may be dominant in Pine–Oak/Heath (Typic Subtype).

The distinction between Pine–Oak/Heath (Typic Subtype) and Low Mountain Pine Forest (Montane Pine Subtype) remains particularly problematic. Occurrence of different pine species at lower elevations is irregular and is probably tied to community fire dynamics and the history of logging and southern pine beetle disturbance. Most examples of Pine–Oak/Heath and Low Mountain Pine Forest are dominated by a mixture of at least two of the same pine species. Certain tree species confined to lower elevations — *Pinus echinata, Quercus falcata, Quercus stellata*, and slightly less narrowly, *Quercus marilandica* — definitively indicate Low Mountain Pine Forest. A more diverse suite of shade-intolerant herbs (e.g., *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens,* and *Symphyotrichum patens*) is somewhat correlated with the presence of these trees. These species undoubtedly were much more abundant when fire was more frequent. However, many plots and site descriptions from elevations below 2000 feet lack all of these species and are indistinguishable from examples of the Typic Subtype at middle elevations. Field observations by the author, site surveys by numerous biologists, and multiple approaches to plot data analysis by Wentworth et al. (in prep) have found overlap among vegetation groupings at lower elevations.

It is possible that the widespread lack of fire and other alterations have led to the loss of all plant species that might definitively separate Pine–Oak/Heath (Typic Subtype) and Low Mountain Pine Forest (Montane Pine Subtype). However, it is also possible that some lower elevation sites, by virtue of slope aspect or other aspects of the physical environment, allow characteristic Pine–Oak/Heath vegetation to naturally exist. It does not appear that the ambiguous low elevation communities are more altered than other communities that fit the central concepts of the communities better. It is possible that an increase in prescribed burning will reveal additional differences, but this will take time. Single burns, and even several burns, can drastically change the vegetation structure of a stand, can induce proliferation of weedy species, but are slow to change the composition of more enduring species.

The NVC associations that represent Low Mountain Pine Forest (Montane Pine Subtype), especially *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119), also reflect some ambiguity. The latter appears to be described with a very wide range of vegetation and is attributed to a very large geographic, physiographic, and geologic range. This is discussed further in the Low Mountain Pine Forest description.

Rare species:
Vascular plants – *Dendrolycopodium hickeyi, Eurybia spectabilis, Fothergilla major, Hexastylis contracta, Juniperus communis* var. *depressa*, *Lysimachia fraseri, Monotropsis odorata, Quercus ilicifolia, Robinia hispida* var. *kelseyi, Thermopsis fraxinifolia,* and *Thermopsis mollis*.

Vertebrate animals – *Neotoma magister.*

Invertebrate animals – *Patera clarki Nantahala.*

PINE–OAK / HEATH (HIGH ELEVATION SUBTYPE)

Concept: Pine-Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate or higher elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The High Elevation Subtype covers higher elevation examples, generally above 3500 feet, containing *Rhododendron catawbiense*.

Distinguishing Features: Pine-Oak/Heaths are generally distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Beetle-killed stands generally are dominated by understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum*, with oaks less abundant than in typical oak forests. Stands that have seen increases in oaks because of fire suppression or logging often have more abundant *Quercus coccinea* than *Quercus montana*, and they tend to have abundant *Acer rubrum*. However, it may not be possible to know if a *Quercus montana* forest with a minority component of pine might be pine-dominated under a more natural fire regime.

Carolina Hemlock Forest (Pine Subtype) is distinguished by a dominance or codominance of *Tsuga caroliniana*. If hemlock woolly adelgids have killed the hemlocks, it may be difficult to distinguish.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit, Low Elevation Granitic Dome, or High Elevation Granitic Dome communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

The High Elevation Subtype is distinguished from the Typic Subtype and Linville Gorge Subtype of Pine-Oak/Heath by the presence of characteristic high elevation species, particularly *Rhododendron catawbiense*. The canopy may be dominated by either *Pinus rigida* or *Pinus pungens*. A high frequency of several other species, including *Eubotrys recurvus*, also distinguishes the High Elevation Subtype from the Typic Subtype but is shared with the Linville Gorge Subtype.

Crosswalks: *Pinus rigida - (Pinus pungens) / Rhododendron catawbiense - Kalmia latifolia / Galax urceolata* Woodland (CEGL004985).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine WoodlandGroup.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).

Sites: The High Elevation Subtype occurs in sites similar to the Typic Subtype, primarily sharp ridge tops and, less often, shallow-soil areas near rock outcrops. It typically occurs at elevations from 3500 feet to as high as 4800 feet.

Soils: As in other Pine–Oak/Heaths, soils of the High Elevation Subtype are generally rocky and often shallow. Mapped soils include Typic Dystrudepts (Ashe, Chestnut), Lithic Dystrudepts (Cleveland), Typic Humadepts (Wayah, Plott) and Humic Dystrudepts (Porters).

Hydrology: The High Elevation Subtype occurs in the driest parts of the landscape, with sites well drained because of sharply convex slopes. Sites are presumably less xeric than those of the Typic Subtype because of the cooler high elevation climate and possibly higher rainfall.

Vegetation: The High Elevation Subtype is most often dominated by *Pinus rigida*, but *Pinus pungens* is frequent and may dominate patches. *Pinus virginiana* is moderately frequent but seldom has much cover. *Quercus montana* occurs with high constancy in plots and *Quercus coccinea* and *Pinus strobus are* frequent and sometimes abundant. *Tsuga caroliniana* and *Tsuga canadensis* are also fairly frequent. Dominant understory trees with high constancy in CVS data (Wentworth et al. in prep) are *Acer rubrum, Nyssa sylvatica*, and *Amelanchier laevis*, while *Oxydendrum arboreum* is almost as frequent and potentially abundant. Other frequent understory tree species include *Sassafras albidum* and *Castanea dentata* sprouts. *Picea rubens* occasionally occurs. The shrub layer is usually dense under present conditions. It is typically codominated by *Kalmia latifolia* and *Rhododendron catawbiense*. *Eubotrys racemosus* is also highly constant and occasionally abundant. Other frequent shrubs include *Clethra acuminata, Vaccinium corymbosum, Gaylussacia ursina, Gaylussacia baccata, Vaccinium pallidum, Hamamelis virginiana, Symplocos tinctoria,* and *Ilex montana*. *Lyonia ligustrina, Vaccinium corymbosum,* and *Rhododendron carolinianum* may also be present. *Smilax rotundifolia* is highly constant though seldom with high cover. The herb layer is generally sparse, but *Galax urceolata* is highly constant and sometimes has very high cover. *Gaultheria procumbens, Epigaea repens, Chimaphila maculata, Goodyera pubescens, Schizachyrium scoparium*, *Pteridium latiusculum*, and *Melampyrum lineare* are also present. With more frequent burning, some of the shade-intolerant herbs listed for the Typic Subtype might occur, but the higher elevation would exclude some.

Range and Abundance: Ranked G2. The High Elevation Subtype is much rarer than the Typic Subtype, with fewer than 20 occurrences widely scattered throughout the Mountain region. It may be endemic to North Carolina but is questionably attributed by the NVC to Tennessee. The High Elevation Subtype appears to be rarer not only because there is less acreage at higher elevations but because it is less likely to occur in intact landscapes in its elevational range.

Associations and Patterns: All subtypes of Pine–Oak/Heath are treated as small patch communities. Patches are fairly small and are not predictable, but sometimes occur in clusters that occasionally add up to dozens of acres.

Variation: The High Elevation Subtype is less heterogeneous than the Typic Subtype and may be more narrowly defined. No variants are recognized.

Dynamics: The general dynamics of pine communities discussed for the theme apply to the High Elevation Subtype. The reasons why the High Elevation Subtype is rarer than the Typic Subtype are unclear. It may be that the cooler temperatures and higher rainfall at higher elevations lead to fewer fires or to more rapid growth of hardwoods when fire is suppressed. Given the lower herb diversity, it is unclear if the High Elevation Subtype would have as much herb cover as lower elevation pine communities if burned more frequently. However, the slow recovery of *Kalmia latifolia* and likely *Rhododendron catawbiense* after fire suggest it would be less shrubby.

Comments: Some authors, such as Whittaker (1956) have discussed variation in pine communities with elevation. However, the patterns of vegetation mentioned, such as an elevation gradient from *Pinus virginiana* to *Pinus rigida* to *Pinus pungens,* does not appear to work in general. While *Pinus virginiana* is uncommon in the High Elevation Subtype, the other two primary pines may dominate anywhere in the elevational range of pine communities.

Rare species:
Vascular plants – *Thermopsis fraxinifolia, Rhododendron vaseyi,* and *Robinia hartwigii.*

PINE–OAK/HEATH (LINVILLE GORGE SUBTYPE)

Concept: Pine–Oak/Heath communities are naturally open-canopy woodlands of sharp ridges and dry slopes at moderate elevations, dominated by yellow pines. They generally have a dense shrub layer but may have been more open and herb-dominated when regularly burned in the past. The Linville Gorge Subtype encompasses the distinctive communities occurring in Linville Gorge and potentially in other gorge settings with quartzite substrate, which share characteristics of both the Typic Subtype and High Elevation Subtype.

Distinguishing Features: Pine–Oak/Heaths are distinguished from various oak forests by a greater proportion of pine cover or basal area in the canopy under natural conditions. This can be a difficult distinction to make if southern pine beetles have killed the canopy pines long enough ago that snags are not visible, or if long absence of fire has led to proliferation of oaks in formerly open Pine–Oak/Heath. Extreme wildfires also can confuse the distinction.

The Linville Gorge Subtype is easily distinguished from the Typic Subtype by its occurrence in Linville Gorge at elevations below 3500 feet. It has not been found elsewhere, but it could occur in other topographically sheltered sites with quartzite subtypes. Vegetational characteristics that are distinctive to it include abundant *Rhododendron carolinianum,* frequent *Eubotrys recurvus* at elevations below that of the High Elevation Subtype, and frequent *Symplocos tinctoria* at elevations above that of Low Mountain Pine Forest.

The High Elevation Subtype also occurs in Linville Gorge at elevations above 2500 feet. It may be distinguished by a codominance or substantial presence of *Rhododendron catawbiense*.

Vegetation similar to Pine–Oak/Heath may be present as patches in Low Elevation Rocky Summit and other rock outcrop communities. In general, these patches should be treated as part of the rock outcrop community unless they occupy an area several acres in extent or an area larger than the open zones of the rock outcrop.

Crosswalks: No NVC equivalent. A new association needs to be created.
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).

Sites: The Linville Gorge Subtype occurs on spur ridges and convex slopes within the gorge, probably most on a substrate of quartzite. The combination of local topographic exposure with broader scale topographic sheltering may be distinctive.

Soils: Soils are rocky, often thin, and probably are more extremely acidic than in other subtypes. They are mapped as various Typic Dystrudepts (Soco, Ditney, Ashe, Chestnut, Buladean, Stecoah) or Lithic Dystrudepts (Unicoi, Cleveland).

Hydrology: Sites are very well drained and dry.

Vegetation: The Linville Gorge Subtype is presumed to naturally have an open canopy similar to other Pine–Oak/Heaths, but at present the canopy can range from closed to open to sparse. In many places, most trees may have been recently killed by wildfire or southern pine beetles. The canopy is usually dominated by a mix of *Pinus pungens* and *Pinus rigida*. In CVS plots, *Quercus montana* and *Pinus strobus* presently are highly constant and occasionally locally codominant. Other frequent canopy species in plots include *Pinus virginiana, Quercus coccinea,* and *Tsuga caroliniana*. Highly constant or frequent understory trees that may be abundant include *Acer rubrum, Nyssa sylvatica,* and *Oxydendrum arboreum. Amelanchier arborea/laevis* and *Sassafras albidum* are also frequent. The shrub layer is generally dense, sometimes extremely so. *Kalmia latifolia* is constant and usually dominates, but *Rhododendron carolinianum* dominates or codominates in about half of plots and *Vaccinium pallidum* is also highly constant and sometimes locally dominant. Other constant or frequent shrubs include *Eubotrys recurvus, Gaylussacia baccata,* and *Symplocos tinctoria*, all of which may be fairly abundant. *Lyonia ligustrina, Castanea pumila, Hamamelis virginiana, Vaccinium stamineum, Vaccinium simulatum, Rhododendron maximum,* and *Fothergilla major* are also frequent in plots, but some of these might be not be characteristic under a more natural fire regime. Also perhaps characteristic is *Clethra acuminata*. *Smilax rotundifolia* and *Smilax glauca* are highly constant. The herb layer is generally sparse, but dense patches of *Galax urceolata* may occur. Other frequent species include *Gaultheria procumbens, Epigaea repens, Xerophyllum asphodeloides, Iris verna, Hexastylis shuttleworthii, Hexastylis virginica, Chimaphila maculata,* and *Pteridium latiusculum*. At lower elevations, *Coreopsis major, Schizachyrium scoparium, Danthonia sericea*, and *Hieracium venosum* also become more frequent.

Range and Abundance: This subtype is known only from Linville Gorge, forming a fairly small minority of the vegetation in an area of roughly 10,000 acres. No G-rank has been assigned, but this community would be G1 or G2 in light of its narrow endemic range and limited extent.

Associations and Patterns: The Linville Gorge Subtype is a small patch community, but one that may have many patches within the site, so that the acreage is substantial. It is associated primarily with Chestnut Oak Forest (Dry Heath and White Pine Subtypes). Low Elevation Rocky Summit and Montane Cliff communities are often adjacent or nearby. Canada Hemlock Forest, Acidic Cove Forest, and Carolina Hemlock Forest may also be adjacent or nearby.

Variation: Two variants are recognized based on analysis of plot data.

1. Typic Variant occurs from roughly 2000 feet to 3500 feet in elevation and best fits the vegetation described above. It has limited *Pinus virginiana* and more abundant *Pinus pungens*.

2. Low Elevation Variant occurs below roughly 2000 feet. It has similar vegetation but has high constancy of *Pinus virginiana*, limited *Pinus pungens*, and sometimes has a few species more associated with Low Mountain Pine Forest. These include *Quercus marilandica, Coreopsis major, Schizachyrium scoparium,* and *Pityopsis graminifolia*. However, it has less of the characteristic species of lower elevation than does typical pine forest at similar elevations.

Dynamics: Dynamics are probably generally similar to those for other Pine–Oak/Heath subtypes, but the topography of Linville Gorge may modify the fire regime. Though the rim appears to be highly prone to lightning fire ignition, steep slopes and abundant rock outcrops must often limit spread of fires downhill. Recent wildfires have shown some extreme behavior when spreading uphill when they have spread to the bottom of the gorge. The fire regime may thus be one of less frequent but more catastrophic natural fire. This needs further investigation. As in other dry mountain communities, modern fire suppression has undoubtedly modified the fire regime and led to changes in the vegetation.

It is not entirely clear what factors lead to the distinctness of Pine–Oak/Heath in Linville Gorge, nor why it appears to have species of high elevations extending farther downhill. The topographic sheltering by the gorge walls or the different fire regime may be responsible.

Comments: Linville Gorge has the most intensively sampled pine vegetation, thanks to the work of Claire Newell (1997). The Linville Gorge Subtype was newly recognized during the final stages of preparation of 4th Approximation community descriptions. Intensive analysis of CVS plot data (Wentworth et al. in prep) identified anomalies in vegetation patterns that were associated almost exclusively with plots from Linville Gorge. These plots, though at middle elevations, clustered with plots of the High Elevation Subtype, yet lacked the characteristic abundance of *Rhododendron catawbiense*. Other species that generally increase with higher elevation, such as *Eubotrys recurvus*, were nevertheless abundant. *Rhododendron carolinianum*, absent in most pine communities, was abundant. These characteristics led to the decision to recognize this subtype. There remains some uncertainty how to treat the lower elevation portions of this community. Plots in the normal lower elevational range of Low Mountain Pine Forest in Linville Gorge separate from the middle elevation Linville Gorge plots but also separate from other Low Mountain Pine Forest plots. They are included provisionally in the Linville Gorge Subtype.

Rare species:
Vascular plants – *Dicentra eximia, Fothergilla major, Liatris turgida,* and *Robinia hispida* var. *kelseyi*.

CAROLINA HEMLOCK FOREST (TYPIC SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Typic Subtype consists of examples where *Pinus* spp. and *Tsuga canadensis* are both absent or minor components, generally occurring on ridge tops or upper slopes. Small groves of *Tsuga caroliniana* in oak forests are not included here.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. (A single occurrence of Swamp Forest–Bog Complex is known to have *Tsuga caroliniana* codominant). The Typic Subtype is distinguished from the Pine Subtype by the dominance of *Tsuga caroliniana* and the absence of an appreciable pine component. Some oaks or other hardwoods may occasionally be codominant. The Typic Subtype is distinguished from the Mesic Subtype by occurrence in dry, topographically exposed environments, and by a shrub layer dominated by *Kalmia latifolia, Rhododendron catawbiense*, or *Rhododendron minus*, with little or no *Rhododendron maximum*.

Crosswalks: *Tsuga caroliniana / Kalmia latifolia - Rhododendron catawbiense* Forest (CEGL007139).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).
Carolina Hemlock Bluff (Third Approximation).

Sites: Carolina Hemlock Forest (Typic Subtype) usually occurs on upper slopes, occasionally on spur ridges or higher ridges. A few examples occur on lower sites on river bluffs. This community is often, but not always, on the edges of rock outcrops or on very steep slopes. Most occurrences are at 2000-4000 feet, but foothills examples range to under 1000 feet and higher ones up to at least 4700 feet.

Soils: The Typic Subtype occurs on rocky Typic or Lithic Dystrudepts such as Ashe and Porters. Some foothills and lower elevation examples may occur on various Typic Hapludults or even Typic Kanhapludults.

Hydrology: The Typic Subtype occurs in dry, well-drained upland sites. Because many sites are convex slopes or have shallow soil, they are particularly prone to drought stress.

Vegetation: All Carolina Hemlock Forests are dominated by *Tsuga caroliniana*, with this species making up at least half of the canopy. In the Typic Subtype, pines do not codominate, but *Pinus rigida, Pinus pungens*, or *Pinus virginiana* may be present in smaller numbers. Various hardwoods may be abundant, especially *Quercus montana* and *Quercus coccinea*. Frequent understory trees in CVS plots, local vegetation studies, and site descriptions are *Nyssa sylvatica, Acer rubrum*, *Oxydendrum arboreum, Amelanchier laevis*, *Sassafras albidum*, and *Castanea dentata*. *Kalmia latifolia* is nearly constant and usually dominates the shrub layer, but *Rhododendron catawbiense* and *Gaylussacia baccata* are also highly constant in CVS plot data. Other shrubs that are frequent include *Vaccinium pallidum, Eubotrys recurvus, Rhododendron carolinianum, Hamamelis virginiana, Vaccinium corymbosum, Clethra acuminata*, and *Ilex montana*. *Smilax rotundifolia* and *Smilax glauca* are also frequent. Herbs are generally low in density and in diversity, though

Galax urceolata sometimes may have high cover. In addition to widespread species of highly acidic sites, such as *Chimaphila maculata* and *Goodyera pubescens*, fairly frequent species include *Xerophyllum asphodeloides* and *Cypripedium acaule*. Species such as *Asplenium montanum* may be present locally on rocks within the community.

Range and Abundance: Ranked G2, however, the rank may soon become G1 in light of the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*) to the dominant tree species. The NVC association shows a Southern Blue Ridge endemic pattern, ranging a short distance into Virginia, Tennessee, and South Carolina. In North Carolina, the Typic Subtype ranges throughout the interior Blue Ridge and foothills, with a couple of disjunct examples in the upper Piedmont. Examples are most abundant along the Blue Ridge escarpment; they also appear to be more abundant north of Asheville in the interior.

Associations and Patterns: Carolina Hemlock Forests are small patch communities. A few occurrences are reported to be more than 50 acres, but most are just a few acres. The Typic Subtype is often associated with rock outcrops, which may support Low Elevation Rocky Summit or Low Elevation Granitic Dome communities. Because it occurs in sites similar to Pine–Oak/Heath, it is often associated with that community. Otherwise, examples are usually surrounded by dry forest communities such as Chestnut Oak Forest or Montane Oak–Hickory Forest. A few examples grade into more mesic sites with Carolina Hemlock Forest (Mesic Subtype), Acidic Cove Forest, or Canada Hemlock Forest.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities. Otherwise, the shrub layer is the most variable part of the community, and examples dominated by *Rhododendron catawbiense* or *Rhododendron carolinianum* rather than *Kalmia latifolia* should be investigated for whether they warrant recognition as variants.

Dynamics: All aspects of the dynamics of Carolina Hemlock Forests are now in question because of the impact of the introduced hemlock woolly adelgid (*Adelges tsugae*). This insect is lethal to adult and young hemlocks. It initially appeared that *Tsuga caroliniana* might be less susceptible than *Tsuga canadensis*, but many stands have since suffered severe mortality. Slower initial mortality may have been due solely to general small size and isolated occurrence of Carolina Hemlock Forests. It is unclear if any examples of this community will remain distinct and viable in the future. While the immediate fate of affected stands is to become dominated by the associated canopy and understory tree species, it is unclear if they will ultimately develop into Pine–Oak/Heath, become indistinguishable from the surrounding oak forests, or form a different distinct community.

Relatively little is known about the dynamics of Carolina Hemlock Forests, even before the recent mortality, compared to the intensive study of pine and oak forests. Two studies that addressed population dynamics of the hemlocks in specific sites (Humphrey 1989 and Rentch, et al. 2000) have described a pattern indicative of a stress-tolerating life history, with multi-aged stands that seemed to be self-sustaining and similar to old-growth forests of other types. Trees exceeding 300 years old were found in both sites.

A crucial question for these communities is the role of fire. *Tsuga caroliniana* has thicker bark than *Tsuga canadensis*, and it may be more tolerant of fire, though it seems unlikely to match the fire tolerance of pines or most oaks. The dry, topographically exposed sites where these communities occur would seem prone to fire, but the frequent association with rock outcrops hints at a possible need for some natural sheltering from fire. The persistence of older trees that pre-date modern fire suppression suggests either that they are protected from fire or tolerate it well, though they may be survivors of fires that killed some part of the canopy. Newell (1997) noted that there was evidence of fire in 55% of her *Tsuga caroliniana* sites, a grouping which appears to combine all three subtypes, but that fire was less recent than in the pine communities and that the community did not appear to depend on fire.

Given that the Typic Subtype and Pine Subtype of Carolina Hemlock Forest occur in sites similar to those that support Pine–Oak/Heath, it is a question why Carolina Hemlock Forests occupy certain sites instead of them. One possibility is a shifting mosaic, with Carolina Hemlock Forests, Pine–Oak Heath, and perhaps Chestnut Oak Forests having a successional relationship, probably with Carolina Hemlock Forests taking over if enough time passes without severe disturbance. Another possibility is chance establishment followed by persistence. *Tsuga caroliniana* individuals may be observed as scattered groves in oak forests in some areas. These often appear to have a single or small group of founder trees, with younger trees surrounding them, as if the grove is expanding slowly. While these oak forest groves are small and are not associated with the kinds of sites where most Carolina Hemlock Forests occur, it is possible that a grove established on a sharper or steeper slope could expand into a community patch. It remains a possibility, however, that Carolina Hemlock Forest sites differ from others in ways that are not perceived, perhaps in ways that are only apparent when fire occurs. These same questions likely are important for the relationship between the Typic Subtype and the Pine Subtype. The answers to these questions may be crucial to the future of Carolina Hemlock Forest communities after hemlock woolly adelgid mortality.

Comments: Carolina Hemlock Forests have had limited focused study, and they are a rare part of the landscape, but they have been recognized in several local vegetation studies (e.g., McLeod 1988, Newell and Peet 1995, Newell 1997). Newell (1997) recognized a *Tsuga caroliniana* type that appears to combine all three subtypes. A proposal for federal listing of *Tsuga caroliniana* led to an extensive survey in 2022-2023, and additional study may occur.

As a species, *Tsuga caroliniana* appears to have an odd, patchy distribution. Where it is present in the landscape, besides occurring in Carolina Hemlock Forest communities, it may occur as scattered individuals and small groves in several oak forest communities, but it does not occur in most oak forests. As noted above, these groves appear to be spreading, but it is possible this is an artifact of fire suppression, and that regular fire would quickly eliminate them. A similar pattern can be seen for *Tsuga canadensis,* and for *Picea rubens* in mountain ranges where it occurs, but *Tsuga caroliniana* appears more likely to mature and produce offspring in isolated groves.

Rare species:
Vascular plants – *Buckleya distichophylla, Monotropsis odorata,* and *Quercus ilicifolia*.

Invertebrate animals – *Hypochilus coylei.*

CAROLINA HEMLOCK FOREST (PINE SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Pine Subtype covers examples with yellow pines abundant or codominant.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. The Pine Subtype is distinguished from the other subtypes by an appreciable component of yellow pines, which may be codominant, though *Tsuga* still makes up at least 50% of the canopy. Some oaks and other hardwoods may be present.

Crosswalks: *Tsuga caroliniana - Pinus (rigida, pungens, virginiana*) Forest (CEGL006178).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).
Carolina Hemlock Bluff (Third Approximation).

Sites: The Pine Subtype usually occurs on upper slopes, occasionally on spur ridges or higher ridges. This community is often on the edges of rock outcrops or on very steep slopes. Examples are known from 1600-4200 feet in elevation.

Soils: Most examples of the Pine Subtype are likely on Lithic or Typic Dystrudepts such as Ashe or Porters, with some on Typic Hapludults such as Cliffield. Some examples are included in rock outcrop map units.

Hydrology: The Pine Subtype occurs in dry, well-drained upland sites. Because many sites are convex slopes or have shallow soil, they are particularly prone to drought stress compared to other sites at the same elevation.

Vegetation: All Carolina Hemlock Forests are dominated by *Tsuga caroliniana*, with this species making up at least half of the canopy. The Pine Subtype has *Pinus virginiana, Pinus rigida*, or *Pinus pungens* as a canopy codominant or at least an abundant associated species. Limited CVS plot data and site descriptions show that other frequent canopy species include *Quercus montana, Quercus coccinea*, *Betula lenta*, and *Pinus strobus*. Frequent understory trees include *Acer rubrum, Oxydendrum arboreum, Nyssa sylvatica, Amelanchier laevis*, and *Castanea dentata* sprouts. The shrub layer is moderate to dense. *Kalmia latifolia* may dominate but other species are almost as frequent with high cover, including *Rhododendron carolinianum, Gaylussacia baccata*, and *Vaccinium pallidum*. Other frequent shrubs include *Vaccinium stamineum, Eubotrys racemosus, Ilex montana,* and *Vaccinium corymbosum*. *Smilax rotundifolia* is highly constant. The herb layer is sparse. Species tolerant of very acidic conditions, such as *Galax urceolata* and *Gaultheria procumbens*, prevail, but other species that are fairly frequent are probably associated with small rock outcrops: *Polypodium appalachianum, Danthonia spicata, Asplenium montanum, Schizachyrium scoparium*, and *Coreopsis major*.

Range and Abundance: Ranked G2, but may soon become G1 in light of the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*) to the dominant tree species. This community is known only in North Carolina and Tennessee. It is difficult to tell how abundant it is in the state. It is a fairly new concept, recognized only in early drafts of the 4th Approximation. It is difficult to distinguish in existing site reports, because the Typic Subtype often has at least some pine in it. It is unclear if some sites contain both subtypes, and, if so, what their relative amounts are. The Pine Subtype appears to be somewhat rarer than the Typic Subtype. Known occurrences range through the mountains and foothills but are most concentrated along the Blue Ridge escarpment.

Associations and Patterns: The Pine Subtype is a small patch community. Most occurrences are a few acres. The few reported acreage figures over 20 acres are highly uncertain, and survey work in progress has found many examples to be smaller than reported. The Pine Subtype is often associated with rock outcrops, perhaps more than the Typic Subtype. It may thus grade into Low Elevation Rocky Summit or Low Elevation Granitic Dome communities. It is unclear how much it is associated with the Typic Subtype. Because it occurs in sites similar to those supporting Pine–Oak/Heath, it is often associated with that community. Otherwise, examples are usually surrounded by dry forest communities such as Chestnut Oak Forest or Montane Oak–Hickory Forest.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities. Otherwise, the shrub layer is the most variable part of the community, and examples dominated by *Rhododendron catawbiense* or *Rhododendron carolinianum* rather than *Kalmia latifolia* should be investigated for whether they warrant recognition as variants.

Dynamics: See the discussion of dynamics for the Typic Subtype. The dynamics of the Pine Subtype are even more uncertain, because it is codominated by two genera of trees that appear to have very different life histories and different relationships with fire. It is possible they represent an intermediate stage of succession, with the pines having once been dominant but now in decline as hemlocks take over, but field observations do not generally show the pines to appear older than the hemlocks. It is possible they represent an accident of tree establishment after some historical event, representing an additional patch type in a shifting mosaic. Especially if they are in rocky sites, it is possible the sites are heterogeneous and contain a mix of microsites optimal for both genera, either in soil properties or in typical fire behavior.

Future dynamics, and even future existence of the Pine Subtype in the face of hemlock woolly adelgid (*Adelges tsugae*) are as uncertain as for the Typic Subtype, but the trajectory may be different. It is reasonable to expect that, with abundant associated pines and with occurrence in similar sites, that *Tsuga* mortality will lead to pine dominance and create a community indistinguishable from Pine–Oak/Heath. However, because yellow pines have difficulty reproducing under current conditions without fire, long-term pine dominance in these communities may be as tenuous as it is for hemlock.

Comments: The Pine Subtype is one of the less distinctive communities in the 4th approximation. It is included only provisionally. Newell (1997) recognized only a single *Tsuga caroliniana* community in Linville Gorge, one that appears to combine the Typic, Pine, and Mesic Subtypes. It may be arguable that recognizing a separate association and subtype for the Pine Subtype is simply a result of the "conifer bias" that affects many forest classifications. However, pine and

Carolina hemlock communities may have very different dynamics, and a community that combines elements of both may be of special interest. In addition, the abundance of pines suggests a different possible future for the community if Carolina hemlock is permanently lost as a dominant species.

Rare species:
Vascular plants – *Buckleya distichophylla, Monotropsis odorata, Quercus ilicifolia,* and *Sisyrinchium dichotomum*.

Invertebrate animals – *Hypochilus coylei.*

CAROLINA HEMLOCK FOREST (MESIC SUBTYPE)

Concept: Carolina Hemlock Forest communities are forests or woodlands where *Tsuga caroliniana* dominates the canopy at least weakly. The Mesic Subtype covers examples in moister, more sheltered sites, with more mesic composition transitional to Canada Hemlock Forest.

Distinguishing Features: Carolina Hemlock Forests are distinguished from all other upland communities by the dominance or codominance of *Tsuga caroliniana* in the canopy. The Mesic Subtype is distinguished by occurrence in topographically sheltered or valley bottom environments (but not wetlands), by having a shrub layer dominated by *Rhododendron maximum* rather than less mesic species, and often by having *Tsuga canadensis* codominant.

Crosswalks: *Tsuga caroliniana - (Tsuga canadensis) / Rhododendron maximum* Forest (CEGL007138).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Montane Pine Forest and Woodland Ecological System (CES202.331).
Carolina Hemlock Bluff (Third Approximation).

Sites: The Mesic Subtype occurs in valley bottoms and on lower slopes, often in gorges. Known examples range from 2000-4100 feet in elevation.

Soils: Soils associated with the subtype are not well known, but probably can include a range of Lithic and Typic Dystrudepts, Typic Humadepts, and Typic Hapludults. Soils are presumably deeper and less rocky than in the other subtypes.

Hydrology: The Mesic Subtype occurs in well-drained upland sites that are mesic because of lower slope positions and topographic sheltering.

Vegetation: The Mesic Subtype canopy is dominated by *Tsuga caroliniana*. *Tsuga canadensis*, *Acer rubrum*, *Pinus strobus, Quercus coccinea*, or *Quercus montana* may be abundant or occasionally codominant. In CVS plot data, understory species that are constant or at least moderately frequent include *Oxydendrum arboreum, Nyssa sylvatica, Acer rubrum, Amelanchier laevis, Acer pensylvanicum, Ilex opaca, Sassafras albidum*, and *Betula lenta*. The shrub layer is generally moderate to dense. *Rhododendron maximum* is highly constant and often strongly dominant. *Kalmia latifolia* is highly constant and may be dominant or abundant. Other frequent shrubs include *Hamamelis virginiana, Ilex montana, Leucothoe fontanesiana,* and *Viburnum cassinoides*. *Smilax rotundifolia* and *Smilax glauca* are frequent. *Galax urceolata* may have high cover in the herb layer. Otherwise, herbs are sparse and are largely confined to very acid-tolerant species such as *Chimaphila maculata* and *Goodyera pubescens*.

Range and Abundance: Ranked G1G2, but probably appropriately G1 even before the severe damage and ongoing threat caused by the hemlock woolly adelgid (*Adelges tsugae*). The Mesic Subtype is rarer than the other subtypes. Examples are scattered in the Blue Ridge escarpment and mountain interior. None are known in the foothills, but occurrence is possible. The NVC association is reported only for North Carolina and Tennessee.

Associations and Patterns: The Mesic Subtype is a small patch community. All known occurrences are just a few acres. It may grade uphill to the Typic Subtype. More often, it is associated with Acidic Cove Forest or Canada Hemlock Forest, potentially with Rich Cove Forest or various oak forests.

Variation: No patterns of variation have been identified, other than the gradation to adjacent communities.

Dynamics: See the discussion of dynamics for the Typic Subtype. It is uncertain how similar the dynamics of the Mesic Subtype are. Given the moister conditions and lower topographic position, fire and drought are less likely to be important. Dynamics may be more similar to Acidic Cove Forest or Canada Hemlock Forest. However, the factors that lead to establishment and persistence of Carolina Hemlock Forest rather than one of those communities are not known.

Future dynamics and even future existence of the Mesic Subtype in the face of hemlock woolly adelgid (*Adelges tsugae*) are as uncertain as for the Typic Subtype, but the trajectory may be different. Because of the mesic location and general proximity to seed sources, it is reasonable to expect that, with *Tsuga caroliniana* mortality, they most likely will come to resemble Acidic Cove Forests.

Comments: The Mesic Subtype is one of the less distinctive communities in the 4th approximation, though it differs more in sites and composition than the Pine Subtype. Newell (1997) recognized only a single *Tsuga caroliniana* community in Linville Gorge, one which appears to combine the Typic, Pine, and Mesic Subtype.

The placement of the Mesic Subtype has been problematic because it has affinities with more mesic communities such as Canada Hemlock Forest and Acidic Cove Forest as well as with the other Carolina Hemlock Forest subtypes. It was previously placed in the Southern and Central Appalachian Cove Forest ecological system.

Rare species: No rare species are known to be associated with this community.

WHITE PINE FOREST

Concept: The White Pine Forest natural community encompasses rare upland forests that are strongly dominated by *Pinus strobus* in natural condition. *Pinus strobus* forests that result from planting, from past land clearing, or from logging of other types of forest are not included. Forests where *Pinus strobus* is naturally codominant with oaks, *Tsuga canadensis*, or other species characteristic of other natural communities, or that are in floodplain or wetland natural communities, are not included.

Distinguishing Features: White Pine Forests are distinguished from the White Pine Subtype of Chestnut Oak Forest, the White Pine Subtype of Montane Oak–Hickory Forest, and all other forests that may contain a mixture of *Pinus strobus* by having *Pinus strobus* naturally making up more than 66 percent of the canopy over an area more than 1 acre. Distinguishing natural from unnatural successional white pine forests can be difficult. In general, natural White Pine Forests are on slopes of gorges or on ridges, while successional white pine forests are in accessible sites such as valley flats or gentle lower slopes. However, clearcutting may allow white pine to become dominant in Montane Oak–Hickory Forests or Chestnut Oak Forests in some parts of the state.

Crosswalks: *Pinus strobus / Kalmia latifolia - (Vaccinium stamineum, Gaylussacia ursina)* Forest (CEGL007100).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Low-Elevation Pine Forest Ecological System (CES202.332).

Sites: White Pine Forests are typically on open slopes, generally at lower elevations. Many are within gorges, but some are on more exposed mountain ridges. Slopes are generally planar or convex, but not sharp ridges. Elevations typically are 1200-3500 feet, but at least one example extends to 4000 feet.

Soils: White Pine Forests generally occur on the widespread soils of mountain slopes, usually Typic Dystrudepts such as Ashe, Edneyville, Chestnut, Cleveland, and Buladean. A few are mapped as Tusquitee (Humic Dystrudept) or Toecane (Humic Hapludult). Pinchot and Ashe (1897) noted that *Pinus strobus* prefers loamy soil, but this includes most soils in the region.

Hydrology: White Pine Forests occur in dry-mesic to dry upland conditions. Soils are generally well drained, and sites may be topographically sheltered or exposed.

Vegetation: White Pine Forests, by definition, are dominated by *Pinus strobus*. Associated canopy species most frequently are *Quercus coccinea* and *Quercus montana*, but they may also include *Pinus virginiana, Pinus rigida*, *Quercus alba, Quercus rubra, Betula lenta*, *Tsuga canadensis,* or other species. In both CVS plot data and site descriptions, the understory species with high constancy to medium frequency and sometimes high cover are *Acer rubrum, Oxydendrum arboreum*, and *Nyssa sylvatica*, with *Ilex opaca* having lesser cover. Other understory species may include *Magnolia fraseri, Tsuga canadensis, Castanea dentata*, and *Diospyros virginiana*. *Kalmia latifolia* is highly constant in the shrub layer and is often very dense. *Vaccinium pallidum* or *Gaylussacia ursina* may also dominate patches. Other shrubs with high frequency include *Symplocos tinctoria, Rhododendron maximum*, and *Hamamelis virginiana*, while *Rhododendron* *minus* is codominant in at least one example. *Smilax rotundifolia*, *Smilax glauca*, and *Muscadinia rotundifolia* are frequent. Herbs are generally sparse and consist mainly of species of shaded acidic sites, such as *Chimaphila maculata, Epigaea repens, Mitchella repens,* and *Goodyera pubescens*, but *Iris verna, Pteridium latiusculum*, and *Cypripedium acaule* also occur with moderate frequency.

Range and Abundance: Ranked G2G3. Only about ten occurrences are recorded in North Carolina, most of them south of Asheville but a few farther north. The abundance of *Pinus strobus* in mixed communities and in successional communities makes it difficult to recognize natural examples. Some additional occurrences may be overlooked or may be in less explored areas. The NVC association ranges into South Carolina, Georgia, and Tennessee.

White pine has an odd native range in North Carolina. Pinchot and Ashe (1897) noted: "The woodland in which white pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest, and southern and eastern slopes of the Blue Ridge or on the low hills on the west." They go on to list these areas as the South Fork New River valley of Ashe and Watauga Counties, the upper valley of the Linville River in Mitchell County, the valley of the French Broad River in Transylvania County, and the southern parts of Macon and Jackson Counties. They also note the escarpment in Wilkes and McDowell Counties as a place where both white and yellow pines occur together. This range corresponds better to the range of the White Pine Subtypes of oak forests than it does to known White Pine Forests, but the community should be sought in these other areas.

Associations and Patterns: White Pine Forests are usually associated with oak forests, particularly the White Pine Subtype of Montane Oak–Hickory Forest and Chestnut Oak Forest. They may also grade to Acidic Cove Forest or Canada Hemlock Forest, and potentially to other communities.

Variation: Little is known about the variation in this community.

Dynamics: Dynamics of White Pine Forests in North Carolina are less studied than those of the yellow pine forests. In the Northeast and upper Midwest, naturally occurring white pine forests are generally considered to be the result of catastrophic fire. The species can survive to 350-400 years of age (Pinchot and Ashe 1897). Though *Pinus strobus* is considered poorly adapted to surviving fire, it readily invades areas disturbed by severe fire or wind storms. Such stands can then mature to become large-stature old-growth forests. In this view, northern white pine forests act as part of a shifting mosaic, as is more common in the West, establishing as a result of rare events in somewhat random places, then persisting until long-term succession or another catastrophic event naturally leads to a different community. In the South, where fire was more frequent but less severe, such dynamics would be rare, if not absent. Pinchot and Ashe (1897) noted that *Pinus strobus* is susceptible to fire until it is 10 inches dbh. However, one of the characteristic settings for White Pine Forest — gorges — is sheltered from much of the fire in the surrounding landscape yet can burn intensely on the rare occasions when fire reaches the gorge bottom and then runs up steep slopes. Nevertheless, recent severe fires in Linville Gorge do not appear to have resulted in creation of pure *Pinus strobus* stands in what had been other communities.

If White Pine Forest patches do depend on catastrophic disturbances to establish, they might then persist for 100-200 years or more. Since *Pinus strobus* is about as shade tolerant as oaks, either genus could establish in canopy gaps once the canopy is mature enough that gaps start forming, but known occurrences have not been examined for evidence of the future trajectory. The tendency to develop a more shade-tolerant understory might make it difficult for either genus to regenerate until fire again occurs. DeYoung (1979), in his study on the Tennessee side of the Great Smoky Mountains, describes some forests containing *Pinus strobus* as apparently self-sustaining, but these were mixed forests resembling the White Pine Subtype of Chestnut Oak Forest and Montane Oak–Hickory Forest. Purer pine forests in that area appeared to be anthropogenic successional communities.

Comments: The historical and natural abundance and distribution of White Pine Forest is more difficult to discern than for most natural communities. Since the species is both readily able to invade disturbed areas and is a highly desired timber tree that might be selectively removed, past logging may have either increased or decreased its abundance in any given site. Since young individuals are susceptible to fire while seedling establishment is also potentially enhanced after fire, the modern change in fire regime also had uncertain effects. Descriptive literature is confused by the abundance of anthropogenic successional forests established on former fields and clearings, as well as by the apparently more widespread distribution of the species in mixed forests. Pinchot and Ashe (1897) described *Pinus strobus* as often forming large patches of nearly pure forest, though it is unclear if these were natural communities or old field stands, but elsewhere they said that the species typically occurred dispersed in hardwood forests as single trees or small groups.

Rare species: No rare species are known to be associated with this community.

LOW MOUNTAIN PINE FOREST (SHORTLEAF PINE SUBTYPE)

Concept: Low Mountain Pine Forests are yellow-pine-dominated forests or woodlands containing both montane flora and low-elevation species such as *Pinus echinata*, occurring in the lower elevations of the Mountains and foothills. The Shortleaf Pine Subtype encompasses communities dominated by *Pinus echinata*, with other pines and hardwoods collectively less than 50% of the canopy in natural condition.

Distinguishing Features: Low Mountain Pine Forest (Shortleaf Pine Subtype) is distinguished from all other communities by the natural, long-term dominance of *Pinus echinata* in an upland setting. *Pinus echinata* is generally present in the Montane Pine Subtype, and likely once was more abundant in it, but did not dominate. As with the other subtype, Low Mountain Pine Forests are distinguished from Pine–Oak/Heath by occurring at lower elevations and by containing characteristic low elevation species such as *Pinus echinata*, *Quercus stellata*, and *Quercus falcata*, but see the discussion in the Pine—Oak/Heath description regarding low elevation pine communities that appear indistinguishable from higher elevation Pine—Oak/Heath.

Crosswalks: *Pinus echinata / Vaccinium (pallidum, stamineum) - Kalmia latifolia* Forest (CEGL007078).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine WoodlandGroup.
Southern Appalachian Low-Elevation Pine Forest Ecological System (CES202.332).

Sites: Low Mountain Pine Forests occur on low elevation slopes and broad to sharp ridges. Most examples of the Shortleaf Pine Subtype are at 1200-2000 feet in elevation, but a couple of examples range higher.

Soils: The Shortleaf Pine Subtype may potentially occur on a wide variety of mountain upland soils. Soils mapped at examples include Typic Kanhapudults such as Hayesville and Sauratown, Typic Hapludults such as Brevard, and Typic Dystrudepts such as Ashe, Cleveland, and Chestnut.

Hydrology: Low Mountain Pine Forests are dry, as a result of rapid drainage and warm slope aspects, along with the warm temperatures at low elevations.

Vegetation: The Shortleaf Pine Subtype is a dense to open forest dominated, at least weakly, by *Pinus echinata* in natural condition. Stands more altered by fire exclusion or southern pine beetles may have less *Pinus echinata* but will show evidence of it having been abundant. Highly constant canopy tree species, in CVS plots or site descriptions, include *Quercus falcata, Quercus coccinea,* and *Acer rubrum*, while *Pinus strobus, Pinus rigida, Quercus alba, Quercus stellata, Carya glabra,* and *Carya tomentosa* are frequent. The dominant understory trees are *Oxydendrum arboreum, Nyssa sylvatica*, and *Ilex opaca*, the latter presumably increased due to lack of fire. *Benthamidia* (*Cornus*) *florida* and uncharacteristic *Tsuga canadensis* and *Liriodendron tulipifera* are also frequent. *Vaccinium pallidum* is highly constant in the shrub layer and often dominant. *Kalmia latifolia* is frequent and may be abundant. Other frequent shrubs in plots or site reports include *Gaylussacia ursina, Symplocos tinctoria, Vaccinium arboreum, Ceanothus americanus*, and *Euonymus americanus*. Herbs are generally sparse. *Coreopsis major, Pteridium latiusculum, Danthonia spicata, Iris verna*, *Chimaphila maculata, Polystichum acrostichoides, Stenanthium* *gramineum*, and *Antennaria plantaginea* are frequent in plots. A number of additional species are frequently mentioned in site descriptions. Presumably they occur at lower density and are seldom encountered in plots, but many are probably more abundant when sites are regularly burned. These species include *Schizachyrium scoparium, Pityopsis graminifolia, Solidago odora, Tephrosia virginiana, Desmodium viridiflorum, Desmodium rotundifolium, Ageratina aromatica, Mimosa microphylla,* and *Silphium reniforme*. Other herbs that are infrequent but may be characteristic include *Danthonia sericea, Rudbeckia hirta, Gillenia trifoliata, Nabalus serpentaria, Lespedeza hirta, Baptisia tinctoria, Helianthus microcephalus,* and *Chamaecrista* spp.

Range and Abundance: Ranked G4? but might be rarer if the concept is truly confined to natural communities. In North Carolina, the Shortleaf Pine Subtype is very rare, with only a dozen occurrences known. Most are in the far southwestern mountains of Graham and Cherokee counties and in the South Mountains. This community was apparently once extensive in the southwestern mountains. The NVC association is said to range from South Carolina and Georgia to Kentucky.

Associations and Patterns: The Shortleaf Pine Subtype is a large patch community, with most known occurrences in the range of 20-75 acres but a few larger and smaller. It is believed to have once been more extensive in Cherokee County and in adjacent states, though it is difficult to tell how many of the reported extensive stands were natural long-term communities. The Shortleaf Pine Subtype may be associated with Southern Mountain Pine–Oak Forest or Montane Oak–Hickory Forest (Low Dry Subtype).

Variation: Examples vary with the gradation to adjacent communities.

Dynamics: Dynamics of the Shortleaf Pine Subtype are probably similar to those of other yellow-pine-dominated Mountain Dry Coniferous Woodlands. *Pinus echinata* is tolerant of frequent fire and appears to have dominated savanna-like communities farther west, but it is unclear that such frequent fire regimes occurred natural in North Carolina.

Comments: *Pinus echinata / Schizachyrium scoparium* Appalachian Woodland (CEGL003560) is an association defined for South Carolina and Georgia, which appears to be a more frequently burned version of this.

Rare species:
No rare species are known to be associated with this community.

LOW MOUNTAIN PINE FOREST (MONTANE PINE SUBTYPE)

Concept: Low Mountain Pine Forests are yellow-pine-dominated forests or woodlands containing both montane flora and low-elevation species such as *Pinus echinata*, occurring in the lower elevations of the Mountains and foothills. The Montane Pine Subtype encompasses those that are dominated by combinations of *Pinus virginiana, Pinus rigida*, and *Pinus pungens*, with *Pinus echinata* a minor component or absent.

Distinguishing Features: Low Mountain Pine Forests are distinguished from Pine–Oak/Heath by occurring at lower elevations and by containing characteristic low elevation species such as *Pinus echinata*, *Quercus stellata*, and *Quercus falcata*. The distinction between the Montane Pine Subtype and Pine–Oak/Heath is problematic in some examples. See the discussion of relevant issues in the description of Pine–Oak/Heath (Typic Subtype). Low Mountain Pine Forests always occur below 2000-2500 feet in elevation, are more likely to have abundant *Pinus virginiana*, and are indicated by the presence of species confined to low elevations, such as *Pinus echinata, Quercus falcata, Quercus stellata*, and *Quercus marilandica*. They also tend to have a greater diversity of shade-intolerant herbs, which are more abundant in burned examples. *Schizachyrium scoparium, Coreopsis major, Danthonia sericea, Pityopsis graminifolia, Solidago odora, Danthonia spicata, Silphium reniforme, Tephrosia spicata, Eupatorium rotundifolium, Eupatorium album, Lespedeza hirta, Lespedeza repens, Symphyotrichum patens*, and *Scleria triglomerata/nitida* are species that are generally more frequent and abundant in Low Mountain Pine Forest, though many can also occur in Pine–Oak/Heath (Wentworth et al. in prep). *Quercus velutina, Carya pallida, Carya glabra, Carya tomentosa, Ilex montana, Ilex montana, Castanea pumila, Vaccinium stamineum, Rhus copallinum*, and *Magnolia fraseri* are also more frequent in Low Mountain Pine Forest. Nevertheless, many stands at low elevation have none of the definitive indicator species and appear indistinguishable from Pine–Oak/Heath communities at higher elevation. A careful search of the vicinity, including roadsides and forest edges, may reveal indicator species that have been lost from the interior of the stand. However, some stands may not be able to be definitively classified with our current level of understanding.

The Montane Pine Subtype is distinguished from the Shortleaf Pine Subtype by having a canopy dominated by one of the above pines, with *Pinus echinata* either absent or a smaller component.

Crosswalks: *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119). *Pinus virginiana - (Pinus rigida, Pinus pungens) / Schizachyrium scoparium* Forest (CEGL008500).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Low-Elevation Pine Forest Ecological System (CES202.332).

Sites: Low Mountain Pine Forests occur on broad to sharp ridges, or on low elevation slopes, often facing south or west. Most examples of the Montane Pine Subtype are at 1200-2500 feet in elevation, but a couple apparent examples range higher.

Soils: Soils of the Montane Pine Subtype may be shallow and rocky or may be deeper. Most examples are mapped as Typic Dystrudepts (Ashe, Chestnut, Soco, Stecoah) or Typic Hapludults (Evard, Cowee, Edneyville), or Humic Dystrudepts (Whiteoak, Porters).

Hydrology: Low Mountain Pine Forests are dry, as a result of rapid drainage and warm slope aspects, along with the warm temperatures at low elevations.

Vegetation: The Montane Pine Subtype is a dense to open forest or woodland usually dominated by *Pinus virginiana, Pinus rigida,* or a mix of the two. *Pinus pungens* may rarely be codominant, and *Pinus echinata, Quercus montana, Quercus coccinea*, *Quercus falcata,* or *Pinus strobus* may be locally abundant. Other constant or frequent potential canopy tree species include *Quercus velutina, Carya glabra, Carya tomentosa*, and *Quercus alba*. Though less frequent in plots, *Quercus stellata* is often observed and is characteristic. Highly constant and sometimes codominant understory species in CVS plot data (Wentworth et al. in prep) are *Nyssa sylvatica, Oxydendrum arboreum,* and *Acer rubrum*. *Quercus marilandica* is also frequent and sometimes abundant. Other frequent understory species in plots include *Sassafras albidum, Diospyros virginiana, Magnolia fraseri, Amelanchier laevis,* and *Ilex opaca*. The shrub layer in present conditions ranges from moderate to dense. *Vaccinium pallidum* and *Kalmia latifolia* are highly constant and often dominant. Other highly constant or frequent shrubs that may have high cover are *Vaccinium stamineum* and *Gaylussacia baccata*. Additional frequent shrubs in plots include *Castanea pumila,* and *Pyrularia pubera*. *Smilax rotundifolia* is highly constant and occasionally can have high cover in patches. *Muscadinia rotundifolia* is also frequent. The herb layer under current conditions ranges from sparse to dense. *Galax urceolata* is the only species that occasionally has high cover. Other frequent herb layer species in plots include *Chimaphila maculata, Coreopsis major, Pteridium latiusculum, Epigaea repens, Dichanthelium commutatum, Tephrosia virginiana, Iris verna, Schizachyrium scoparium, Solidago odora, Hieracium venosum,* and *Lysimachia quadrifolia*. It is presumed that with a more natural fire regime the less fire tolerant trees such as *Pinus virginiana, Quercus coccinea, Pinus strobus, Acer rubrum, Magnolia fraseri,* and *Ilex opaca* would be scarce, shrubs might be less dense, and many of less shade-tolerant of these herbs would be more abundant. Additional species found in the most open plots, which may indicate species that would be more constant and abundant with more frequent fire, include *Ceanothus americana, Arundinaria appalachiana, Hypericum stragulum, Pityopsis graminifolia, Eurybia surculosa, Lespedeza violacea, Lespedeza repens, Lespedeza hirta, Mimosa microphylla, Lilium michauxii, Sericocarpus asteroides, Sorghastrum nutans, Gillenia trifoliata, Helianthus microcephalus, Solidago erecta, Tephrosia spicata, Viola pedata*, and *Scutellaria elliptica*. Even when not present in stands, some of these species can often be found along edges or along forest roads or trails.

Range and Abundance: Ranked G3. The Montane Pine Subtype is scattered through the lower parts of the Mountain Region and foothills, with a few disjunct occurrences farther east in the Sauratown Mountains and Kings Mountains. There are clusters of known occurrences in the far southwestern area (Cherokee and Graham County) and in the South Mountains.

Associations and Patterns: Low Mountain Pine Forests occur now as remnants that are small patch communities. They probably once were large patch or even matrix communities. Montane Pine Subtype patches are most often surrounded by Montane Oak–Hickory Forest or Chestnut Oak Forest. Montane Oak–Hickory Forest (Low Dry Subtype) and Southern Mountain Pine–Oak Forest are closely related in their environment, and patches may occur in the same sites. Low

Mountain Pine Forest (Shortleaf Pine Subtype) is not commonly associated but the two subtypes may once have co-occurred.

Variation: Analysis of plot data (Wentworth et al. in prep.) finds two vegetation groups corresponding to the Montane Pine Subtype, which differ primarily in the relative amounts and diversity of shrubs and herbs. It is unclear how much these differences reflect enduring site differences and how much they represent only recent management and disturbance history. They are recognized as variants to encourage further study. They are discussed further in the Comments section below and they may correspond to the two NVC associations crosswalked to this subtype.

1. Shrub Variant has high shrub cover and limited herb cover and diversity. It is widespread in the Mountains and foothills.

2. Grass Variant has a higher, though still generally low, cover and diversity of herbs, including grasses. Shrubs are still moderate. This variant is generally more open, possibly because of fire history but also possibly because of more rock cover in its sites. It is much rarer, and most of the few known plots are from the lower Chattooga River in South Carolina and Georgia.

Dynamics: The general discussion of dynamics in the theme description applies well to this community, especially the importance of fire. Many impressions of historical fire frequency and beliefs about the appropriate structure for Low Mountain Pine Forests are based on times with heavy influence by modern human activities. However, it is clear that regular fire has been a natural part of these communities for much longer. More frequent fire would remove or greatly reduce some of the less fire-tolerant species in the present-day vegetation. This might include *Pinus virginiana* as well as *Acer rubrum, Quercus coccinea*, potentially *Pinus strobus*, and some of the understory trees. *Kalmia latifolia* does not recover quickly from fire, and presumably was less abundant in the past. However, *Vaccinium pallidum*, *Gaylussacia baccata*, and other shrubs recover quickly from burning and can be seen to spread after contemporary fires. Herbs presumably were dense and more diverse with regular burning. The tree species used as indicators of this community, being fire-tolerant, presumably were also more common.

Comments: As discussed in the comments on Pine–Oak/Heath (Typic Subtype), mountain pine communities as a group are distinctive, but the boundary between Pine–Oak/Heath and Low Mountain Pine Forest is blurred. Many plots of Low Mountain Pine Forest and some whole stands at low elevation contain none of the indicator species and have no recognizable evidence in the vegetation to distinguish them from Pine–Oak/Heath at higher elevation. It is unclear if this is solely because the indicator species have been lost with the long absence of fire and with other land use, or if there are sites that naturally support Pine–Oak/Heath vegetation at these low elevations.

The two variants appear to correspond to the two NVC associations listed in synonymy, with *Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest (CEGL007119) approximating the Shrub Variant and *Pinus virginiana - (Pinus rigida, Pinus pungens) / Schizachyrium scoparium* Forest (CEGL008500) the Grass Variant. Interpretation of the concepts of these association is uncertain. The first, in particular, is described with a wide range of vegetation and a very large geographic range. Beside the Southern Appalachian states, it is attributed to states from Alabama to Ohio and Indiana, spanning the Ridge and Valley, Cumberland Plateau, and Interior Low Plateaus physiographic regions. As described, it could apply to successional forests as well as natural pine forests and woodlands. Given a general belief that fire was naturally more frequent and that it led to more herbaceous and less shrub vegetation, the natural state of Low Mountain Pine Forest would match more closely to the Grass Variant. However, the NVC description of the association corresponding to the Grass Variant is also unclear, suggesting the openness might be due to fire, other disturbance, or to site rockiness. It might thus include natural vegetation in good condition, excessively burned vegetation, or communities that might be better regarded as glades or at least as being transitional to them. Because it is unclear if these variants and corresponding associations represent different enduring natural vegetation, they are not recognized as subtypes. Further investigation may clarify the distinction, or an increase in fire management of lower elevation pine forests may eventually lead to more natural vegetation that may yield answers.

Similar questions remain for the relationship of Low Mountain Pine Forest to Southern Mountain Pine-Oak Forest. It is also unclear how it is related to Southern Mountain Xeric Pine–Oak Woodland and Montane Oak–Hickory Forest (Low Dry Subtype). Several of these communities are included only provisionally. All share the same suite of indicator species for warm, low elevation climate, influence of fire, and more plentiful sunlight. The differences between them are also in proportions of species that might be modified by historical events. All of these communities need substantial study, preferably of examples with restored natural fire regimes.

Rare species:
Vascular plants – *Cirsium carolinianum, Hexalectris spicata, Hexastylis contracta, Liatris squarrulosa,* and *Thermopsis mollis*.

SOUTHERN MOUNTAIN PINE–OAK FOREST

Concept: Southern Mountain Pine–Oak Forests are mixed, potentially open forests of low elevation mountain slopes and ridges, where *Pinus echinata* and dry-site oaks characteristic of lower elevations codominate. They occur in lower elevation valleys and basins, and in the foothills.

Distinguishing Features: Southern Mountain Pine–Oak Forests are distinguished by canopies that are naturally codominated by *Pinus echinata*, other pines, and combinations of dry-site oaks that include some *Quercus falcata* or *Quercus stellata,* as well as *Quercus alba*, *Quercus montana,* and *Quercus coccinea*. At the edges of the foothills, they grade into Dry Oak–Hickory Forest of the Piedmont. They are distinguished by a significant presence of Blue Ridge flora such as *Kalmia latifolia, Gaylussacia baccata, Gaylussacia ursina, Rhododendron calendulaceum*, and *Castanea dentata* sprouts. They are differentiated from Low Mountain Pine Forest by a greater component of oaks and from Montane Oak–Hickory Forest (Low Dry Subtype and Low Dry Basic Subtype) by a greater pine component. Because the ratios of pines to oaks can be widely altered by both logging and fire suppression, as well as altered by chestnut blight, distinguishing this community can be particularly difficult, requiring judgment of what vegetation would develop over time with regular fire. *Pinus echinata, Quercus stellata*, and *Quercus falcata* are all species that are believed to have decreased in the absence of fire; their presence in small numbers suggests that they once were more abundant in the community. Abundant *Quercus montana* or *Quercus alba* likely suggest they were naturally abundant. *Quercus coccinea* and *Pinus virginiana*, along with *Acer, Liriodendron*, and many other hardwoods, likely are artificially increased and give little information on the natural composition of the community.

Crosswalks: *Pinus echinata - Quercus (montana, falcata) / Oxydendrum arboreum / Vaccinium pallidum* Forest (CEGL007493). *Pinus echinata - Quercus alba / Vaccinium pallidum / Hexastylis arifolia - Chimaphila maculata* Forest (CEGL008427).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Low-Elevation Pine Forest Ecological System (CES202.332).

Sites: Southern Mountain Pine–Oak Forests occur on slopes, spur ridges, and ridge tops, usually convex and usually facing south or west. Ridge-top occurrences tend to be on broader ridges than Low Mountain Pine Forest or Pine–Oak/Heath. Most examples are 1000-2000 feet in elevation, but a few occur higher on steep slopes that face south or west.

Soils: Southern Mountain Pine–Oak Forests may potentially occur on a wide variety of mountain upland soils, but most are probably the Typic Hapludults that are widespread at lower elevations. Evard and Cowee are frequently mapped series in the foothills.

Hydrology: Southern Mountain Pine–Oak Forests are dry and well-drained.

Vegetation: Southern Mountain Pine–Oak Forests are presently often dense forests but likely were fairly open with a natural fire regime. The canopy in remaining examples is dominated by a varying mix of *Quercus montana, Quercus coccinea*, *Quercus alba, Pinus virginiana*, and other pines, including *rigida, pungens*, and *strobus*. *Pinus echinata, Quercus falcata*, and *Quercus stellata* are indicators of the community and likely would codominate with regular fire, but at present usually occur only in small numbers. *Carya glabra, Carya pallida, Acer rubrum*, *Quercus velutina*, and other species may also be present. Highly constant species in the understory in CVS plot data and site descriptions are *Oxydendrum arboreum, Acer rubrum,* and *Nyssa sylvatica*, and frequent species include *Sassafras albidum, Amelanchier arborea*, *Diospyros virginiana, Benthamidia* (*Cornus*) *florida, Magnolia fraseri,* and uncharacteristic mesophytic species such as *Magnolia acuminata* and *Ilex opaca*. The shrub layer may be dense, moderate, or sparse. *Vaccinium pallidum* is highly constant and often dominant, and *Kalmia latifolia* and *Gaylussacia baccata* are frequent and sometimes dominant. Infrequent but occasionally dominant is *Gaylussacia ursina*. Other frequent shrubs include *Corylus cornuta, Castanea dentata* sprouts, *Vaccinium stamineum, Arundinaria appalachiana, Rhododendron calendulaceum,* and *Euonymus americanus*, while *Hypericum stragulum, Vaccinium arboreum*, and *Amorpha glabra* are infrequent but may once have been more abundant. *Smilax glauca* and *Smilax rotundifolia* are highly constant, and *Muscadinia rotundifolia* is frequent. The herb layer is usually sparse in present-day examples that have not burned, but likely was fairly dense when burned. Frequent herbs in plots include *Coreopsis major, Carex nigromarginata, Dichanthelium boscii, Dichanthelium commutatum, Galium circaezans, Hexastylis arifolia, Lysimachia quadrifolia, Polystichum acrostichoides, Polygonatum biflorum, Chimaphila maculata, Endodeca serpentaria, Galax urceolata, Hylodesmum nudiflorum, Lespedeza violacea, Solidago odora, Solidago arguta, Goodyera pubescens*, and *Viola hastata*. Other herbs that are not frequent in plots but are found in occurrences and are likely characteristic of the community when burned include *Piptochaetium avenaceum, Schizachyrium scoparium, Iris verna, Danthonia spicata, Danthonia sericea, Silphium reniforme, Baptisia tinctoria, Scleria oligantha, Tephrosia virginiana, Pityopsis graminifolia, Liatris spicata, Mimosa microphylla, Clitoria mariana, Desmodium rotundifolia, Dichanthelium dichotomum, Hypoxis hirsuta, Helianthus* spp., *Solidago erecta, Solidago nemoralis, Viola pedata, Viola hastata, Eupatorium rotundifolium, Ionactis linariifolia, Sericocarpus asteroides, Sericocarpus linifolius, Cunila origanoides, Sorghastrum nutans,* and *Eryngium yuccifolium*.

Range and Abundance: Ranked G3G4. In North Carolina, this community is very rare, with only a dozen occurrences known. Most are in the far southwestern mountains of Graham and Cherokee County and in the South Mountains. It is possibly unrecognized in other lower areas of the Blue Ridge escarpment, the Asheville Basin, or other lower elevation valleys, or has been lost from these areas. The related NVC associations range widely, from South Carolina, Georgia, and Alabama to Kentucky, but may be conceived overly broadly.

Associations and Patterns: Southern Mountain Pine–Oak Forests now occur as small patch communities, absent from most landscapes and, when present, usually no more than a few acres. However, a couple of large clusters of 25 acres or more apparently exist. It likely was once more widespread, and unrecognizable altered examples may still be present. Examples may grade into Montane Oak–Hickory Forest (Low Dry Subtype) or Low Mountain Pine Forest, but more often appear to be surrounded by Chestnut Oak Forest (Dry Heath or White Pine Subtype) or Montane Oak–Hickory Forest (Acidic or White Pine Subtype).

Variation: Examples are highly variable, but it is difficult to tell natural variation from alteration. It is not clear that the two related NVC associations can be distinguished in North Carolina, but variants are defined to encourage investigation of this question.

1. Chestnut Oak Variant has *Quercus montana* as the predominant oak and is generally drier.

2. White Oak Variant has *Quercus alba* as the predominant oak and is generally somewhat more mesic, though still containing the other drier-site oaks characteristic of the community.

Quercus montana and *Quercus alba* both are highly constant in site descriptions and in the few plots that have been sampled in North Carolina, but *Quercus montana* dominates all the plots.

Dynamics: Southern Mountain Pine Oak Forests, like most pine and oak forests, are believed to depend on regular fire to maintain their natural composition and structure. They presumably lie between the pine-dominated and oak-dominated communities of the Mountains in the effects of fire, but it is unclear what aspects of the fire regime are most important for allowing a more even mix of these genera. If we presume most of the fires that burned a given area had spread from some distance, fire frequency likely was similar to that of the oak forests, with the dry slope aspect and convex topography serving to increase fire intensity at times. As with other oak and pine communities, in the long absence of fire, canopies, understories, and often shrub layers have become denser, herbs have been greatly reduced, and many characteristic herbs have probably been lost from each example.

Comments: Southern Mountain Pine–Oak Forest remains a poorly understood community, and its classification and interpretation need further study. Given the rarity and heavy alteration of Low Mountain Pine Forests, which contain some oaks, and of the dry, low elevation oak forest communities, which contain some pines, it is difficult to determine what the natural state of a stand would be. If Southern Mountain Xeric Pine–Oak Woodland also occurs in North Carolina, it too would be difficult to distinguish from this community. The classification may be too finely divided to be readily applied to the natural state of communities, let alone to the current degraded state. However, further study, especially in areas that are now receiving prescribed fire, may allow for better understanding.

Southern Mountain Pine Oak Forest was initially believed to be a peripheral community to North Carolina, more characteristic of Tennessee and Georgia and present only in Cherokee County. However, vegetation attributable to it was later found in the South Mountains, and recognized occurrences are now as abundant there as anywhere in the state. It may exist unrecognized elsewhere in the state. However, the abundance of plots attributed to it in the lower Chattooga River valley of Georgia and South Carolina suggest that its primary range is peripheral to North Carolina.

The relationship of North Carolina's examples to the NVC also remains uncertain. It is unclear how widely either of the crosswalked associations is applied to altered, partly successional vegetation. The two NVC associations that appear to overlap it conceptually are fairly distinguishable in analysis of CVS plots in other states, with one being generally more mesic than the other. However, the differences beyond dominant oaks are not dramatic, and most of the species distinguishing the more mesic association are ones that could be expected to have increased with fire suppression (e.g., *Ilex opaca, Liriodendron tulipifera, Magnolia acuminata,* and *Kalmia latifolia*). These species are fairly abundant in North Carolina examples that are dominated by *Quercus montana* and have little *Quercus alba*, blurring the distinction here. However, the few plots in North Carolina are all attributed to the *Quercus montana*-dominated association and statistically resemble those attributed to it in other states. A couple of the known North Carolina sites, where no plots have been sampled, have been described as having *Quercus alba* dominant.

Rare species: No rare species are known to be associated with this community.

SOUTHERN MOUNTAIN XERIC PINE–OAK WOODLAND

Concept: Southern Mountain Xeric Pine–Oak Woodland is an open woodland dominated by *Pinus echinata, Quercus stellata*, and *Quercus marilandica*, occurring on the driest low elevation slopes. It is not documented in North Carolina but may possibly occur as extant or degraded examples, as examples are known close to the state line.

Distinguishing Features: Southern Mountain Xeric Pine–Oak Woodland would be distinguished from Southern Mountain Pine–Oak Forest by a more open canopy, more xerophytic composition, and occurrence in the driest sites. It is distinguished from Low Mountain Pine Forest, which might be similarly open and on similarly dry sites, by the codominance of oaks.

Crosswalks: *Pinus echinata - Quercus stellata - Quercus marilandica / Vaccinium pallidum* Woodland (CEGL003765).
G905 Southern Appalachian Virginia Pine - Table Mountain Pine Woodland Group.
Southern Appalachian Low-Elevation Pine Forest Ecological System (CES202.332).

Sites: Southern Mountain Xeric Pine–Oak Woodland occurs on steep slopes that face south or west, at low elevations in the foothills or Mountains.

Soils: Soils likely would be one of the Typic Hapludults common in the foothills or low mountains.

Hydrology: Sites are very dry due to steepness, convex slopes, and warm slope aspect.

Vegetation: Southern Mountain Xeric Pine–Oak Woodlands are open-canopy woodlands dominated by a mix of *Pinus echinata, Quercus stellata*, and *Quercus marilandica*. In the several plots in Georgia that are the basis of the NVC association, other highly constant canopy trees are *Quercus velutina* and *Quercus coccinea*, while *Quercus falcata, Carya tomentosa, Quercus montana, Carya pallida, Pinus strobus, Pinus virginiana*, and *Quercus alba* are at least fairly frequent. Dominant understory tree species are *Benthamidia* (*Cornus*) *florida, Nyssa sylvatica,* and *Oxydendrum arboreum*, and frequent species are *Diospyros virginiana* and *Sassafras albidum*. *Vaccinium pallidum* is constant and usually dominant in the shrub layer, and *Smilax glauca* and *Muscadinia rotundifolia* are highly constant. The only other frequent shrub is *Symplocos tinctoria,* but *Vaccinium arboreum, Kalmia latifolia,* and *Vaccinium stamineum* also occur and may be characteristic. No herbs appear strongly dominant in the plot data, and only *Pteridium latiusculum, Euphorbia corollata/pubentissima, Goodyera pubescens, Iris verna, Asclepias amplexicaulis*, and *Coreopsis major* occur with even moderate frequency. However, other herbs that occur occasionally and likely were more abundant in the past include *Baptisia tinctoria, Chamaecrista fasciculata, Chamaecrista nictitans, Chrysopsis mariana, Clitoria mariana, Coreopsis tripteris, Crotalaria sagittalis, Desmodium rotundifolium, Erianthus giganteus, Helianthus atrorubens, Helianthus microcephalus, Pityopsis graminifolia, Polygala verticillata, Rudbeckia hirta, Schizachyrium scoparium, Mimosa microphylla, Silphium reniforme, Sorghastrum nutans, Stylosanthes biflora*, and *Tephrosia virginiana*.

Range and Abundance: Ranked G4? This community has not been documented in North Carolina but may occur. The NVC association is attributed to South Carolina, Tennessee, and potentially

Kentucky as well as Georgia and North Carolina, and is said to "probably extend into the southern Ridge and Valley, Cumberland Plateau, and Piedmont." Given the extreme nature of the community, and its presumed dependence on fire, it probably is rarer than the G4 rank suggests.

Associations and Patterns: Where it is documented in Georgia, this community appears to be associated with Southern Mountain Pine–Oak Forest and perhaps Low Mountain Pine Forest.

Variation: Because good examples are not known in North Carolina, nothing can be said of variation within the state.

Dynamics: This community presumably is dependent on fire in the same way the Southern Mountain Pine–Oak Forest is. The distinctive character is probably due to drier site conditions.

Comments: This community is provisionally included in the 4th Approximation on the basis of the NVC and the possibility that it might occur here, but no occurrences are known and no plots in North Carolina have been attributed to it. The most xeric slopes known in the foothills of North Carolina, in areas with low rainfall, appear to support the less xeric Low Mountain Pine Forest or Southern Mountain Pine–Oak Forest. The nearest known occurrence is 11 miles from North Carolina in the lower Chattooga River valley.

This community may be a montane analogue of the Xeric Piedmont Slope Woodland community. It is not entirely clear how it would be distinguished if occurred beyond the fringes of the Southern Blue Ridge.

Rare species: No rare species are known to be associated with this community.

MOUNTAIN OAK FORESTS THEME

Concept: Mountain Oak Forests occur on Blue Ridge and foothills slopes and ridges and are dominated by various species of *Quercus*. Most of them were once naturally dominated or codominated by *Castanea dentata*. These forests make up much of the mountain landscape at low to moderate elevations and may be extensive at all but the highest elevations.

Distinguishing Features: Mountain Oak Forests are distinguished from most other mountain communities by dominance or codominance of *Quercus* and, formerly, *Castanea dentata*. Rare examples may be dominated by *Carya* spp. Montane Oak Forests can usually be easily distinguished from Piedmont and Coastal Plain Oak Forests by location on or above the Blue Ridge escarpment, or in rugged areas in the South Mountains, Brushy Mountains, and other mountain-like foothill ranges. They are also distinguished by flora. A large pool of species is typical of the Blue Ridge but is scarce or absent to the east, at least in North Carolina. *Castanea dentata*, still present as root sprouts in many occurrences, was once the most important distinguishing species. Other species that sometimes distinguish Mountain Oak Forests and are rarely in Piedmont communities include *Rhododendron maximum, Rhododendron catawbiense, Rhododendron calendulaceum, Gaylussacia baccata, Pyrularia pubera, Pinus strobus*, *Magnolia fraseri, Tsuga caroliniana, Tsuga canadensis, Magnolia acuminata*, *Acer pensylvanicum*, *Pinus pungens*, and *Pinus rigida*. *Quercus falcata, Quercus stellata*, and *Pinus echinata* are typical Piedmont species that are usually absent in Mountain Oak Forests but may be present in a few of the communities.

Sites: Mountain Oak Forests occur on open slopes, ridge tops, spur ridges, and even low rises and flats in valleys. Slopes are usually convex or planar. These communities range from the lowest elevations to the tops of many mountain ranges or to the edge of the spruce-fir forests around 5500 feet. At low to middle elevations, they generally make up the majority of the natural landscape. At higher elevations, they become increasingly confined to south- and west-facing slopes.

Soils: Most mountain soils, with the exception of wetland soils, can potentially support Mountain Oak Forests. They may have a wide range of depth, rock content, and chemistry. Most soils are Typic Hapludults or Typic Dystrudepts.

Hydrology: Mountain Oak Forests are well drained, and they range from marginally mesic through dry-mesic to almost the driest sites.

Vegetation: Mountain Oak Forests are almost always dominated at least weakly by some combination of *Quercus alba, Quercus rubra, Quercus montana*, or *Quercus coccinea*, with a few unusual sites dominated by some species of *Carya* or by *Quercus velutina*. Most once had *Castanea dentata* as the dominant or codominant canopy tree and have developed stronger oak dominance since its widespread mortality in the early 1900s. Other trees that sometimes form part of the canopy include *Acer rubrum*, any species of *Pinus*, and a variety of mesophytic species shared with Mountain Cove Forest communities. Canopies generally are fairly continuous, though gaps are naturally abundant. Abundant understory tree species in many communities include *Oxydendrum arboreum, Nyssa sylvatica, Benthamidia* (*Cornus*) *florida, Amelanchier arborea,* and *Acer pensylvanicum*, as well as root sprouts of *Castanea dentata*. Many communities have substantial shrub layers dominated by various members of the Ericaceae, especially *Kalmia* *latifolia, Rhododendron maximum, Gaylussacia baccata, Gaylussacia ursina, Vaccinium pallidum, Vaccinium stamineum*, and *Rhododendron calendulaceum*. Other shrubs that are widespread include *Pyrularia pubera*, *Ilex montana*, and *Calycanthus floridus*. Herb layers vary widely. Some acid-tolerant species are widespread, including *Chimaphila maculata, Goodyera pubescens, Galax urceolata, Lysimachia fraseri, Maianthemum racemosum, Uvularia* spp., and *Solidago* spp. Less common communities have herbaceous flora more typical of rich soils, many shared with Rich Cove Forests. A suite of herb species characteristic of somewhat open, frequently burned habitats is present in some of the drier communities at lower elevations and probably was more extensive when fire was more frequent.

Dynamics: Under natural conditions, Mountain Oak Forests are uneven-aged, with numerous old trees present but with trees of a broad range of ages intermixed at a fine scale. While most of the remaining forests have been altered by logging, a number of uncut remnants exist where this structure can be observed. Older second-growth stands can be seen beginning to develop this structure, and stands that were selectively logged often have a smaller but significant component of old trees. The newer understandings of the role of fire in these communities, discussed below, do not change this view of natural structure since the historic fires caused only limited mortality to older trees. The dominant oaks are among the most long-lived tree species in North Carolina, with maximum life spans of 400-600 years, 300 years for associated hickories (literature summarized in Loehle 1987). Successful regeneration of canopy trees occurs primarily in small canopy gaps caused by the death of one or a few trees. Trees produce irregular seed crops, with mast years resulting in large numbers of seedlings that can survive for several years beneath the canopy. The oaks that establish in canopy gaps generally are from this pool of advanced regeneration. Though less well known, the *Castanea dentata* that once dominated many of these forests likely had similar behavior. Russell (1987) cites early sources saying that their seedlings could not tolerate shade, while others said they could thrive for a couple years.

Ongoing processes such as lightning and severe thunderstorms create individual gaps. Occasional extensive disturbances such as hurricanes create many gaps throughout a stand at one time, but most of the individual gaps are small openings the size of one or a few trees. At a stand scale, old-growth is expected over the vast majority of the landscape, while at a fine scale there is a dynamic equilibrium of gaps in different stages of succession. The fine-scale dynamics are represented by the state-transition models produced by the Landfire program, though it is difficult to test how accurate the details are. Estimates of gap formation rates have generally been an average of 0.5-1% per year for canopy tree mortality in a wide variety of forests (Lorimer 1980, Lorimer 1989, Greenberg, et al. 1997, Greenberg, et al. 2011). Greenberg, et al. (2011), in Bent Creek Experimental Forest, found an overall average rate of about 1% canopy mortality/year over 15 years. About half was from "oak decline," at a steady rate of 0.5% per year. Another 0.4% was caused by wind throw, all during two hurricanes, while 0.1% was attributable to lightning and unknown causes. However, both the oak decline and wind throw mortality were concentrated on *Quercus coccinea*, a shorter-lived species that has increased in abundance with past logging. Mortality rates were much lower for other species of oaks that are more typically dominant in old-growth forests, with the lowest rates for *Quercus montana*.

Besides windstorms, recent decades have seen several ice storms that caused widespread disturbance, creating many small gaps and causing a short-lived, widespread decrease in canopy shade. Abel (1934) noted the impacts of earlier severe ice storms, citing oral reports of 4 in the previous 75 years. Oaks were found to be intermediate in sensitivity to ice damage, compared to other species. Damage was greater in pole size stands and uniform canopies, as well as to earlier successional species such as *Acer rubrum, Robinia pseudo-acacia*, and *Quercus coccinea*, suggesting that ice storms would cause less damage in more natural old-growth forests.

One of the most important, though poorly understood, dynamic aspects of the present Montane Oak Forests is the ongoing effect of the loss of *Castanea dentata* due to the chestnut blight (*Cryphonectria parasitica*) in the 1920s and 1930s. Root sprouts remain common, though rarely do they become large enough to flower before succumbing to the blight. The effect of the loss of the most abundant tree species acted as a widespread disturbance. Several studies documented how *Quercus rubra, Quercus montana, Quercus alba*, and *Acer rubrum*, already present, quickly filled in the space and led to the tree composition that still dominates these forests (Keever 1953, Woods and Shanks 1959, Karban 1978, McCormick and Platt 1980). Some areas where *Castanea* was more strongly dominant, where established oaks could not fill the space, regenerated in successional species or became dominated by understory species. Stephenson and Fortney (1998), in Virginia, reported that existing canopy oaks and hickories had filled in the gaps in the 20 years after chestnut mortality. However, by 1993, *Acer rubrum*, scarce before, had drastically increased, and *Quercus rubra* had surpassed the previously dominant *Quercus montana* and abundant *Quercus alba*. Day and Monk (1974) suggest that the widespread dense stands of *Kalmia* and *Rhododendron maximum* resulted from the chestnut blight. It is worth noting that the demise of the chestnut trees occurred near the start of effective fire control and that logging was widespread both before and after it. The coincidence of these changes makes it difficult to determine the primary drivers of the changes in vegetation since that time.

Following severe canopy disturbance such as clerarcutting, examples of Mountain Oak Forests tend to regenerate as even-aged successional forests dominated by *Liriodendron tulipifera*, *Acer rubrum*, *Robinia pseudo-acacia*, or *Pinus* spp., often with large numbers of sprouts of understory species. Various oaks often are present, but in much smaller numbers. Carter, et al. (2000), sampling successional forests in the high rainfall area around Highlands, found *Robinia pseudo-acacia*, *Betula lenta*, and *Liriodendron tulipifera* to be common early successional species over a broad range of environments and elevation, but they also found some *Carya glabra, Quercus coccinea, Quercus rubra*, and *Quercus alba* present in early successional forests in xeric and intermediate sites at mid to high elevations. Somewhat different successional patterns appear to have prevailed after timber harvest in the early 20th century. Most areas regenerated to the characteristic oaks, in unnaturally even-aged stands but without a large component of successional species. This appears to be true both in stands regenerated before the chestnut blight and those regenerated in the several decades after. Because much early logging was at least somewhat selective, unmarketable older oaks often remain in moderate numbers. *Quercus coccinea*, a short-lived oak that responds well to severe disturbance, increased in some stands, even becoming dominant or codominant in some, but apparently not in the majority of stands. *Acer rubrum* is increasing in many oak forests in recent decades but did not become abundant in the canopy after earlier logging. Though potentially long-lived, *Liriodendron* is scarce or absent in older second-growth stands. Dying *Robinia* and snags of this decay-resistant species are visible in many second growth forests but generally do not appear to have been dominant.

Fire has been recognized as an important ecological driver in Mountain Oak Forests, with knowledge increasing rapidly in the last couple of decades. It is increasingly being recognized that fire likely is a crucial process and that the near-universal removal of fire is altering oak forests. It is generally acknowledged that human-caused fire was frequent after European settlement and during the widespread logging of the early 1900s, ending abruptly with the advent of fire control in the 1930s. It is more difficult to determine fire regimes before settlement, and post-settlement burning is not always differentiated from presettlement in fire history studies. Lafon et al. (2017), in their synthesis and meta-analysis of tree ring studies, charcoal studies, and other evidence, indicate that burning was widespread and frequent in pre-European times in the Southern Blue Ridge and Ridge-and-Valley, though less so in the Appalachian Plateau.

It is also difficult to tell how much the presettlement fire regime was human-caused versus caused by lightning. Earlier historical explorers reported that Native Americans ignited forests regularly. Such travelers tended to follow Indian paths and stay in Indian villages, giving them a biased view of how much human influence there was on the land. It is clear that human-caused fires were common at least in those areas, but the archaeological record also suggests that habitation was quite variable in time and space. Substantial areas were unoccupied and may have been visited only infrequently. Even harder to determine is how much human ignition changed the frequency, intensity, and seasonality of fire and how much it merely preempted burning that would have happened without it. Though data are sparse, Lafon, et al. (2017) did not find evidence that fire frequencies were greater in areas with dense prehistoric human populations than in sparsely populated areas, nor did frequencies greatly decline in the period after Native American populations were decimated by European diseases but before settlers arrived. Aldrich, et al. (2009), in a long fire history in Virginia, found no significant difference in fire frequency between times of low and very high human presence.

Lightning ignition is believed by many not to be adequate to explain historical fire regimes, and indeed most present day wildfires in the region are human-caused. Cohen, et al. (2007) reported 122 fires in 56 years of record in Great Smoky Mountains National Park and 16 fires in 8 more recent years. While a selected set of the latter were allowed to burn and did not become large, it is not known how the other fires would have spread if not suppressed. It can be assumed that those selected to be allowed to burn were those least likely to spread far. At the same time, though difficult to demonstrate, it is widely believed that forests were more flammable in the past and that fire might have spread more readily. In any case, the large number of species that are well adapted to fire suggests a history of fire extending back well before Native American agriculture and, indeed, before human presence in North America. Regardless of the centrality of human influence on fire in prehistoric times, it appears that increasing the amount of fire by prescribed burning, at least at moderate frequency and intensity, and by allowing naturally ignited fires to burn where possible, can be expected to be beneficial to oak forests. Burning tends to favor more drought-tolerant species, and burning is additionally likely to make forests better adapted to future climatic warming and drying.

Most natural and human-caused fires were low to moderate in intensity. Because the dominant canopy trees are tolerant of such fires, fire likely was not a major cause of canopy gaps. Instead, as suggested by McEwan, et al. (2013) for an old-growth oak forest in Kentucky, and generalized by Lafon, et al. (2017), fire's primary role was as a filter on the pool of young trees present when canopy gaps formed by wind, lightning, or other natural disturbance. Fire determined what species could regenerate, while the time and location of regeneration of individuals was determined by formation of canopy gaps by wind, lighting, ice, and occasional hotter fires. The dominant oak species, with the exception of *Quercus coccinea*, tolerate fire better than the associated hardwoods as seedlings and saplings as well as mature trees. Allocation of resources to roots makes them better able to sprout repeatedly if burned, giving them an advantage over most trees.

Castanea dentata too shows adaptation to fire (Belar, et al. 2018). Russell (1987) cites early reports of it sprouting after fire, but believed fire to be detrimental to chestnut, citing reports of damage to timber. Damage to oak timber was similarly blamed on fire in early forestry literature. The author has observed chestnut sprouting vigorously, outgrowing oaks and other hardwood competitors, in recently burned, previously existing canopy gaps. This perhaps illustrates how the species was able to dominate the oak forests.

More frequent fire presumably also led to much lower understory density and also longer persistence times for canopy gaps, which resulted in more open canopies and more light reaching the forest floor. This made for denser and more diverse herb layers than can thrive in the present shady conditions. These herb layers would have made it easier for fire to spread in these forests. Though Vander Yacht, et al. (2018) reported little effect of single burns without canopy disturbance in Mountain Oak Forests at Green River Game Land, Holzmueller, et al. (2009), looking at oak-hickory forests burned different numbers of times in the Great Smoky Mountains, found increased species richness in burned areas, and this persisted 15-22 years after the fire. The author has observed similar effects of fire, notably including areas with no canopy mortality. Oak and hickory seedlings were denser in burned sites. Other tree seedlings were often also dense, but with more variability. Findings from other studies vary.

It must be noted that the expected effects of past fire are the result of a chronic fire regime and its effects on population dynamics, not short-lived results of individual fires. The effect of chronic fire is not to initiate secondary succession but to change the competitive environment in a way that favors fire-adapted species. The legacy of decades of missing fire is not easily or immediately reversed for several reasons. The desired higher diversity consists mostly of conservative species adapted to that regime, species that are slow to colonize and that now have reduced populations. More severe prescribed fires and wildfires generally result in the appearance of a few ruderal species in large numbers. These are sometimes mistakenly interpreted as successful restoration of a fire-tolerant herb layer if species are not distinguished or if their ecology is not considered.

There has been growing concern in recent decades that oaks are failing to regenerate throughout the eastern deciduous forest region, including the Blue Ridge and Piedmont of North Carolina (Loftis and McGee 1993, Rodewald 2003, Knott, et al. 2019). While this phenomenon is noted through the Eastern United States, details in these sources show substantial variation, including local areas where it does not appear to be occurring. Because the detection of this pattern is at a broad scale, much of the area affected is influenced by ongoing timber management and variation in logging practices.

It can be observed in many Mountain Oak Forests that oaks are scarce or absent in the understory, and that other species are gradually replacing them in the canopy. If the prevalence of the introduced Asiatic oak weevil (*Cyrtepistomus castaneus*) found in southern Ohio (Lombardo and McCarthy 2008) is widespread in the Appalachians, it may be contributing to the reduction in oak regeneration by feeding on the roots and leaves of oak seedlings. However, oak seedlings can be observed to be abundant in most Mountain Oak Forests after mast years; it is saplings and understory individuals that are scarce. Various shade-tolerant mesophytic trees in the understory are believed to have increased shading on the ground, reducing the survival and growth of the less shade-tolerant oak seedlings. *Acer rubrum* is by far the most common species appearing to replace oak in most Montane Oak Forests, but at higher elevations, *Acer saccharum, Betula alleghaniensis*, and other species of Northern Hardwood Forests also are dense in understories and increasing in overstories. In more mesic oak forests, *Tsuga canadensis* and species of cove forests are abundant in smaller sizes and appear to be increasing. Abella and Shelburne (2003) documented the establishment of *Pinus strobus* and abundance of young pines in an oak forest at Ellicott Rock Wilderness where none had been present before 1900 and few even after 1950. Once a dense understory is established, the forest floor is too shady for oak seedlings to grow to saplings, and the established shade-tolerant trees capture more of the canopy gaps.

The term "mesophication" has been applied to this process (Nowacki and Abrams 2008), because the tree species that are increasing are more mesophytic than the oaks. Mesophication also changes the environment within the forest, with humidity increased beneath a dense understory, the thinner leaves of mesophytic trees matting down and holding moisture more than oak leaves do, and less long-lived duff being formed. This creates a feedback, whereby the effect of removing fire is to make forests less able to burn. The higher humidity may also favor mesophytic species; however, given the increased root competition with denser vegetation and the lower water use efficiency of most mesophytic species, it is not clear whether moisture would actually be more available to seedlings.

Mesophication is believed to result from lack of fire, though there are views that subtle climate changes could be behind it. McEwan, et al. (2011) and Nowacki and Abrams (2014) cite statistics indicating that the overall range of eastern oak forests was wetter after 1970 than in the earlier 1900s, coinciding with the period of rapid maple increase, and that there were more droughts in the several centuries before 1900. It is very difficult to sort the effects of fire suppression and rainfall shifts from other phenomena, including loss of chestnut, the recovery from extensive logging in the early 1900s, and increasing deer populations. The apparent failure of oak regeneration is nearly universal despite variability in all of the hypothesized drivers.

It should be noted that, though *Acer rubrum* has mesophytic characteristics such as shade tolerance and susceptibility to fire, it has an extremely broad moisture tolerance and does well in dry sites. It also has ruderal characteristics such as prolific seeding, widespread seed dispersal, and rapid seedling growth in high light. It benefitted from the chestnut blight and can be observed to increase following present day logging. While the increase of *Tsuga*, *Rhododendron maximum*, *Fagus grandifolia*, and other species suggests a general increase in mesophytic species, their expansion is much more limited. Other species that are not considered mesophytic have also increased and potentially interfere with regeneration of oak and even pines; these include *Nyssa sylvatica, Oxydendrum arboreum,* and *Kalmia latifolia*. The more extensive spread of *Acer rubrum*, along with the increase of *Liriodendron* in oak forests, may be due to their ruderal characteristics -- an accumulating effect of exponentially growing seed rain resulting from generations of drastic canopy opening in the landscape by chestnut blight, land clearing, and logging. Nevertheless, this spread would not have happened in a landscape with more frequent fire, and a return to the earlier fire regime begins reversing it. *Acer rubrum* stems can be observed to be killed by fires that do not kill oaks of similar size, across a wide range of sizes. However, given *Acer rubrum's* vigorous sprouting, only repeated fire can reduce its abundance in the long term.

Though there is general agreement that the natural fire regime (or past fire regime whether natural or not) would have produced different forest structure, with more open canopies, the appropriate density is not easily determined. The extreme openness suggested by some managers, such as the thinning to woodland and even savanna density done in the experiments of Vander Yacht, et al. (2018), does not seem supported as a natural condition in the Mountain Oak Forests of North Carolina. The sources they cite in support are in other regions, with different climates. Oak savannas and barrens such as those found on the fringe of the tallgrass prairies far to the west occurred in North Carolina only on rare extreme soils. The early ecological studies of forests in the Southern Blue Ridge do not depict landscapes of oak savanna. Seminal studies in uncut forests, such as Whittaker (1956), were done within a couple decades of the beginning of effective fire control, well before a fire-maintained sparse understory could have turned an open savanna into the dense forests he found.

It is similarly not well supported that thinning to woodland or savanna density will restore the herb and shrub layers of fire-maintained systems. Indeed, though Vander Yacht, et al. (2018) interpreted their results from thinning as beginning to reverse mesophication, the data they present shows their North Carolina study area to have drastic increases in *Acer rubrum* and understory species, as well as in *Rubus*, *Rhus*, other ruderal species, along with most of the shrub species already present. Though the number of oak saplings increased, the increase in undesired species was much greater. Without repeated fire, the thinned forests in their study will become more dominated by mesophytic species than before, rather than less. With repeated fire, the burned-only forests would be more dominated by oaks than the thinned forests. The most crucial question for natural area management and ecological restoration, whether oaks would capture canopy gaps that form naturally, does not appear to have been addressed in any of the recent studies of fire effects. Most studies also do not assess herbs in detail. In general, burning can be observed to increase the vigor of any established individuals of most herbaceous species. Where the burn is intense enough to kill many canopy trees, ruderal herbs and briers appear or increase, just as they do with cutting of canopy trees. Establishment of new individuals of the long-lived species expected in regularly burned natural communities generally is sparse and slow in both mild and severe burns.

Appropriate fire return intervals for Mountain Oak Forests are still uncertain but probably are about 10 years, once more natural structure has been restored. Frost's (1998) small scale map of presettlement fire frequency, based on fire compartment size and vegetational indicators, showed 13-25 years for the western mountains of North Carolina and 8-12 years for the eastern part and the Asheville Basin. Aldrich, et al. (2009), in dry pine sites in Virginia, found mean fire intervals of 7.3-15.9 in different stands, with a wide range of 2-59 years in individual stands. Likely natural fire regimes can also be inferred to some degree from the ecology of the dominant species. More frequent fire would make regeneration of oaks difficult, confining it to rare longer fire-free intervals. Belar, et al. (2018) found physiological and structural characteristics of chestnut saplings that suggest they are more tolerant of shade than *Quercus rubra*, but less tolerant of drought and less able to keep resprouting after multiple top-kills. They concluded chestnut could benefit from occasional fire and from canopy gaps, but their evidence suggests somewhat less fire and less open forest than might be inferred from oak ecology alone.

Besides affecting the structure of oak forests, fire may affect the boundaries between them and adjacent communities. Oaks are naturally present in more mesophytic forests in smaller numbers. Logging may increase their abundance in mesophytic sites. It is unclear how much of the concern about lack of oak regeneration is in sites that may be returning to a naturally lower density of oak after having had it increased by past logging or clearing. Dey and Fan (2008) used the terms "oak accumulator systems" and "recalcitrant oak accumulator systems", noting that in more mesophytic sites oak seedlings are numerous but compete poorly and, being less vigorous, are more prone to being killed by fire. In dry sites, in contrast, fire preferentially benefits oaks.

Along with the increase of mesophytic trees, there has been interest in evergreen heaths in mountain forests. Monk, et al. (1985) noted in their study in chestnut oak forests that both *Rhododendron maximum* and *Kalmia latifolia* plants averaged 38 years, dating them to the 1940s, with plants of all sizes clustering at that age. Only a couple of individuals were older than the chestnut blight. They note that these species can be an important component of biomass in some forests (though they would be less so in an old-growth forest with larger trees). Brose (2016), in Pennsylvania oak forests with different logging history and canopy age structure, found *Kalmia latifolia* largely to have established after 1950, with continuous establishment in both wet and dry periods since then. However, in both, the oldest stems were near the maximum life span reported in the literature for stems of the species, making it unclear how abundant *Kalmia* might have been farther in the past. If the high cover of evergreen heaths in many oak forests is indeed a recent phenomenon, it is difficult to tell which of several potential causes is most important. Whittaker (1956) found abundant heath communities in the Great Smoky Mountains just a couple of decades after effective fire suppression began and after chestnuts had died. His study included forests that had not been logged. But the extent of heath shrubs on the landscape was not quantified. As with the spread of mesophytic trees, the removal of fire is the most likely cause for whatever expansion has occurred. *Kalmia latifolia* and evergreen *Rhododendron* spp. sprout after burning but less vigorously and less quickly than most hardwood trees or most deciduous shrubs. Deciduous heaths, especially *Gaylussacia baccata, Gaylussacia ursina*, and *Vaccinium pallidum*, can have extensive cover in oak forests as well. All sprout vigorously after burning. The early result of more fire is generally to increase the cover of the deciduous species at the expanse of *Kalmia latifolia*, though long term more frequent fire might result in lower density of all. Not addressed in any literature is the fact that oak forests with less acidic soils, such as Montane Oak—Hickory Forest (Basic Subtype) and Chestnut Oak Forest (Herb Subtype), do not have substantial heath cover. This is the case despite a similar history of chestnut death, logging, exclusion of fire, and presumably most other ecological factors.

Oaks are generally more tolerant of drought than other trees species in the region, with the exception of most pine species. *Quercus rubra* generally is associated with more mesic sites, *Quercus montana* with the driest sites, and *Quercus alba* with intermediate moisture levels. *Quercus coccinea* appears to have a broader moisture tolerance, but this species is short lived and appears to have been a smaller component of natural forests than of the younger forests at present.

However, Blackman and Ware (1982), based on direct measurements of soil moisture at two sites in Virginia, caution against assuming *Quercus rubra* always indicates moister conditions than *Quercus montana*.

Comments: The Mountain region has had a number of studies that have described forest vegetation patterns and classified communities into types. Whittaker (1956) was particularly influential, given its thoroughness at an early date. This work guided and helped structure decades of subsequent site description and more focused studies and was the single largest influence in structuring the mountain forest portion of the 4th approximation and previous approximations. However, its focus was a single mountain range, the Great Smoky Mountains, and in fact was largely confined to the middle and western Tennessee side of the range. Several more recent studies on particular mountain ranges or regions in North Carolina have shown the similarities and contrasts in forest vegetation patterns, including McLeod (1988 – Black and Craggy Mountains) and Newell (1997 – Linville Gorge, Shining Rock Wilderness, Joyce Kilmer-Slickrock Wilderness). All have identified topography and elevation as important factors differentiating communities. Later studies, drawing on the large accumulated body of plot data, especially Ulrey (2002), have identified soil chemistry as an important independent factor.

KEY TO MOUNTAIN OAK FORESTS

1. Forests (or occasional open woodlands) at high elevations, generally above 4500 feet elevation. Canopy dominated by *Quercus rubra*; except for ecotonal communities with abundant *Quercus montana*, no other oaks are abundant. *Betula alleghaniensis, Fagus grandifolia, Aesculus flava, Acer saccharum*, or other mesophytic hardwoods may approach codominance, or may be more abundant in density but subordinate in basal area ………… **High Elevation Red Oak Forest** (see Key A below)

1. Communities at low to high elevation, but not as above.

2. Substrate dolomite or limestone; canopy containing appreciable or codominant *Quercus muhlenbergii* or *Juglans nigra*.. **Calcareous Oak–Walnut Forest**

2. Substrate not dolomite or limestone; canopy not dominated by *Quercus muhlenbergii* or *Juglans nigra*.

3. Forest dominated by *Quercus rubra*, at low to moderate elevations (generally below 4500 feet), with little or no *Quercus alba* or *Quercus montana*, and without other species characteristic of high elevations.

4. Low elevation forest (below 3600 feet) dominated by *Quercus rubra* without appreciable *Quercus montana* or *Quercus alba*, and without appreciable numbers of more mesophytic species (sometimes with abundant *Carya glabra* or other species) ……………………………………………………………… **Low Montane Red Oak Forest**

4. Low to moderate elevation forest on sheltered concave slopes, codominated by *Quercus rubra* along with diverse mesophytic species such as *Betula lenta, Tilia americana* var. *heterophylla, Aesculus flava*, and *Magnolia acuminata*, with a lush herbaceous layer .... **Rich Cove Forest (Red Oak Subtype) in Montane Cove Forests**

3. Forest low to high elevation but dominated or codominated by other *Quercus* species (though *Quercus rubra* may be codominant.

5. Forest containing appreciable amounts of *Quercus alba*, which may be dominant, codominant, or less abundant but making up more than 10% of the canopy cover or basal area.

6. Rare forests of exposed high elevation sites, above 4500 feet, strongly dominated by *Quercus alba*... **High Elevation White Oak Forest**

6. Forests with *Quercus alba* dominant or not, but not strongly dominant in sites over 4500 feet in elevation; common to rare communities in a wide variety of topography and elevations. .... **Montane Oak–Hickory Forest** (see key C below).

5. Forest dominated by *Quercus montana, Quercus coccinea*, rarely Q*uercus velutina*, sometimes with abundant pines, with less than 10% *Quercus alba*. ....…………………………………………….. **Chestnut Oak Forest** (see key B below)

Key A. High Elevation Red Oak Forest

1. Forest on a well-developed boulderfield, with large, detached rocks covering near 100% of the ground surface, generally with open spaces between and beneath many of the boulders; soil consisting of pockets of material accumulated on or between boulders; herb and shrub layers sparse and containing species capable of growing on rock or in shallow soil.. .... **High Elevation Red Oak Forest (Boulderfield Subtype)**

1. Forest not on a well-developed boulderfield, though substantial loose rock or bedrock may be present; shrub and herb layers various but their structure and composition not greatly affected by boulder cover.

2. Community occurring on sharp ridge tops or shallow soils; shrub layer dense, and dominated by evergreen, generally ericaceous, species

3. Canopy notably open and stunted .... **High Elevation Red Oak Forest (Stunted Woodland Subtype)**

3. Canopy not notably open and stunted...**High Elevation Red Oak Forest (Heath Subtype)**

2. Community occurring on slopes or broader ridgetops, on a variety of soils; shrub layer open to moderate, predominantly of deciduous species.

4. Herb layer containing significant numbers of species shared with Rich Cove Forests, such as *Actaea racemosa*, *Collinsonia canadensis*, *Solidago curtisii*, *Sanguinaria canadensis*, and *Caulophyllum thalictroides*. Canopy containing species of rich mesophytic sites, such as *Fraxinus americana, Acer saccharum*, *Prunus serotina, Carya ovata*, and *Tilia americana* var. *heterophylla*. Substrate amphibolite, calc-silicate, or other mafic or calcareous rock .... **High Elevation Red Oak Forest (Rich Subtype)**

4. Herb layer sparse to dense, but lacking species of rich mesophytic sites as above. Canopy lacking species of rich sites, though it may have other species typical of Northern Hardwood Forest.

5. Forest structure orchard-like, trees somewhat stunted but canopy not notably open, with limited understory and shrub layer, and with a dense but not rich or diverse herbaceous layer generally dominated by *Carex pensylvanica* or *Angelica triquinata*...................................... .... **High Elevation Red Oak Forest (Orchard Forest Subtype)**

5. Forest structure more typical, not orchard-like; generally with a moderate understory and deciduous shrub layer, and with a sparse to moderately dense herb layer with a greater variety of species..................................... **High Elevation Red Oak Forest (Typic Herb Subtype)**

Key B. Chestnut Oak Forest

1. Forest on a well-developed boulderfield, with large, detached rocks covering near 100% of the ground surface, generally with open spaces between and beneath many of the boulders; soil consisting of pockets of material accumulated on or between boulders; herb and shrub layers sparse and containing species capable of growing on rock or in shallow soil.. ....**Chestnut Oak Forest (Boulderfield Subtype)**

1. Forest not on a well-developed boulderfield, though substantial loose rock or bedrock may be present; shrub and herb layer various but their structure and composition not greatly affected by boulder cover.

2. Canopy with *Pinus strobus* naturally occurring in more than minor amounts, often codominant; (Note that *Pinus strobus* may be introduced in plantations or old fields, occasionally by under planting, and that its abundance where it naturally occurs may be increased or decreased by logging and alteration of fire regimes. This subtype applies to areas where its presence appears natural).. **Chestnut Oak Forest (White Pine Subtype)**

2. Canopy without *Pinus strobus* naturally present, or present in only very small amounts.

3. Trees in addition to *Quercus montana* and *Quercus coccinea* more xeric, generally *Pinus* spp., or *Quercus velutina*; shrub layer dense to moderate, dominated by *Kalmia latifolia, Gaylussacia baccata, Gaylussacia ursina*, *Vaccinium pallidum,* or occasionally *Rhododendron minus, Rhododendron carolinianum,* or other evergreen Ericaceae; if *Rhododendron maximum*

is abundant, more xerophytic shrubs are also abundant and the community is on a ridge top, upper slope, spur ridge, or convex slope............. **Chestnut Oak Forest (Dry Heath Subtype)**

3. Trees in addition to *Quercus montana* more mesophytic, generally *Quercus rubra* or species shared with Acidic Cove Forest; lower strata various.

4. Community occurring on north-facing slopes, sheltered slopes, or other somewhat mesic areas; shrub layer usually dense, dominated by *Rhododendron maximum*; canopy usually containing mesophytic species such as *Betula lenta*, *Liriodendron tulipifera, Halesia tetraptera, Betula alleghaniensis*, or *Tsuga canadensis.*............……………………………..
……………………………………………………**Chestnut Oak Forest (Mesic Subtype)**

4. Occurring on a variety of topography, but not generally obviously mesic sites; shrub layer sparse to moderate, dominated by deciduous species such as *Rhododendron calendulaceum, Vaccinium stamineum, Pyrularia pubera*, or other species of less extreme sites; herb layer sparse to dense, containing widespread species of acidic forests or occasionally species of basic soils .... **Chestnut Oak Forest (Herb Subtype)**

Key C. Montane Oak–Hickory Forest

1. Forest on a well-developed boulderfield, with large, detached rocks covering near 100% of the ground surface, generally with open spaces between and beneath many of the boulders; soil consisting of pockets of material accumulated on or between boulders; herb and shrub layers sparse and containing species capable of growing on rock or in shallow soil...
....**Montane Oak–Hickory Forest (Boulderfield Subtype)**

1. Forest not on a well-developed boulderfield, though substantial loose rock or bedrock may be present; shrub and herb layers various but their structure and composition not greatly affected by boulder cover.

2. Forest occurring at low elevations on sites with westerly or southerly aspect or otherwise dry. Canopy containing species typical of low elevation dry areas, particularly *Pinus echinata*, *Quercus falcata*, and *Quercus stellata*, though *Quercus alba*, *Quercus montana*, and *Quercus coccinea* generally dominate and pines are not codominant; herb layer naturally containing species typical of dry, fire maintained areas, such as *Schizachyrium scoparium, Baptisia tinctoria, Iris verna* var. *smalliana*, *Viola pedata*, and *Silphium reniforme*, though these may have become confined to edges or have been lost due to exclusion of fire.

3. Community occurring on mafic rock substrate; additionally containing species indicative of basic soil conditions, such as *Fraxinus americana, Fraxinus biltmoreana, Frangula caroliniana, Rosa carolina*, or *Ptelea trifoliata* ………………………………………………………
…………………………………….. **Montane Oak–Hickory Forest (Low Dry Basic Subtype)**

3. Community lacking species indicative of basic soil conditions; all species acid-tolerant .....
.... **Montane Oak–Hickory Forest (Low Dry Subtype)**

2. Community occurring at low to high elevation, but in less dry sites and lacking the above suite of species indicating low elevation dry conditions.

4. Community occurring on mafic or calcareous rock substrate; herb layer containing significant numbers of species shared with Rich Cove Forests, such as *Actaea racemosa*, *Collinsonia canadensis*, *Solidago curtisii*, *Sanguinaria canadensis*, and *Caulophyllum thalictroides;* canopy containing species of rich mesophytic sites, such as *Acer saccharum*, *Prunus serotina, Carya ovata*, and *Tilia americana* var. *heterophylla*, though dominated by *Quercus rubra*, *Quercus alba*, and *Carya* spp. ....
.... **Montane Oak–Hickory Forest (Basic Subtype)**

4. Community occurring on felsic rock or other acidic rocks; lacking species indicative of basic soil conditions.

5. Canopy with *Pinus strobus* naturally occurring in more than minor amounts, often codominant; (Note that *Pinus strobus* may be introduced in plantations or old fields, occasionally by under planting, and that its abundance where it naturally occurs may be increased or decreased by logging and alteration of fire regimes. This subtype applies to areas where its presence appears natural …………………………………………………... .... **Montane Oak–Hickory Forest (White Pine Subtype)**

5. Community lacking *Pinus strobus* as a natural codominant or abundant species; canopy generally dominated by combinations of *Quercus alba, Quercus montana*, and *Quercus rubra*, with varying amounts of *Carya* spp………………………………………………… .... **Montane Oak–Hickory Forest (Acidic Subtype)**

HIGH ELEVATION RED OAK FOREST (TYPIC HERB SUBTYPE)

Concept: High Elevation Red Oak Forests are *Quercus rubra* or one-time *Castanea dentata–Quercus rubra* forests, without *Quercus alba,* at higher elevations, generally above 3500 feet and ranging up to the highest elevations of any oak forest. The Typic Herb Subtype includes the central concept of the type, the most widespread and abundant of High Elevation Red Oak Forest subtypes. Herbs and deciduous shrubs generally occur at moderate density.

Distinguishing Features: High Elevation Red Oak Forests are distinguished by having *Quercus rubra* dominating the canopy cover or basal area under current natural conditions (with *Castanea* largely eliminated), having no appreciable presence of *Quercus alba*, and occurring at elevations above about 3500 feet. *Quercus rubra* predominates over *Picea rubens* and over the mesophytic hardwoods of Northern Hardwood Forest, at least among older canopy trees. High Elevation Red Oak Forest is distinguished from Montane Oak–Hickory Forest, which may have abundant *Quercus rubra*, by having less than 10% *Quercus alba* in the canopy.

The Typic Herb Subtype is distinguished by not meeting the criteria for the other subtypes. It has a shrub layer dominated by deciduous species rather than evergreen, or a sparse shrub layer with less than 20% cover, and an herb layer that may vary widely in density and species composition but which is not a dense lawn of *Carex pensylvanica*. The flora lacks significant presence of species indicative of less acidic, base-rich soils, such as *Fraxinus americana, Tilia americana var. heterophylla, Actaea racemosa, Caulophyllum thalictroides, Prosartes lanuginosa, Collinsonia canadensis*, and *Sanguinaria canadensis*. This subtype is distinguished from the Stunted Heath Subtype by having a full stature canopy, more than 8 meters tall unless very young.

Crosswalks: *Quercus rubra / (Vaccinium simulatum, Rhododendron calendulaceum) / (Dennstaedtia punctilobula, Thelypteris noveboracensis*) Forest (CEGL007300).
Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: High Elevation Red Oak Forests occur on open slopes and ridge tops, usually on convex topography. They range from a low of around 3500 feet elevation to the upper elevation limit of oak forests, around 5900 feet. Most are on warm slope aspects (south and west), though they may be on cooler aspects at lower elevations.

Soils: A wide variety of soil series is mapped. Porters (Humic Dystrudept), Wayah (Typic Humadept), and Chestnut (Typic Dystrudept) are most frequent. Most other mapped soils are Inceptisols, but some are Ultisols.

Hydrology: Sites are well-drained but mesic due to cool temperatures and high rainfall at their high elevations.

Vegetation: The forest canopy is dominated by *Quercus rubra*, probably usually var. *ambigua*, and may be closed or somewhat open. Before the chestnut blight, some examples had *Castanea dentata* codominant but this species apparently was less dominant than in other oak forests (Whittaker 1956). *Quercus montana* may codominate in lower elevation transitional examples.

Mesophytic hardwoods, particularly *Betula alleghaniensis, Fagus grandifolia*, *Acer rubrum*, or *Acer saccharum* may codominate in many examples. The same mesophytic species often dominate the understory. CVS plot data show *Acer pensylvanicum* and *Amelanchier arborea* or *laevis* fairly constant and *Magnolia fraseri* less frequent but sometimes dominant in the understory. The shrub layer usually is sparse to open, though it may be dense. *Castanea dentata* sprouts, *Rhododendron calendulaceum*, *Ilex montana*, and *Vaccinium corymbosum* are the most constant species and sometimes dominant. Other species that sometimes dominate include *Vaccinium corymbosum, Vaccinium erythrocarpum, Vaccinium simulatum*, *Corylus cornuta, Viburnum acerifolium, Hamamelis virginiana, Gaylussacia ursina*, and, in forests with canopy disturbance, *Rubus canadensis* or *Rubus alleghaniensis*. The evergreen shrubs *Rhododendron maximum, Kalmia latifolia, Rhododendron catawbiense*, or *Rhododendron minus* may be present in small numbers. The herb layer ranges from dense to sparse. Plot data show *Amauropelta* (*Parathelypteris*) *noveboracensis* and *Sitobolium* (*Dennstaedtia*) *punctilobulum* with high constancy and sometimes overwhelmingly dominant. Other high constancy species that do not tend to dominate include *Lysimachia quadrifolia, Medeola virginica, Dioscorea villosa*, *Maianthemum racemosum,* and *Conopholis americana*. Other species that may dominate in plots include *Athyrium asplenioides, Carex pensylvanica, Ageratina roanensis, Anemone quinquefolia,* and *Maianthemum canadense*. A diverse suite of herbs may occur less frequently, including *Clintonia umbellula, Arisaema triphyllum, Eurybia chlorolepis, Osmundastrum cinnamomeum, Osmundastrum claytoniana, Nabalus latissimus, Nabalus serpentaria, Goodyera pubescens, Polystichum acrostichoides, Silene stellata, Stellaria pubera, Oclemena acuminata*, and *Amianthium muscitoxicum*. Natural Heritage Program descriptive reports and local studies report similar composition (e.g., Day and Monk 1974, DeLapp 1978, Elliott and Hewitt 1997, McLeod 1988, Newell 1997, Rohrer 1983, Whigham 1969).

Range and Abundance: Ranked G4. The Typic Subtype occurs throughout the mountains of North Carolina, in every range that reaches 4000 feet. The equivalent association ranges from Georgia northward to West Virginia.

Associations and Patterns: High Elevation Red Oak Forest occurs in large patches below the spruce-fir forests in the highest mountain ranges and at the tops of lower and more southerly ranges. In the zone where it is abundant, it often occurs in a mosaic, occupying the warmer slope aspects while Northern Hardwood Forest occupies the cooler. It may grade to Montane Oak–Hickory Forest or Chestnut Oak Forest at lower elevations. The Typic Herb Subtype may grade to the Heath Subtype on sharper topography or shallower soils and may abruptly transition to the Rich Subtype if the geologic substrate changes.

Variation: The Typic Herb Subtype shows substantial variation in its lower strata, but it is not obvious how to structure it into variants. Whittaker (1956) indicated that higher elevations had less *Castanea dentata* originally and therefore less alteration by the chestnut blight. He suggested many of the differences between high and low elevations might be the result of that different disturbance, but the previous difference in *Castanea* abundance hints at other elevation-related differences as well. DeLapp (1978) classified High Elevation Red Oak Forest into seven phases. Three would fall within the Typic Herb Subtype. His deciduous heath phase and mixed fern phase do not seem distinguishable in later experience. His third phase, described as having dense *Corylus cornuta*, is intriguing, as this species is not at all frequent in the CVS plots for this community, and only one plot has as much as 10-25% cover. Other communities where the author has observed *Corylus cornuta* appear to fit the Rich Subtype better. Given this uncertainty, no variants are recognized.

Dynamics: The Typic Subtype is similar to most Montane Oak Forests in its dynamics, including natural occurrence as uneven-aged, old-growth forests and in having most tree regeneration in small to medium canopy gaps. However, its location at higher elevation likely leads to more disturbance by wind and ice and less by drought. It is somewhat uncertain how fire dynamics compare to those in other oak forests, though fire is believed to be important. The cooler, moister climate, shorter growing season, greater snowfall, and the landscape association with less flammable Northern Hardwood Forests might suggest less frequent fire; however, the location at tops of slopes, where fires can spread from extensive slopes below, may compensate for this. Recent changes in High Elevation Red Oak Forests are similar to those attributed to lack of fire in other oak forests.

It is widely observed that many examples of High Elevation Red Oak Forest, particularly of this subtype, have a dense understory of mesophytic trees characteristic of Northern Hardwood Forest canopies (*Betula alleghaniensis, Acer saccharum, Fagus grandifolia,* and *Aesculus flava*). *Quercus rubra* is often scarce or absent from the understory, and the forests appear to be succeeding to Northern Hardwood Forest. Patches where old canopy oaks have died may already be dominated by these species, though they can generally be recognized as belonging to a surrounding stand still dominated by *Quercus rubra*. The failure of oak regeneration and the transition to mesophytic hardwoods seems to be more pronounced or faster than in lower elevation oak forests. As in those forests, the likely reason is loss of fire. *Quercus rubra* appears to be less tolerant of fire than the dominants of other Montane Oak Forests, but it is more tolerant than the thin-barked mesophytic species with which it competes.

Comments: Communities comparable to High Elevation Red Oak Forests have been recognized in most plot classification studies, such as McLeod (1988), Newell (1997), and Ulrey (2002), as well as Whittaker (1956) and earlier works. Most recognize only a single class corresponding to High Elevation Red Oak Forest. Where more classes are recognized (e.g., Newell 1997), the boundaries placed on their units do not always correspond closely with those of the Typic Herb Subtype. DeLapp (1978) conducted detailed analysis of High Elevation Red Oak Forests, recognizing several subdivisions comparable to most of the subtypes now recognized.

Some literature specifically indicates that the oak in this community is the taxon now called *Quercus rubra* var. *ambigua*, but most sources do not distinguish varieties. Weakley (2018) indicates a break in elevational range of the two varieties near the lower limit of High Elevation Red Oak Forest, but it is not known if this community is exclusively characterized by the higher elevation variety.

Rare species:
Vascular plants – *Calamagrostis porteri, Carex roanensis, Lilium grayi, Lysimachia fraseri, Platanthera peramoena, Rhododendron vaseyi, Robinia hispida* var. *kelseyi*, *Robinia viscosa, Thermopsis fraxinifolia,* and *Thermopsis mollis*.

Nonvascular plants – *Cephalozia hampeana, Cetrelia cetrarioides, Dicranum undulatum,* and *Metzgeria consanguinea.*

Vertebrate animals – *Catharus guttatus, Coccyzus erythropthalmus*, *Poecile* (*Parus*) *atricapillus,* and *Sphyrapicus varius.*

HIGH ELEVATION RED OAK FOREST (RICH SUBTYPE)

Concept: High Elevation Red Oak Forests are *Quercus rubra* or one-time *Castanea dentata-Quercus rubra* forests, without *Quercus alba,* at higher elevations, generally above 3500 feet. The Rich Subtype includes red oak forests of mafic rock or comparable substrates, whose flora contains species typical of high pH, base-rich sites.

Distinguishing Features: High Elevation Red Oak Forests are distinguished by having *Quercus rubra* making up more than 50 percent of the canopy cover under current natural conditions (with *Castanea* largely eliminated), while occurring at elevations above about 3500 feet. The Rich Subtype is distinguished from all other subtypes by having a substantial presence of base-loving plants. *Fraxinus americana* and *Acer saccharum* are generally important in the canopy, and *Prunus serotina, Aesculus flava*, and *Tilia americana var. heterophylla* may also be present. Herbs more typical of Rich Cove Forest, such as *Actaea racemosa, Caulophyllum thalictroides, Prosartes lanuginosa, Collinsonia canadensis, Sanguinaria canadensis*, and *Impatiens pallida*, are abundant. Ericaceous shrubs are not dominant but may be present in small numbers.

It can be difficult to distinguish the Rich Subtype from Rich Cove Forests at its lower elevations. *Quercus rubra* also dominates in Rich Cove Forest (Red Oak Subtype) and can be abundant in other subtypes of Rich Cove Forest, especially in ecotonal areas. The classification of High Elevation Red Oak Forest (Rich Subtype) should be used where *Quercus rubra* dominance is extensive in a stand that is primarily on exposed or convex slopes; it should not be used in ecotones where the combination of oak dominance with rich herbs is narrow. Rich Cove Forest (Red Oak Subtype) occurs on concave slopes in upper drainages, and grades to other subtypes of Rich Cove Forest below. The floristic differences among these communities need further clarification. High Elevation Red Oak Forest (Rich Subtype), while sharing many herbaceous species with Rich Cove Forest, typically has them at lower density and has different species dominant.

Crosswalks: *Quercus rubra - Fraxinus americana - Acer saccharum / Actaea racemosa - Caulophyllum thalictroides - Collinsonia canadensis* Forest (CEGL004256).
G015 Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: The Rich Subtype occurs on open slopes and ridge tops comparable to those of the Typic Herb Subtype but with a substrate of amphibolite, calc-silicate, or other mafic or calcareous rock. Examples range from 3500 feet or a bit lower up to about 5500 feet elevation.

Soils: Most examples are mapped as Porters (Humic Dystrudept), some as Edneyville (Typic Dystrudept), or Unaka (Humic Dystrudept). A wide variety of other series is mapped occasionally, mostly Inceptisols but some Ultisols.

Hydrology: Sites are well-drained but mesic due to cool temperatures and high rainfall at their high elevations.

Vegetation: This community's closed-to-somewhat-open canopy is dominated by *Quercus rubra*, but often only weakly so. The oak probably is usually var. *ambigua*. Some examples had *Castanea* *dentata* codominant; it is unclear if Whittaker's (1956) observation of less *Castanea* in red oak forest applies to this subtype or not. A varying set of species characteristic of rich mesophytic sites is present in the canopy; one may codominate or they may collectively make up a moderate to large minority of the canopy. CVS plot data and extensive observations show high constancy and sometimes high cover for *Acer saccharum, Prunus serotina, Fraxinus americana, Tilia americana* var. *heterophylla*, *Betula lenta, Carya ovata, Carya cordiformis, Magnolia acuminata, Aesculus flava, Acer rubrum, Carya glabra*, and *Betula alleghaniensis*. These same species may make up much of the understory, though *Acer pensylvanicum, Amelanchier laevis, Crataegus macrosperma*, or *Ostrya virginiana* may dominate the understory instead. Shrubs generally have low cover, and only *Castanea dentata* sprouts, *Ilex montana*, and *Rhododendron calendulaceum*, have constancy as high as 50%. *Hydrangea arborescens* and *Ribes cynosbati* are also fairly frequent. Vines are not prominent, but *Isotrema macrophyllum* or *Parthenocissus quinquefolia* may be locally abundant. The herb layer is moderate in density. In CVS plots, *Solidago curtissii* is almost always present but not often dominant, but in observations later in the growing season it often is dominant. *Ageratina roanensis*, *Eurybia chlorolepis*, *Amauropelta* (*Parathelypteris*) *noveboracensis*, and *Carex pensylvanica* also may dominate sizeable areas at least in some seasons. A diversity of herbs typical of rich sites is usually present, along with most of the species abundant in the Typic Herb Subtype. Species with high constancy in CVS data include *Prosartes lanuginosa, Arisaema triphyllum, Collinsonia canadensis, Sanguinaria canadensis, Maianthemum racemosum, Dioscorea villosa, Caulophyllum thalictroides, Conopholis americana, Polystichum acrostichoides, Actaea racemosa, Asclepias exaltata, Clintonia umbellula, Ligusticum canadense, Botrypus virginianus, Silene stellata, Stellaria pubera, Geranium maculatum, Lysimachia quadrifolia, Veratrum parviflorum, Athyrium asplenioides, Eutrochium purpureum, Lilium superbum, Medeola virginiana, Smilax herbacea*, and *Tradescantia subaspera*. Other species with fairly high frequency include *Dryopteris marginalis, Galium triflorum, Thalictrum dioicum, Trillium erectum, Viola sororia, Galium lanceolatum, Galium latifolium, Nabalus latissimus, Polygonatum biflorum, Adiantum pedatum, Actaea pachypoda* (and possibly *podocarpa*), *Phryma leptostachya, Potentilla canadensis*, *Symphyotrichum cordifolium*, *Thaspium barbinode, Laportea canadensis*, and *Osmorhiza claytoniana*. Though the species present from this pool vary widely, the high species richness of this community is indicated by an average of 84 species per 1/10 hectare plot in the CVS data and by a total of over 400 species in the set of plots.

Range and Abundance: Ranked G2. The Rich Subtype ranges through much of the Mountain region but is widely scattered. It is extensive only in a few areas such as the Amphibolite Mountains, portions of the Craggy Mountains, Great Balsam Mountains, and Nantahala Mountains, where amphibolite is abundant. It may be endemic to North Carolina, though the association is considered potential in Tennessee and would be possible in Georgia or southern Virginia.

Associations and Patterns: The Rich Subtype can occur in large patches, occupying the tops and warm sides of mountains. It may also occur in small patches, associated with dikes or small bodies of mafic rock. In extensive mafic rock areas, it grades to Northern Hardwood Forest (Rich Subtype) in more mesic sites and may grade to Montane Oak–Hickory Forest (Basic Subtype). It may also change more rapidly to other subtypes of High Elevation Red Oak Forest at geologic contacts.

Variation: Examples vary substantially in the abundance of associated species in the canopy and in the herb layer, but no clear patterns have been recognized.

Dynamics: The Rich Subtype is believed to be similar to the Typic Herb Subtype in its dynamics and generally similar to most other Montane Oak Forests. The general pronounced increase in mesophytic trees and failure of regeneration of oaks is similar in this subtype, though with a larger set of mesophytic species. Some of the characteristic trees of this subtype are not tolerant of fire and would have been less abundant under a natural fire regime, while others, such as *Carya ovata* and *Fraxinus americana*, may have been moderately tolerant and similarly or more abundant. As mentioned in the discussion for the theme as a whole, it is notable that this subtype has not seen the increase in evergreen shrubs that has occurred in other forests, despite having experienced chestnut death, fire exclusion, and other factors that are considered drivers of it.

Comments: This subtype is closely related to Montane Oak–Hickory Forest (Basic Subtype) and to Northern Hardwood Forest (Rich Subtype) in overall flora. The three are differentiated largely by their canopy dominants. They share a sizeable suite of "rich" or "base-loving" herbs, understory, and canopy trees that are common in Rich Cove Forests but that occur on ridges, higher slopes, and drier slope aspects only in association with amphibolite, calc-silicate, or comparable rocks. This suite is diverse but is smaller than the pool of species in Rich Cove Forest, and species usually occur in different proportions. Often, species such as *Solidago curtissii*, *Eurybia chlorolepis*, or *Ageratina roanensis* are dominant and the base-loving species are limited in cover compared to Rich Cove Forests.

This subtype, along with its equivalent association, was specifically recognized only midway through the development of the 4th Approximation, later than the Typic Herb, Heath, and Orchard Forest subtypes and their equivalent NVC associations. It is described in some site-specific descriptions but is rare enough that it is not apparent in most vegetation studies. It appears to be included in DeLapp's (1978) tall herb phase, given that several characteristic species are mentioned in the description. Recognition in other local studies is usually ambiguous.

Quercus rubra - Carya ovata - Fraxinus americana / Actaea racemosa - Hydrophyllum virginianum Forest (CEGL008518) is an analogous association in the Central Appalachians. Plot data analysis by the Virginia Natural Heritage Program (2007) found North Carolina's Rich Subtype to be distinct from this association.

Rare species:
Vascular plants – *Allium allegheniense, Bromus ciliatus, Carex roanensis, Clematis occidentalis* var. *occidentalis, Cypripedium parviflorum* var. *parviflorum, Dendrolycopodium hickeyi, Diervilla rivularis, Euphorbia purpurea, Geum geniculatum, Platanthera peramoena, Pyrola elliptica, Rhododendron prinophyllum, Rhododendron vaseyi, Silene ovata, Stachys cordata.*

Vertebrate animals – *Catharus guttatus, Coccyzus erythropthalmus, Setophaga* (*Dendroica*) *caerulea, Poecile* (*Parus*) *atricapillus,* and *Sphyrapicus varius.*

Invertebrate animals – *Sphinx chersis*.

HIGH ELEVATION RED OAK FOREST (HEATH SUBTYPE)

Concept: High Elevation Red Oak Forests are *Quercus rubra* or one-time *Castanea dentata-Quercus rubra* forests, without *Quercus alba,* at higher elevations. Elevations are generally above 3500 feet, but some examples of the Heath Subtype are as low as 3000 feet. The Heath Subtype includes forest with well-developed shrub layers of predominantly evergreen heaths, typically occurring on narrow ridges, rocky areas, or strongly convex slopes.

Distinguishing Features: High Elevation Red Oak Forests are distinguished by having *Quercus rubra* making up more than 50 percent of the canopy cover under current natural conditions (with *Castanea* largely eliminated), having no appreciable presence of *Quercus alba,* and occurring at high elevations, above about 3500 feet. At lower elevations, examples transitional to Chestnut Oak Forest, with large minorities of *Quercus montana*, are common.

The Heath Subtype is distinguished from the Herb, Rich, and Orchard Forest subtypes by naturally having more than half of the shrub cover of evergreen species and having greater than 20 percent shrub cover. It is distinguished from the Stunted Woodland Subtype by having a full stature canopy, not stunted by wind (more than 8 meters tall unless young). The Stunted Woodland Subtype generally has more mixed canopy composition, less strongly dominated by *Quercus rubra*.

Crosswalks: *Quercus rubra / (Kalmia latifolia, Rhododendron catawbiense, Rhododendron maximum) / Galax urceolata* Forest (CEGL007299).
G015 Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: The Heath Subtype occurs on strongly convex topography, more convex and more exposed than that of the Typic Herb Subtype. Elevations are primarily 3500-5500 feet, but examples may extend higher and may be found as low as 3000 feet.

Soils: A wide variety of soil series is mapped. Wayah (Typic Humadept), Porters (Humic Dystrudept), and Burton (Typic Humadept) are most frequent. Most other mapped soils are Inceptisols, but some are Ultisols.

Hydrology: Sites are well-drained but mesic due to cool temperatures and high rainfall at their high elevations. The Heath Subtype presumably is better drained than the Typic Subtype.

Vegetation: The forest is dominated by *Quercus rubra*, probably usually var. *ambigua*. Associated canopy species often include *Quercus montana* at lower elevations, *Betula lenta*, *Betula alleghaniensis*, and occasionally *Picea rubens* at the highest elevations. The mixture of mesophytic hardwoods in the canopy appears to be generally less in this subtype than in others. *Acer rubrum, Acer pensylvanicum*, and *Amelanchier arborea/laevis* are most often the dominant understory species, while *Nyssa sylvatica* and *Oxydendrum arboreum* are less likely to be abundant. The shrub layer is dense to moderate, with *Kalmia latifolia, Rhododendron maximum*, or *Rhododendron catawbiense* dominant. *Castanea dentata* sprouts, *Vaccinium corymbosum,* and *Ilex montana* are the most constant or frequent other shrubs, and *Vaccinium simulatum, Vaccinium erythrocarpum,* *Clethra acuminata*, *Eubotrys recurvus, Vaccinium stamineum, Gaylussacia ursina*, or *Vaccinium stamineum* are sometimes abundant. *Smilax rotundifolia* may form tangles in patches. The herb layer is low in density and in diversity. *Galax urceolata* is the only relatively constant species. *Conopholis americana, Lysimachia quadrifolia, Medeola virginica*, and *Maianthemum racemosum* are fairly frequent. Other species in few plots but reported in descriptions include *Pteridium latiusculum* (*aquilinum*), *Coreopsis major, Melampyrum lineare, Sitobolium* (*Dennstaedtia*) *punctilobulum, Goodyera pubescens, Amianthium muscitoxicum*, and *Ageratina roanensis*.

Range and Abundance: Ranked G4. This subtype probably occurs in most, if not all, mountain ranges, throughout the mountains of North Carolina, but is much less extensive than the Typic Herb Subtype. The association ranges from Virginia to Georgia.

Associations and Patterns: The Heath Subtype occurs in small to large patches, below the spruce-fir zone in the highest mountain ranges and up to the tops of lower and more southerly ranges. Though generally on the sharpest ridge tops or spur ridges, it may also occur on other topography around rock outcrops. It usually occurs in a mosaic with the Typic Herb Subtype and with Northern Hardwood Forest. Small patches of High Elevation Rocky Summit or High Elevation Granitic Dome may be embedded.

Variation: DeLapp (1978) recognized three phases that fall within this subtype. Because of the fairly clear distinction in dominant shrubs and reported associations with different environments, they are recognized as variants:

1. Mountain Laurel Variant has a shrub layer dominated by *Kalmia latifolia* and occurs on drier slopes with shallow soil.

2. Great Rhododendron Variant has a shrub layer dominated by *Rhododendron maximum* and occurs at lower elevation and with more shelter. It is conceptually transitional to Chestnut Oak Forest (Mesic Subtype).

3. Catawba Rhododendron Variant has a shrub layer dominated by *Rhododendron catawbiense* and occurs in higher elevation, highly exposed sites. It is much less common than the other variants.

It may be noted that the range of undergrowth species composition among these three variants is no larger than in the Typic Herb and Rich subtypes, but the simpler composition allows ready distinction among variants. Other variation includes abundant *Quercus montana* at lower elevations and admixture of *Picea rubens* in some examples at higher elevations.

Dynamics: Dynamics of the Heath Subtype are similar to those of other High Elevation Red Oak Forests and of most oak forests. The more exposed locations for this subtype presumably lead to more intense fire behavior when fires occur. Exposure may also lead to more lightning strikes and more frequent wind disturbance, creating more canopy gaps and a younger age overall. The interaction of fire with the shrub component needs further investigation. All of the dominant shrubs sprout after burning, but observations suggest they don’t recover quickly. A more natural fire regime might lead to a different composition, though this subtype is expected to still be distinguishable from other subtypes.

Comments: Although the evergreen heath component would appear to make this subtype easy to recognize, and it was clearly distinguished by DeLapp (1978), it does not always appear in general vegetation studies. Whittaker (1956) noted an absence of *Kalmia*, didn't mention evergreen *Rhododendron* species, and emphasized a submesic composition with deciduous shrubs in his red oak-chestnut forest. The description of the red oak forests in McLeod (1988) did not mention evergreen shrubs. Newell's (1997) fine-scale classification distinguished the Heath Subtype vegetation in Shining Rock Wilderness but not in Joyce Kilmer-Slickrock. Nevertheless, many CVS plots have been attributed to it. It is unclear if the lack of mention indicates that it is absent in many areas that have other subtypes, or if, being a small minority of the High Elevation Red Oak Forest, it is overlooked.

This subtype occurs in topographic settings that, at lower elevations, often support Pine–Oak/Heath. Transitional communities containing pines seem possible but are not generally noted.

Rare species:
Vascular plants – *Rhododendron cumberlandense* and *Rhododendron vaseyi.*

Nonvascular plants – *Dicranum undulatum*.

Vertebrate animals – *Plethodon wehrlei* and *Sphyrapicus varius*.

HIGH ELEVATION RED OAK FOREST (ORCHARD FOREST SUBTYPE)

Concept: High Elevation Red Oak Forests are *Quercus rubra* forests, or one-time *Castanea dentata-Quercus rubra* forests, without *Quercus alba,* at higher elevations. The Orchard Forest Subtype consists of examples at the highest elevations, generally above 5000 feet, with low shrub cover and a dense but low-diversity herb layer dominated by *Carex* spp. or other species typical of the highest elevations.

Distinguishing Features: High Elevation Red Oak Forests are distinguished by having *Quercus rubra* dominating the canopy cover or basal area at higher elevations under current natural conditions, with no appreciable presence of *Quercus alba*. The Orchard Forest Subtype is distinguished from all other subtypes by having little shrub layer and a dense but low diversity herb layer dominated by *Carex pensylvanica*, other *Carex* spp., *Ageratina altissima, Danthonia compressa, Claytonia caroliniana, Angelica triquinata*, or other species typical of the higher elevations. The more diverse species of the Typic Herb Subtype are absent or scarce, and the characteristic shrubs, such as *Rhododendron calendulaceum* and *Ilex montana* are also scarce. *Rhododendron catawbiense* and other evergreen heaths may be present but are sparse. The canopy trees in the Orchard Forest Subtype often are gnarled and short, appearing stunted.

Crosswalks: *Quercus rubra / Carex pensylvanica - Ageratina altissima var. roanensis* Forest (CEGL007298).
G015 Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: The Orchard Forest Subtype tends to occur on gentle to moderate slopes, broad ridges, and in ridgetop gaps, but may also be on steeper slopes. It occurs at the highest elevations where oak forests are found, generally above 5000 feet.

Soils: Examples may occur on a variety of high elevation soils, most often Typic Humadepts such as Cheoah, Oconaluftee, Tanassee, Balsam, or Wayah.

Hydrology: Sites are well-drained but mesic due to cool temperatures, high rainfall, and frequent fog at their high elevations.

Vegetation: The forest canopy is dominated by *Quercus rubra*, probably always var. *ambigua*. Trees may be stunted or gnarled. The canopy often is more open than most oak forests. As in other High Elevation Red Oak Forests, *Castanea dentata* may have been less important in this community than in most Montane Oak Forests (Whittaker 1956), but its sprouts are often present. Mesophytic hardwoods, particularly *Betula alleghaniensis, Fagus grandifolia*, *Acer rubrum*, or *Acer saccharum* may codominate in many examples, and *Picea rubens* may be present. The understory is often sparse but may be moderate to dense. It consists of the same species found in the canopy, and may also include *Crataegus* spp., *Amelanchier arborea, Acer pensylvanicum*, or other species. Shrubs are sparse, but some *Ilex montana, Hamamelis virginiana, Vaccinium simulatum, Rhododendron catawbiense, Rhododendron maximum*, or other species may be present. In areas with canopy disturbance, *Rubus alleghaniensis* or *Rubus canadensis* often becomes abundant. The herb layer is dense and lush, but low in diversity. *Carex pensylvanica* is the most characteristic species, but other *Carex* spp., *Danthonia compressa, Sitobolium* (*Dennstaedtia*) *punctilobulum, Amauropelta* (*Parathelypteris*) *noveboracensis, Angelica triquinata, Ageratina roanensis, Oclemena acuminata, Festuca subverticillata, Claytonia caroliniana*, or other species of high elevations may be abundant.

Range and Abundance: Ranked G2. Examples are scattered in the higher mountain ranges, with most in the Great Balsam Mountains and possibly in the Great Smoky Mountains. The association also occurs in Tennessee, where it may be confined to the Great Smoky Mountains.

Associations and Patterns: The Orchard Forest Subtype occurs in small or large patches. It often grades to other subtypes of High Elevation Red Oak Forest and to Northern Hardwood Forest.

Variation: No variants are recognized.

Dynamics: The high elevation and moistness of this community likely makes fire less important than in other High Elevation Red Oak Forests, but it may still be important for determining the boundary with Northern Hardwood Forest and for preventing mesophytic hardwoods from replacing the oak. The lush herb layer probably carries fire well only in the dormant season. This subtype may be more subject to natural disturbance by ice and wind.

Many, if not all, examples of this subtype have been grazed in the past. While forest grazing was very widespread even in the high mountains, the typical location of the Orchard Forest Subtype in gaps and on broad ridge tops may have led to more intense grazing. It is sometimes suggested that some of the distinctive characteristics are a result of grazing. This may be true of the common limited understory and shrub layer, and possibly for the strong graminoid dominance in the herb layer. Worton and Smathers (1981) found that tree ages at Frying Pan Gap were bimodal, with a 30 year gap around 1860-1890, presumably due to grazing but possibly caused by fire.

Comments: There is some confusion or disagreement over circumscription of this community. As defined here, it is a community of the highest elevations, bearing an analogous relationship to other High Elevation Red Oak Forests that the Beech Gap Subtype does to other Northern Hardwood Forests. Parts of the corresponding NVC association appear to suggest it is conceived more broadly, defined by a threshold of 20% shrub cover and extending to lower elevation. It is unclear how much this would broaden the concept of this subtype and narrow the concept of the Typic Herb Subtype, but potentially significantly. Shrub cover in the Typic Herb Subtype is highly variable, and portions of many occurrences would cross the 20% threshold. It likely would make such a definition strongly dependent on the scale observed and might lead to definition of very fine-scale mosaics that would have little ecological meaning. It might also depend on recent fire history. The G2 rank probably reflects the narrower definition. I have retained the narrower orchard forest concept, believing it to be more likely to correlate with other characteristics of the ecosystem and to define a unit of conservation interest. However, further investigation is needed.

Rare species:
Vascular plants – *Rhododendron vaseyi*.

Nonvascular plants – *Cetrelia cetrarioides, Dicranum undulatum*, and *Pohlia lescuriana.*

HIGH ELEVATION RED OAK FOREST (STUNTED WOODLAND SUBTYPE)

Concept: The Stunted Woodland Subtype is a rare, poorly understood *Quercus rubra* woodland of extremely exposed narrow ridges and peaks or edges of rock outcrops, where canopy trees are notably stunted, short, and low in density. Conceptually it lies on the boundary of High Elevation Red Oak Forest and Montane Oak–Hickory Forest, with *Quercus rubra* sometimes strongly dominant and *Quercus alba* sometimes codominant. It has a dense shrub layer which is dominated by evergreen heath species but sometimes is fairly diverse.

Distinguishing Features: The Stunted Heath Subtype is distinguished from other subtypes of High Elevation Red Oak Forest and Montane Oak–Hickory Forest by a more open and very short canopy, less than 8 meters tall even when mature. Trees may be only 5 meters tall and may branch barely above the shrub layer canopy. Care is needed to apply this subtype only to the most extremely stunted forests, as well as to distinguish it from young forests which will develop taller stature in a few years. Examples of other subtypes on ridges may have gnarled trees and canopies that are shorter than those of less exposed forests, but these are not as short unless they are young. The distinction from High Elevation Red Oak Forest (Heath Subtype) is most subtle, since it too has a dense evergreen shrub layer and may be somewhat stunted. The Stunted Heath Subtype is distinguished from the Orchard Forest Subtype, which may have a notably stunted canopy, by having a well-developed, generally very dense, shrub layer and by occurring at lower elevation.

Crosswalks: *Quercus rubra / Rhododendron catawbiense - Rhododendron arborescens* Woodland (CEGL004503).
G015 Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: The Stunted Heath Subtype occurs on sharp ridge tops, peaks, and edges of rock outcrops, where it is exposed to extremes of wind and where soils presumably are shallow or extremely rocky. Known examples range from 3400-5000 feet elevation.

Soils: This subtype occurs on rocky or shallow soils. The few examples are mapped as a variety of soil series, primarily Dystrudepts and Humadepts, with no two of the few known examples being the same.

Hydrology: This subtype presumably is the driest of the subtypes of High Elevation Red Oak Forest, given the exposed and convex topographic setting.

Vegetation: The Stunted Woodland Subtype has a short-stature, open canopy usually dominated by *Quercus rubra*, sometimes with *Quercus alba* codominant or abundant. One apparent example is codominated by *Quercus coccinea*. The most frequent understory or minor canopy species is *Amelanchier arborea/laevis*, but *Acer rubrum* is also frequent. Unexpected mesophytic species such as *Tsuga canadensis* or *Betula lenta* may be present. *Castanea dentata* sprouts are abundant in most examples, suggesting this species was a major part of the canopy. The shrub layer is tall and dense. *Kalmia latifolia* or *Rhododendron catawbiense* dominate, but the shrub layer often is fairly diverse. Other shrub species include *Vaccinium corymbosum, Rhododendron maximum, Ilex montana, Rhododendron calendulaceum, Lyonia ligustrina*, *Aronia melanocarpa, Rhododendron*

(*Menziesia*) *pilosum, Clethra acuminata, Eubotrys recurvus, Viburnum cassinoides*, *Gaylussacia baccata*, and in higher elevation examples, *Vaccinium erythrocarpum, Viburnum lantanoides*, and *Sorbus americana*. *Smilax rotundifolia* or *Smilax glauca* may form tangles. Herbs generally are sparse. *Pteridium latiusculum (aquilinum*) is the most frequent species. Other species may include *Melampyrum lineare, Danthonia spicata, Lysimachia quadrifolia, Campanula divaricata*, and in high elevation examples, *Eurybia chlorolepis, Oclemena acuminata*, and *Angelica triquinata*.

Range and Abundance: Ranked G2, but perhaps better treated as G2? Examples are very widely scattered throughout most of the Mountain Region. The association is also known in Georgia and is considered possible in Tennessee and South Carolina.

Associations and Patterns: The Stunted Woodland Subtype occurs in small patches, generally grading to other subtypes of High Elevation Red Oak Forest or Montane Oak–Hickory Forest, sometimes to High Elevation Granitic Dome or other rock outcrop communities.

Variation: The few known examples are more variable than for most communities, with different shrub layer dominants. The highest elevation examples have a number of high elevation species not found in the other examples, as noted in the vegetation description.

Dynamics: Little is known about the dynamics of the Stunted Woodland Subtype. The stunted canopy suggests harsh conditions that limit tree growth, with wind and ice causing frequent damage to the canopy. Lightning too can be expected to be more frequent in these exposed locations. Unusually severe fires, associated with location on ridges, along with dry conditions, may also be a cause of open canopies and small trees. The dense shrub layer may develop simply because of the open canopy, but also may be related to the conditions that form Heath Balds.

Comments: The Stunted Woodland Subtype was recognized in the 4th Approximation and the NVC to cover distinctive vegetation which did not fit other forest categories. No published literature clearly describes it. It is conceptually transitional to Heath Bald, especially to the Southern Mixed Subtype. However, the dynamics and ecological relationships of this subtype are particularly poorly known, and the conditions that create its distinctive vegetation structure may not be the same in all cases. Understanding is inhibited by the difficulty in recognizing it in earlier site descriptions and also in recognizing its distinctive structure in plot data. No published quantitative studies appear to recognize it. Given its rarity, plots that represent it may be dismissed as outliers in quantitative analysis.

This subtype appears to be quite rare, and many apparently-suitable sites do not have it. The corresponding NVC association is described as being particularly tied to granitic domes, but only a few examples in North Carolina are associated with them. The majority of our examples are on sharp ridge tops.

There appears to be no ecological system placement for this community.

Rare species:
Nonvascular plants – *Dicranum undulatum* and *Gymnoderma lineare*.
Vertebrate animals – *Sphyrapicus varius*.

HIGH ELEVATION RED OAK FOREST (BOULDERFIELD SUBTYPE)

Concept: High Elevation Red Oak Forests are *Quercus rubra* or one-time *Castanea dentata–Quercus rubra* forests, without *Quercus alba,* at higher elevations, generally above 3500 feet and ranging up to the highest elevations of any oak forest. The Boulderfield Subtype encompasses very rare examples on well-developed boulderfields. Substrates are comparable to High Elevation Birch Boulderfield Forest and Rich Cove Forest (Boulderfield Subtype), but mesophytic trees are present in only small numbers if at all.

Distinguishing Features: The Boulderfield Subtype of High Elevation Red Oak Forest, like the High Elevation Birch Boulderfield Forest and the Boulderfield Subtype of Rich Cove Forest, Chestnut Oak Forest, and Montane Oak–Hickory Forest, is distinguished by occurring on well-developed boulderfields, with near complete cover by large rocks, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower vegetation strata substantially influenced by the rock cover. Caution is needed to distinguish well-developed boulderfields from merely rocky soils. High Elevation Red Oak Forest (Boulderfield Subtype) is distinguished from boulderfield subtypes of other communities by having canopy composition dominated by *Quercus rubra*, with no *Quercus alba*, little or no *Quercus montana*, and few or no mesophytic trees other than *Betula alleghaniensis* and *Betula lenta*. Because the lower strata, especially the herb layer, are less dense in most oak forests than in Rich Cove Forest or Northern Hardwood Forest communities, the recognition of the Boulderfield Subtype of High Elevation Red Oak Forest may be more subtle and require more attention to extreme rock cover and space beneath the rocks. Many High Elevation Red Oak Forests are rocky but very few have enough surface boulder cover to affect community composition.

Crosswalks: No NVC equivalent. A new association needs to be created. G015 Southern Appalachian Oak / Chestnut Forest Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: The Boulderfield Subtype may occur on convex, planar, or somewhat concave slopes, generally moderate to steep. It may potentially be on the edges of relict periglacial boulderfields, which tend to be in steeply plunging coves, or it may occur on talus beneath rock outcrops. In known examples, the boulders are smaller than those in the Rich Cove Forest subtype or in High Elevation Birch Boulderfield, but it is uncertain if this is universally true. Examples might occur anywhere in the elevational range of High Elevation Red Oak Forest, roughly 3500-5900 feet.

Soils: Soil consists of accumulations of organic matter on and among the boulders, but patches are small and generally are inclusions in soil map units.

Hydrology: Conditions are generally dry-mesic or mesic due to topography and elevation, but moisture may vary drastically at very fine scale. Shallow soil pockets maybe become dry very quickly. Seepage areas are less likely to be present than in more mesic boulderfields. However, roots of large, established trees presumably reach beneath the boulders and have a greater supply of moisture.

Vegetation: This subtype is only recently recognized, and the range of its vegetation is not well known. All examples are dominated by *Quercus rubra*, at least weakly. Where known, *Betula lenta* is also present in the canopy; the understory contains *Betula alleghaniensis, Acer pensylvanicum, Acer spicatum*, and *Amelanchier laevis*. Some vines, especially *Isotrema macrophyllum* and *Smilax rotundifolia,* are abundant, while shrubs are sparse. The herb layer is sparse, with herbs occurring primarily in soil patches at the bases of trees. Species include *Athyrium asplenioides, Trillium grandiflorum, Thalictrum thalictroides, Goodyera pubescens, Carex* spp., and *Viola* spp. If other examples are found, they may contain a few other tree species, especially *Quercus montana*, and are likely to share herb species with other boulderfield communities. Such species might include *Polypodium virginianum, Dryopteris marginalis*, and *Sedum ternatum*. Herb species typical of other High Elevation Red Oak Forest subtypes may also be present in small numbers.

Range and Abundance: Unranked but likely G1. This community is newly recognized and is not well inventoried, but it is unlikely that more than a handful of examples will be found.

Associations and Patterns: High Elevation Red Oak Forest (Boulderfield Subtype) is a small patch community. It is most likely to be surrounded by other subtypes of High Elevation Red Oak Forests but might be associated with boulderfield subtypes of other communities.

Variation: Nothing is known of variation at present.

Dynamics: While stand dynamics presumably are similar to other oak forests, canopy gaps last longer because of the difficulty of tree establishment. Fire may be less of an influence than in most oak forests because of the discontinuous leaf litter cover on the surface.

Comments: This community is more similar to other High Elevation Red Oak Forest subtypes than High Elevation Birch Boulderfield is to Northern Hardwood Forests, so it is recognized as a subtype rather than a full type. This subtype is one of the most recently recognized communities. Analogous boulderfield subtypes have also been found for Chestnut Oak Forest and Montane Oak–Hickory Forest. More work is needed to fully characterize all of these boulderfield communities. The description is based on only a single known example. However, it is likely that a few other examples have been overlooked because a community had not been described for them. However, some reported oak-dominated boulderfields that were investigated have proven to be the more mesophytic Boulderfield Subtype of Rich Cove Forest, with a limited oak component.

All of the oak boulderfield forests are expected to be extremely rare and likely of limited extent. However, it should be noted that the Boulderfield Subtype of Rich Cove Forest appeared extremely rare when first described but is now known in more than 50 occurrences.

Rare species: No rare species are known to be specifically associated with this community. As with other boulderfields, it may be an important habitat for small mammals, including rare species.

HIGH ELEVATION WHITE OAK FOREST

Concept: High Elevation White Oak Forests are strongly dominated by *Quercus alba* and occur on exposed ridges at higher elevations, without the mixture of canopy species typical of Montane Oak–Hickory Forest.

Distinguishing Features: The High Elevation White Oak Forest type is distinguished from all other high elevation forest types by having *Quercus alba* naturally making up 75% or more of the canopy cover.

Crosswalks: *Quercus alba / Kalmia latifolia* Forest (CEGL007295).
G015 Southern Appalachian Oak Forest & Woodland Group.
Central and Southern Appalachian Montane Oak Forest Ecological System (CES202.596).

Sites: High Elevation White Oak Forest occurs on broad ridges, flats, and upper slopes, generally, perhaps exclusively, above 4000 feet.

Soils: Soils associated with this community are not well understood. Baranski (1975) suggests they are relatively deep, and that *Quercus montana* replaces *Quercus alba* on rocky soils. However, some known occurrences seem to have thin soils near rock outcrops, and others are mapped on soil maps as rocky. The most frequently mapped series is Porters, a Humic Dystrudept.

Hydrology: Sites are well-drained and relatively dry due to convex topography and exposure to wind, but they are cooler and presumably less dry than comparable sites at lower elevations.

Vegetation: This forest is strongly dominated by *Quercus alba*. Sometimes no other canopy species is present, sometimes *Carya glabra* may be abundant, and *Quercus rubra, Quercus coccinea*, or *Quercus velutina* may sometimes be present as a significant minority. The trees generally are stunted and relatively short. There may be little understory, but unusually dense *Castanea dentata* sprouts have sometimes been noted, and *Nyssa sylvatica, Oxydendrum arboreum*, *Benthamidia* (*Cornus*) *florida*, or *Robinia pseudo-acacia* may be present. The shrub layer is usually dense, dominated by *Kalmia latifolia* or occasionally *Gaylussacia ursina*. Herbs are sparse where shrubs are dense, and otherwise usually consist of widespread acid-tolerant species such as *Athyrium asplenioides*. One example has a well-developed herb layer dominated by *Euphorbia purpurea*, with a number of species characteristic of rich sites.

Range and Abundance: Ranked G2Q. This community appears very rare in North Carolina, but uncertainty about identification of several examples makes its abundance uncertain. All or almost all examples are south of Asheville, most in the high rainfall area near the Georgia and South Carolina border. The association is attributed to South Carolina, Georgia, and Tennessee, but this too may be confused by issues of circumscription.

Associations and Patterns: High Elevation White Oak Forest usually occurs as fairly small patches, most well under 100 acres. They are often associated with High Elevation Red Oak Forest. At least a couple are associated with High Elevation Granitic Domes.

Variation: Substantial variation exists in known examples, but the community is not well enough understood to define variants. The example on Riley Knob, on amphibolite substrate and with a rich herb layer, probably warrants a distinct variant or may warrant treatment as Montane Oak—Hickory Forest (Basic Subtype) instead.

Dynamics: The high elevation, exposed position of this community makes it particularly subject to damage by wind, lightning, and ice. Barnaski (1975) noted that trees in these areas often had small yellowish leaves, gnarled shape, and numerous epicormic branches, and attributed this to frost damage. Fire dynamics are probably similar to those of High Elevation Red Oak Forest.

Comments: This remains one of the most problematic community types, with few known well-developed examples and uncertainty as to how distinct it is from other types. Variation in circumscription by different users has led to some confusion of the concept and uncertainty about plot assignment. Some of the few descriptive reports have only limited description of this community.

The concept of a high elevation white oak forest owes much to Whittaker's (1956) study of the Great Smoky Mountains, where he reported a distinct break between low elevation *Quercus alba* forest and those of high elevations. He suggested there were actually two distinct populations or ecotypes of the species. He apparently was not alone. Baranski (1975) quotes a 1952 letter by W.H. Camp to H.J. Oosting, talking of the existence of two ecotypes separated from each other by at least 1500 feet in elevation. Whittaker (1956) described a community with *Quercus alba* strongly dominant, though with *Quercus rubra* usually present, with an open canopy and small trees, above 4500 feet. Carter et al., (2000) too, in their analysis of old-growth plots in the high rainfall area around Highlands, found *Quercus alba* indicative of higher elevations (above 4000 feet) in their data set of old-growth forests, along with *Castanea dentata* and *Gaylussacia ursina*. *Quercus rubra*, in contrast, was indicative of mid elevations, below 4000 feet.

Baranski (1975) addressed the question of ecotypes, demonstrating that *Quercus alba* as a species ranges continuously in elevation, without a break elsewhere in North Carolina, and even on the North Carolina side of the Great Smoky Mountains. He did confirm that Whittaker's primary study area, in the central and western Tennessee side, lacks the species at mid elevations. Baranski's focus was on the species and its overall abundance in broad areas, and he did not always note how it fit into specific communities. But he did note that above 4000 feet it became more prominent and that open flat ridgetops and open slopes could support almost pure *Quercus alba* stands. These trees were small and stunted looking and had smaller leaves and acorns, which he attributed to weather conditions rather than ecotypic variation.

Whittaker's concept of a montane white oak forest was adopted by a number of observers. The concept was expanded to accommodate lower elevations and more mixed communities that were found in North Carolina. The recognition of the Montane Oak–Hickory Forest with the publication of the 3rd Approximation led to narrowing the montane white oak forest concept to something more like its original intent. It thus is narrowly defined here, limited to elevations above 4000 feet and to forests strongly dominated by *Quercus alba*.

Since Montane Oak–Hickory Forests, with mixed canopy composition, can also range to similarly high elevations, occur in similar sites, and overlap in the range of dominant species in lower strata, further study is needed into how distinct High Elevation White Oak Forest is, even with a narrow definition. It is retained at present because some examples that seem to fit it well can be found. Other records are described in ways that make it hard to tell which community they represent. Further investigation is particularly needed here.

Rare species:
Vascular plants – *Bromus ciliatus, Euphorbia purpurea,* and *Rhododendron vaseyi*.

CHESTNUT OAK FOREST (DRY HEATH SUBTYPE)

Concept: Chestnut Oak Forest communities are forests of mountain and foothill dry slopes and ridges at low to moderate elevation, dominated by *Quercus montana*, sometimes in combination with *Quercus coccinea* or *Quercus rubra*, but lacking *Quercus alba*. *Castanea dentata* was once dominant or codominant. The Dry Heath Subtype encompasses the common dry, acidic examples with extensive shrub layers dominated by *Kalmia latifolia* or any of several *Gaylussacia*, *Vaccinium*, or uncommonly, *Rhododendron* species.

Distinguishing Features: Chestnut Oak Forest is distinguished from all other mountain community types by the dominance of *Quercus montana*, alone or in combination with *Quercus coccinea, Quercus rubra*, or *Acer rubrum*. Forests with *Quercus alba* present in more than very small numbers are treated as Montane Oak–Hickory Forest instead, even if *Quercus montana* is more abundant. Chestnut Oak Forest is distinguished from Piedmont Monadnock Forest by occurrence in the Mountain Region or mountain-like foothills and by having a component of species not typical in the Piedmont. Montane species include *Castanea dentata, Rhododendron calendulaceum, Pyrularia pubera, Gaylussacia ursina, Kalmia latifolia*, *Carex pensylvanica*, and usually, *Gaylussacia baccata*. Chestnut Oak Forest is distinguished from Pine—Oak/Heath and Low Mountain Pine Forest by having less yellow pine than oak in the canopy. A few transitional examples may have a substantial minority of pine. The relationship between the Dry Heath Subtype and the pine communities may be confused by the long absence of fire and by pine mortality caused by southern pine beetle. Areas of recent pine mortality tend to have broken canopies in which understory species such as *Nyssa sylvatica* and *Oxydendrum arboreum* are as numerous in the canopy as the oaks, but some examples may be ambiguous.

The Dry Heath Subtype is distinguished from the Herb Subtype and the Mesic Subtype by having a well-developed shrub layer dominated by *Kalmia latifolia, Gaylussacia* spp., or *Vaccinium* spp., occasionally by *Rhododendron minus* or *Rhododendron carolinianum*. The Herb Subtype may have these species but only at low density; it may or may not have substantial herb cover. *Rhododendron maximum*, characteristic of the Mesic Subtype, may be present and may have increased with lack of fire, but in the Dry Heath Subtype it will be accompanied by species of drier sites and absence of more mesophytic species. In examples that have burned recently, shrub cover may be reduced, but the same species will dominate. The Dry Heath Subtype is distinguished from the White Pine Subtype by lacking *Pinus strobus* as a natural long-term part of the forest. Care is needed to distinguish this from cases where *Pinus strobus* was planted, invaded after logging, or has spread into the understory but is absent in the canopy.

Crosswalks: *Quercus (montana, coccinea) / Kalmia latifolia / (Galax urceolata, Gaultheria procumbens)* Forest (CEGL006271).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Dry Heath Subtype occurs on open to convex slopes and ridgetops. It is most extensive at low elevations, 1000-3000 feet, but can occur up to around 4000 feet.

Soils: Soils are acidic and nutrient poor, and they often are rocky. The largest number of examples are mapped as Typic Dystrudepts, especially Chestnut, Edneyville, and Ashe. A substantial number are also mapped as Typic Hapludults, especially Evard, Cowee, and Tate. Porters (Humic Dystrudept) is also mapped for several examples, and many other series occur occasionally.

Hydrology: Sites are well drained and are drier than those of most other mountain forest communities. Within the Mountain Oak Forests theme, only Montane Oak–Hickory Forest (Low Dry Subtype and Low Dry Basic Subtype) appear to be as dry. Chestnut Oak Forests are extensive in the Blue Ridge escarpment and foothills where rainfall is relatively low, but they are also abundant in the highest rainfall areas.

Vegetation: The Dry Heath Subtype canopy is dominated by *Quercus montana*, which usually is strongly dominant, though *Quercus coccinea* may codominate. Other species in the canopy may include *Pinus rigida, Pinus virginiana, Pinus pungens, Acer rubrum, Nyssa sylvatica*, *Oxydendrum arboreum*, *Quercus velutina*, *Carya glabra*, or *Tsuga caroliniana*. Occasionally a few *Pinus echinata* may be present in lower elevation examples. *Quercus rubra* is present in the transition to cove forests and to High Elevation Red Oak Forest but otherwise is scarce to absent. The understory usually is dominated by some combination of *Oxydendrum arboreum, Nyssa sylvatica*, and *Acer rubrum*. Other frequent understory species in CVS plot data include *Sassafras albidum, Castanea dentata* sprouts, *Amelanchier arborea*, *Magnolia fraseri*, and *Benthamidia* (*Cornus*) *florida*. The shrub layer is moderate to very dense. Usually one species strongly dominates locally, either *Kalmia latifolia, Gaylussacia baccata*, *Vaccinium pallidum, Gaylussacia ursina*, or occasionally *Rhododendron minus, Rhododendron carolinianum*, or *Vaccinium stamineum*. Others of these species may be present in small to moderate numbers where they aren't dominant. No other shrubs are very frequent, but *Rhododendron calendulaceum*, *Rhododendron maximum, Symplocos tinctoria, Pyrularia pubera*, or other *Vaccinium* species may occur. Both *Smilax glauca* and *Smilax rotundifolia* have high constancy, and the latter sometimes forms large tangles. The herb layer is usually sparse, though it probably was denser when the forests burned regularly. Species with high constancy in plot data are *Galax urceolata* and *Chimaphila maculata*. Other frequent species include *Goodyera pubescens, Viola hastata, Chamaelirium luteum*, and *Epigaea repens*. Though not well represented in the plot data, examples that have burned recently have less shrub cover, and some that have burned repeatedly may be observed to have greater herb diversity. Under more natural fire regimes, common herbs of dry open sites, described under the Low Dry Subtype, likely would be abundant.

Range and Abundance: Ranked G5. This subtype is one of the most abundant communities in the Southern Appalachians. In North Carolina, it is particularly abundant in the foothills and Blue Ridge escarpment. The association ranges from Georgia to West Virginia and Kentucky.

Associations and Patterns: Dry Heath Subtype is a matrix community, making up much of the landscape mosaic at lower elevations. It grades to Pine–Oak/Heath or Low Mountain Pine Forest on sharper ridges or drier sites. In more sheltered, mesic settings, it grades to other subtypes of Chestnut Oak Forest, to Acidic Cove Forest, Rich Cove Forest, or sometimes Montane Oak–Hickory Forest. It grades to High Elevation Red Oak Forest on similar topography at high elevations. This subtype often surrounds rock outcrop communities at low to mid elevations.

Variation: Several variants may be recognized based on the dominant shrub. Multiple variants may be present in a single occurrence, but patches usually are large, shifting with changes in slope aspect or landform.

1. Mountain Laurel Variant is dominated by *Kalmia latifolia*. It generally occurs on ridges, dry slope aspects, and sharply convex topography. *Kalmia* may be as dense as in Pine—Oak/Heath but may be only moderately dense. The amount of shrub cover is greatly affected by recent fire.

2. Black Huckleberry-Blueberry Variant is dominated by *Gaylussacia baccata* or *Vaccinium pallidum*, occasionally by *Vaccinium stamineum*. It occurs in slightly moister sites. The shrub layer is substantial but usually is not as dense as in the Mountain Laurel Variant.

3. Bear Huckleberry Variant is dominated by *Gaylussacia ursina*. This variant occurs only south of the Asheville Basin; it is very extensive farther south and west in North Carolina. The shrub layer often is very dense, approaching 100% cover, but can be moderate. Vegetation analysis done for the Appalachian Trail corridor found examples with *Gaylussacia ursina* dominating the shrub layer to be distinct from other examples in this subtype.

4. Rhododendron Variant is a rare variant dominated by *Rhododendron minus* or *Rhododendron carolinianum*. These shrub species are uncommon and irregular in distribution, but often dominate where they are present. If examples are found dominated by the newly described *Rhododendron smokianum*, they would also be placed in this variant.

5. Shortleaf Pine Variant is a rare variant recognized by the presence of *Pinus echinata* in the canopy. The amount of this pine likely has declined, and this variant should be recognized even where *Pinus echinata* is present only in small numbers. Recognized examples are all in the foothills in North Carolina but could also occur in the western Mountain region in North Carolina and in the Blue Ridge escarpment. They apparently also occur on the western side of the Blue Ridge in Tennessee. This variant may be appropriate to elevate to a subtype, as it is analogous to the Low Dry Subtype of Montane Oak—Hickory Forest. However, the presence of *Pinus echinata* is not generally accompanied by a greater presence of other indicative plants, as it is in that community.

Dynamics: The Dry Heath Subtype has dynamics similar to those of most Mountain Oak Forests, including the potential changes due to chestnut blight, the effects of past logging, and the role of fire. Examples that were logged in the early 1900s usually regenerated to *Quercus montana*, but the codominance of *Quercus coccinea* in some examples appears to result from logging. Carter, et al. (2000) found *Quercus coccinea* to be common in more recent early successional examples, along with *Liriodendron tulipifera* and *Acer rubrum*. The ability of these reputedly mesophytic species to invade some of the driest oak forest sites might support the belief that the climate has become wetter. But it is also plausibly driven by the greatly increased seed rain that has accompanied ongoing logging and the lack of their being checked by fire.

The dry and topographically high sites where the Dry Heath Subtype occurs makes it susceptible to more frequent and perhaps more intense fire than in other oak forests. *Quercus montana* is among the most fire-tolerant of oaks. The author's observations in burned areas show it surviving much better than most associated species of similar diameters. Nevertheless, intense growing season fires can cause substantial canopy mortality, especially in younger stands. The abundance of *Quercus coccinea* and *Acer rubrum* in canopies is possible only because of the long exclusion of fire, but single catastrophic fires can increase the cover of these vigorously sprouting and readily seeding species.

Conversely, *Quercus montana* can increase in pine communities with exclusion of fire. The extent of pine communities has substantially declined in recent decades, and there is belief among some that Chestnut Oak Forests have replaced Pine–Oak/Heath on many ridge tops. Terrain-based modeling often predicts substantially more pine on ridges than currently occurs. Some such predicted pine sites have mature, even old-growth Chestnut Oak Forest, and probably did not support pine communities. At the same time, careful field observation can distinguish natural Chestnut Oak Forests from many areas where pines have been killed by insects. Given the limitations of generalized terrain measures and the subtleties of fire's interaction with topography, it is unclear how much to trust such predictions in particular sites, in the absence of other evidence. Nevertheless, it is likely that some places that once supported Pine—Oak/Heath now support apparent well-developed Chestnut Oak Forest.

The interaction of the fire regime with the shrub layer in the Dry Heath Subtype is somewhat uncertain. As in other forests, regular fire is expected to reduce shrub cover in favor of herbs; however, even when burning resumes, the suite of fire-tolerant herbs generally is slow to return to sites where they have been lost. The immediate result of even multiple fires usually is increased vigor of individuals that were already present. Species that are capable of clonal spread usually increase the most in cover, but the overall diversity increases only slowly. *Kalmia latifolia* seems to be slow to recover from fire, and its cover is reduced for at least several years. Nevertheless, the moderate fire frequencies that appear to have been natural would leave plenty of time for it to recover between most fires. The dominant *Vaccinium* and *Gaylussacia* species sprout rapidly after fire, quickly regain their cover, spread vegetatively into openings, and fruit vigorously. Reduced understory and canopy cover would create a more favorable environment for shrub as well as herb growth. The more subtle interactions of fire with seedling establishment of shrubs, and with the eventual cover of shrubs and herbs needs further investigation.

Comments: Though the dense shrub layer that most easily distinguishes this subtype could be changed by alteration of the fire regime, the relative proportions of remaining shrubs should be sufficient to distinguish this dry community from the other subtypes. With ongoing burning, differences in the herb layer may become distinguishable in the future.

Rare species:
Vascular plants – *Buckleya distichophylla, Calamagrostis porteri, Celastrus scandens, Hexastylis contracta, Liatris microcephala, Liatris turgida, Lysimachia fraseri, Monotropsis odorata, Quercus ilicifolia, Smilax hugeri, Spiraea corymbosa, Thermopsis fraxinifolia, Thermopsis mollis*.

Nonvascular plants – *Rinodina brodoana*.

Vertebrate animals – *Certhia americana, Crotalus horridus,* and *Neotoma magister*.

Invertebrate animals – *Catocala herodias, Hemeroplani*s sp. 1 nr. *obliqualis.*

CHESTNUT OAK FOREST (HERB SUBTYPE)

Concept: Chestnut Oak Forest communities are forests of mountain and foothill dry slopes and ridges at low to moderate elevation, dominated by *Quercus montana*, sometimes in combination with *Quercus coccinea* or *Quercus rubra*, but lacking *Quercus alba*. The Herb Subtype encompasses those that are somewhat more mesic than the Dry Heath Subtype but lack a dense shrub layer of *Rhododendron maximum*. The herb layer may be sparse or moderate in density.

Distinguishing Features: Chestnut Oak Forest is distinguished from all other mountain community types by the dominance of *Quercus montana*, alone or in combination with *Quercus coccinea, Quercus rubra*, or *Acer rubrum*. Forests with *Quercus alba* present in more than very small numbers are treated as Montane Oak–Hickory Forest instead, even if *Quercus montana* is more abundant. The Herb Subtype is distinguished from the Dry Heath Subtype and the Mesic Subtype by the absence of a substantial shrub layer of the species that characterize the other subtypes. The herb layer may be well developed or may be sparse. *Rhododendron maximum, Kalmia latifolia*, *Vaccinium pallidum, Gaylussacia* spp., and other dominants of the Dry Heath or Mesic Subtype may be present but either have low density or do not dominate over other shrub species. Other species, such as *Rhododendron calendulaceum*, tend to be more abundant.

Crosswalks: *Quercus montana - (Quercus rubra) - Carya* spp. / *Oxydendrum arboreum - Cornus florida* Forest (CEGL007267).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Herb Subtype occurs on open slopes, somewhat convex to somewhat concave. Most examples are between 1000 and 3500 feet elevation, but examples are fairly common up to 4000 feet and a few are reported to occur at 5000 feet or higher.

Soils: Soils apparently are less acidic and nutrient-poor than in the Dry Heath Subtype. The largest number of examples are mapped as Typic Dystrudepts, especially Chestnut, with some Edneyville, and Ashe. A few are mapped as Typic Hapludults such as Tate.

Hydrology: Sites are well drained and generally dry but are less dry than in the Dry Heath Subtype.

Vegetation: The forest canopy is dominated by *Quercus montana*. *Quercus rubra* is usually present and sometimes codominates or even dominates. *Quercus coccinea* may codominate or occasionally dominate. Other canopy species may include *Carya glabra, Carya tomentosa, Acer rubrum*, and *Quercus velutina*. Understory species include *Oxydendrum arboreum, Benthamidia (Cornus) florida, Sassafras albidum, Nyssa sylvatica, Magnolia fraseri*, *Acer pensylvanicum*, and *Castanea dentata* sprouts, as well as the canopy species. Mesophytic species can be present in small numbers in the canopy, especially in the transition to adjacent communities, and may be more numerous in the understory. These often include *Tsuga canadensis*, *Liriodendron tulipifera*, *Betula lenta*, *Halesia tetraptera*, and *Prunus serotina*. The shrub layer is open or sparse. *Kalmia latifolia, Rhododendron maximum,* or *Vaccinium pallidum* are often present in small amounts, but *Viburnum acerifolium*, *Rhododendron calendulaceum*, and *Vaccinium stamineum* are more often abundant. *Smilax glauca* and *Smilax rotundifolia* have high constancy, and other vines such as

Toxicodendron radicans, *Parthenocissus quinquefolia*, or *Vitis* spp. may be present. The herb layer is quite variable, from dense to sparse. In CVS plot data, species of acidic sites, such as *Chimaphila maculata, Goodyera repens*, *Solidago curtisii*, and *Polystichum acrostichoides* are the most constant, but *Dioscorea villosa, Uvularia puberula, Eurybia divaricata, Maianthemum racemosum, Houstonia purpurea*, *Lysimachia quadrifolia*, *Zizia trifoliata, Viola hastata, Hylodesmum nudiflorum, Conopholis americana, Gentiana decora, Nabalus* spp., *Aureolaria laevigata*, *Amauropelta* (*Parathelypteris*) *noveboracensis*, and *Potentilla canadensis* are frequent. A large suite of additional species occurs at low frequency, and the typical species richness of plots in the subtype is notably greater than in the other subtypes. As in the other oak forests, the herb layer likely would be denser and more diverse in forests that burned regularly. Many of the suite of fire-tolerant herbs such as *Schizachyrium scoparium, Tephrosia virginiana,* and *Coreopsis major* probably would be present, but a more mesophytic composition might well be visible in the herb layer.

Range and Abundance: Ranked G4G5. This community is widespread in the mountains and foothills, though it is less abundant than the Dry Heath Subtype. The association ranges from Georgia to West Virginia and Kentucky.

Associations and Patterns: The Herb Subtype occurs most often as small to large patches but may locally make up a sizeable component of the landscape mosaic. It often grades to the Dry Heath Subtype in drier sites and to Acidic Cove Forest in less dry sites.

Variation: Three variants are provisionally recognized:

1. Chestnut Oak Variant includes examples where *Quercus montana* is dominant and *Quercus rubra* is a minor component or is absent. *Quercus coccinea* may be present and sometimes codominant.

2. Red Oak Variant has *Quercus rubra* codominant, sometimes even more abundant than *Quercus montana. Quercus coccinea* usually is scarce but may be fairly abundant. This variant may be what is represented by the NVC's *Quercus rubra – Quercus montana – Magnolia (acuminata, fraseri) / Acer pensylvanicum* Forest (CEGL004817), discussed below.

3. Rich Variant has an herb layer with species characteristic of richer soils, comparable to Montane Oak–Hickory Forest (Basic Subtype). This variant is one of the most marked in the 4th Approximation, and further investigation may lead to recognition as a subtype. It is however a rare community. In most places, Chestnut Oak Forests, even of the Herb Subtype, give way to Montane Oak–Hickory Forest (Basic Subtype) where soils become richer.

Dynamics: Dynamics are similar to those of Mountain Oak Forests in general. Specific details are not well known.

Comments: The Herb Subtype seems particularly difficult to circumscribe. Many plots are assigned to it in the CVS database and in NatureServe plot databases, but fewer occurrences are represented in the Natural Heritage Program database. Something like it is often recognized in local plot analyses that distinguish finer divisions of vegetation, such as Newell's (1997) three study areas and McLeod's (1988) work in the Black and Craggy Mountains. But the description and apparent boundaries tend to differ among studies. Both natural intergradation and the results of past alterations may be particularly subtle in this range of natural communities.

The Herb Subtype occupies an intermediate position on the conceptual topographic moisture gradient, between the Dry Heath Subtype and Acidic Cove Forest. However, its relationship to other intermediate communities is not clear. Especially uncertain is how the conditions that produce this subtype differ from those that lead to the Mesic Subtype or to Montane Oak–Hickory Forest and Low Montane Red Oak Forest. These different communities rarely co-occur. Often Chestnut Oak Forest (Dry Heath Subtype) grades directly to Acidic Cove Forest without any of these communities being recognizable between them. In other places, the Herb Subtype is extensive and seems to occur over a broad range of topography.

The appropriate classification of dry-mesic *Quercus montana* and *Quercus rubra* forests has been particularly confusing and uncertain. They are, in a conceptual sense, intermediate between many different communities and, at the same time, highly variable. *Quercus montana - Quercus velutina / Oxydendrum arboreum - Cornus florida* Forest (CEGL008522) was formerly described as a separate drier, acidic, but non-heath chestnut oak community in western Virginia but has been merged into the primary association crosswalked to the Herb Subtype. *Quercus rubra – Quercus montana – Magnolia* (*acuminata, fraseri*) / *Acer pensylvanicum* Forest (CEGL004817) was another association similar to this one, defined in Virginia and attributed questionably to North Carolina. It too has since been lumped. The combination of oaks with *Magnolia* species in the canopy is not typical in North Carolina. While *Magnolia fraseri* is common in the understory of the Herb Subtype as it occurs in North Carolina, this species is abundant in the canopy only where oaks have been depleted by logging. Canopy *Magnolia acuminata* generally is associated with forests of richer soils, such as Rich Cove Forest or Montane Oak–Hickory Forest (Basic Subtype). Shrub and sapling size individuals of this species are commonly found in many kinds of oak forest occurring near Rich Cove Forests, but they rarely reach the canopy. With regular fire, they probably would quickly be eliminated from oak forests.

Quercus montana - Quercus rubra / Hamamelis virginiana Forest (CEGL006057) is a closely related association of the Central Appalachians.

Rare species:
Vascular plants – *Celastrus scandens, Steironema* (*Lysimachia*) *tonsa, Monotropsis odorata, Sisyrinchium dichotomum, Smilax hugeri, Spiraea corymbosa*, and *Thermopsis fraxinifolia.*

Vertebrate animals – *Certhia americana, Crotalus horridus,* and *Neotoma magister*.

CHESTNUT OAK FOREST (WHITE PINE SUBTYPE)

Concept: The White Pine Subtype encompasses lower elevation *Quercus montana* forests that have a significant component of *Pinus strobus*, which may range from being a substantial minority to codominant in the canopy. The lower strata in this subtype appear to be similar to those in both the Dry Heath Subtype and the Herb Subtype.

Distinguishing Features: Chestnut Oak Forest (White Pine Subtype) is distinguished from all other communities by the combination of *Quercus montana* with *Pinus strobus*, without a component of *Quercus alba*. The White Pine Subtype should only be used where white pine is believed to be naturally present, not for forests where it has been planted or where it likely spread from nearby plantings. Forests with a more mesophytic composition, such as the forests of *Quercus rubra* and *Pinus strobus* with *Rhododendron maximum* that occur around Linville Falls, are treated as the Mesic Subtype.

Crosswalks: *Pinus strobus - Quercus (coccinea, montana) / (Gaylussacia ursina, Vaccinium stamineum)* Forest (CEGL007519).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The White Pine Subtype occurs on open slopes and spur ridges. It often is in steep gorges or in the most rugged foothill ranges. Most examples are at 1000-2500 feet elevation, but a few are reported upward to 4000 feet or even higher.

Soils: Soils are generally Typic Dystrochrepts, especially Chestnut and Edneyville, less often Typic Hapludults such as Tate or Cowee.

Hydrology: Sites are dry and well drained but may be somewhat less stressful because of topographic sheltering.

Vegetation: The forest canopy is dominated by a mix of *Pinus strobus* and *Quercus montana*, occasionally with *Quercus coccinea* or *Quercus rubra* codominant. Other highly constant or frequent canopy species include *Acer rubrum, Carya glabra*, *Liriodendron tulipifera*, *Quercus velutina*, or *Carya tomentosa*. The understory is most often dominated by *Oxydendrum arboreum*, *Nyssa sylvatica*, or *Pinus strobus*. Other frequent species include *Benthamidia* (*Cornus*) *florida, Magnolia fraseri, Sassafras albidum*, and *Castanea dentata* sprouts, as well as canopy species and, in more mesic occurrences, a substantial amount of *Tsuga canadensis*. The shrub layer may be sparse or dense. *Kalmia latifolia* is constant and sometimes dominant. Other high constancy species that sometimes dominate are *Vaccinium pallidum*, *Symplocos tinctoria*, and *Gaylussacia ursina*. *Rhododendron maximum* and *Pyrularia pubera* are frequent. *Smilax glauca* and *Smilax rotundifolia* have high constancy, and the latter sometimes form tangles. The herb layer is usually sparse. High constancy species are *Galax urceolata, Chimaphila maculata*, and *Goodyera pubescens*. Other frequent herbs include *Viola hastata, Chamaelirium luteum, Uvularia puberula,* and *Epigaea repens*. As in the other subtypes, the herb layer likely would be denser and more diverse if the communities burned regularly.

Range and Abundance: Ranked G4. In North Carolina, the White Pine Subtype occurs primarily in the Blue Ridge escarpment and foothills, with only widely scattered occurrences in the rest of the Blue Ridge. The association ranges from North Carolina to Tennessee and Georgia. It is hard to know the historic or natural range and abundance of this subtype. Ayers and Ashe (1905), in describing timber resources, did not indicate widespread abundance of white pine. But a few local lower elevation areas, such as the Wilson Creek valley and the Shelton Laurel area, were singled out for mention of high abundance. Substantial logging had already taken place in the region by this time, so they may have been removed from forests in other places where they had been abundant. Nevertheless, the variation in their statistics suggests the present pattern of irregular distribution and local abundance of this subtype.

Associations and Patterns: The White Pine Subtype sometimes occurs with the other subtypes of Chestnut Oak Forest, or with Montane Oak–Hickory Forest. It often grades to Acidic Cove Forest downslope.

Variation: Examples vary in amount of *Pinus strobus* and in shrub dominants. Variation is not well enough known to recognize variants, but the range of undergrowth composition is broader than in the other subtypes.

Dynamics: The reason for the occurrence of *Pinus strobus* in this subtype and not in others is not well known. Besides occurrence at low elevations, this subtype likely depends on some aspect of dynamics. *Pinus strobus* is generally regarded as intolerant of fire, though catastrophic fire may favor its regeneration. The occurrence of this subtype in gorges and other rugged topography may be due to less frequent, but still occasional, natural fire. Recent wildfires in Linville Gorge, a place with abundant *Pinus strobus*, demonstrate that such settings can experience intense fires at times. The author's observations in other burned areas suggest that large individuals often survive moderate fires, more often than do *Pinus virginiana* or *Pinus pungens*. *Pinus strobus* saplings are fairly tolerant of shade, often persisting in large numbers in the understory in this community, and even around single isolated trees in other communities. They appear to be able to take advantage of canopy gaps to reproduce without fire. Their thin-barked saplings are very susceptible to fire, and chronic fire at moderate frequency likely would prevent reproduction of this species. Thus, reduction in fire frequency by topography may have been an important determiner of their natural occurrence.

Comments: It is particularly hard to know how the ecology of *Pinus strobus* may have been changed by human alterations. The species can take advantage of canopy opening and often is increased by logging. It may have benefitted from the exclusion of fire from some areas, where saplings appear to be establishing in drier areas than adult trees are present. It also has been planted in some areas. At the same time, it is a prized timber tree, and selective removal may have reduced its abundance or range in some forests. Lack of fire too may have favored the increase of more shade-tolerant trees at its expense. However, all of these processes are pervasive in North Carolina. The White Pine Subtype occurs in some local areas but is absent from other areas that likely had similar history. It thus appears that the presence of *Pinus strobus* in Chestnut Oak Forests may represent natural ecological variation that is not yet understood, while the abundance of it may be related to forest history and degree of alteration.

The drivers of the odd distribution of white pine-containing communities are not known. It is apparently of long standing. Pinchot and Ashe (1897) noted: "The woodland in which white pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest, and southern and eastern slopes of the Blue Ridge or on the low hills on the west." They go on to list these areas as the South Fork New River valley of Ashe and Watauga County, the upper valley of the Linville River in Mitchell County, the valley of the French Broad River in Transylvania County, and the southern parts of Macon and Jackson County. They also note the escarpment in Wilkes and McDowell County as a place where both white and yellow pines occur together.

Rare species:
Vascular plants – *Fothergilla major, Hexastylis contracta, Liatris turgida,* and *Thermopsis fraxinifolia*.

Nonvascular plants – *Rinodina brodoana.*

CHESTNUT OAK FOREST (MESIC SUBTYPE)

Concept: The Mesic Subtype encompasses examples with a shrub layer dominated by mesophytic heath species, usually *Rhododendron maximum*, occurring on more mesic sites in the Blue Ridge and foothills. It is usually on steep north-facing slopes or sides of gorges or ravines. The canopy may have as much *Quercus rubra, Liriodendron tulipifera, Oxydendrum arboreum*, or *Nyssa sylvatica* as it does *Quercus montana*, and may be somewhat open. Forests of *Quercus rubra* and *Pinus strobus* with no other tree species but with similar shrub layers are provisionally included here as well.

Distinguishing Features: The Mesic Subtype is distinguished from all other subtypes by the dominance of *Rhododendron maximum,* or occasionally *Leucothoe fontanesiana* in the shrub layer in a mesic slope setting. This is often accompanied by more mesophytic species in the canopy (*Quercus rubra, Tsuga canadensis*), and by absence of more xerophytic species such as yellow pines. Occasional lower elevation slope or plateau stands dominated by *Quercus rubra*, with or without *Pinus strobus*, having a dense evergreen shrub layer and lacking the characteristics of Low Montane Red Oak Forest, may also be classified here.

The Mesic Subtype grades to Acidic Cove Forest, which often has a similar shrub layer and can contain some canopy oaks. It is distinguished by the predominance of oaks over mesophytic hardwoods in the canopy.

Crosswalks: *Quercus montana - Quercus rubra / Rhododendron maximum / Galax urceolata* Forest (CEGL006286).
Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).
Chestnut Oak Forest (Rhododendron Subtype) (early 4th Approximation drafts).

Sites: The Mesic Subtype characteristically occurs on steep north-facing slopes but may occur on other kinds of topographically sheltered sites. Most examples occur from 1000-3500 feet, with a few examples extending to 4000 feet or more.

Soils: Most examples are mapped as Typic Dystrudepts, especially Chestnut and Ashe, Typic Hapludults; a few are on other kinds of Inceptisols.

Hydrology: Sites are well drained but mesic or dry-mesic; they are less dry than other subtypes because of cool slope aspect and topographic sheltering.

Vegetation: The forest is dominated by *Quercus montana* or *Quercus rubra* or both. Most examples have both, but some are exclusively *Quercus montana* and a few are exclusively *Quercus rubra*. The canopy is sometimes very open. More mesophytic trees are usually present in small to moderate numbers. *Acer rubrum*, *Betula lenta*, and *Tsuga canadensis* are most frequent, but *Liriodendron tulipifera*, *Betula alleghaniensis*, and *Nyssa sylvatica* are also frequent. The understory may include *Oxydendrum arboreum, Amelanchier arborea, Magnolia fraseri, Acer pensylvanicum,* or *Castanea dentata* sprouts, in addition to *Acer rubrum*, *Tsuga canadensis*, or other species found in the canopy. The shrub layer is usually dominated by *Rhododendron* *maximum* and often is very dense. *Kalmia latifolia* may also be abundant. *Leucothoe fontanesiana* may occur as a lower shrub layer. *Hamamelis virginiana* is frequent, and the rare *Fothergilla major* may be present. The herb layer is sparse and consists mainly of species tolerant of shade and of very acidic conditions, such as *Galax urceolata, Polystichum acrostichoides, Chimaphila maculata, Goodyera pubescens, Athyrium asplenioides*, and *Medeola virginiana*.

Range and Abundance: Ranked G4. This subtype is scattered throughout the Mountain Region, and has a few disjunct occurrences in the foothills and upper Piedmont. Its overall abundance in North Carolina is somewhat uncertain because of confusion in distinguishing it, but it is not rare. The association ranges from Georgia to West Virginia and Kentucky.

Associations and Patterns: The Mesic Subtype usually occurs as small patches, though clusters of them can amount to a substantial acreage in some sites. Occasionally it may occur as large patches. This subtype characteristically is on steep north-facing slopes or spur ridges, grading to Acidic Cove Forest below and on more concave slopes. It often grades to Chestnut Oak Forest (Dry Heath Subtype) or Montane Oak–Hickory Forest (Acidic Subtype) uphill but may be bordered by Pine–Oak/Heath, or other dry forests.

Variation: The *Quercus rubra-Pinus strobus* forests that are tentatively included here are distinct enough to recognize as a variant. Otherwise, this subtype varies little other than in the mix of oak dominants.

1. Typic Variant includes most examples and fits the description here closely.

2. Red Oak–White Pine Variant covers the distinctive communities around the crest of the Blue Ridge escarpment near Linville Falls, where *Pinus strobus* codominates. It is uncertain whether this variant is better treated as part of this subtype, as part of the White Pine Subtype, or as a distinct community. More study may lead to a different conclusion.

Dynamics: The dynamics of this subtype are particularly unclear. The mesophytic and topographically sheltered sites likely burn less frequently and less intensely than in most oak forests, but evidence of fire can be found in many examples. The dense evergreen shrub layer would likely inhibit regeneration of oaks, even prior to the recent general decrease in oak regeneration. Examples are more likely than other oak forests to have a very open canopy, and this may suggest difficulty in tree regeneration. Yet, both apparent old-growth and younger examples are known. It is possible that the dense shrub layer is of recent development. It is also possible that occasional fires, though less frequent than in other oak forests, are sufficient to allow tree regeneration in the long run.

Comments: Despite the low species richness and the dominance by widespread species, The Mesic Subtype is usually quite distinctive. It occurs conceptually, and generally spatially, between Acidic Cove Forests and drier oak forests, which are often Montane Oak–Hickory Forest rather than other subtypes of Chestnut Oak Forest. It appears uncommon, however, and is not detectable in most places where Acidic Cove Forests and drier oak forests adjoin. It is unclear how closely they are related to other Chestnut Oak Forests. It often occurs in regions where other subtypes of Chestnut Oak Forest are scarce or absent. It is the primary mountain habitat for *Fothergilla major*.

This subtype was called the Rhododendron Subtype in earlier drafts of this guide. The name was changed to be clearer about the concept. *Rhododendron maximum* occurs at moderate frequency in the Dry Heath Subtype, though its presence there is probably an artifact of fire suppression. The Mesic Subtype is always associated with more mesic topographic settings and has few of the more xerophytic species.

The circumscription of this subtype appears to be particularly difficult and subject to varying interpretations. Field surveys do not report it in most sites in North Carolina, yet many plots have been attributed to it. In plot data, it can be hard to tell from local concentrations of oak in Acidic Cove Forests. The group of low elevation, more mesophytic oak forests, of which it is one, seem particularly complex and variable.

Rare species:
Vascular plants – *Dicentra eximia, Fothergilla major, Hexastylis contracta, Monotropsis odorata, Smilax hugeri,* and *Thermopsis fraxinifolia.*

Nonvascular plants – *Rinodina brodoana.*

CHESTNUT OAK FOREST (BOULDERFIELD SUBTYPE)

Concept: Chestnut Oak Forest (Boulderfield Subtype) communities are forests of low-to-moderate elevation, well-developed boulderfields, dominated by *Quercus montana*, with or without *Quercus rubra*. Substrates are comparable to High Elevation Birch Boulderfield Forest and Rich Cove Forest (Boulderfield Subtype), but mesophytic trees are present in only small numbers if at all.

Distinguishing Features: The Boulderfield Subtype of Chestnut Oak Forest, like the High Elevation Birch Boulderfield Forest and the Boulderfield Subtype of Rich Cove Forest, is distinguished by occurring on well-developed boulderfields, with near complete cover by large rocks, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower vegetation strata substantially influenced by the rock cover. Chestnut Oak Forest (Boulderfield Subtype) is distinguished from boulderfield subtypes of other communities by having canopy composition comparable to other Chestnut Oak Forest subtypes: dominance or codominance of *Quercus montana* without any appreciable *Quercus alba*.

Because the lower strata, especially the herb layer, are less dense in oak forests in general than in Rich Cove Forest or Northern Hardwood Forest communities, the recognition of the Boulderfield Subtype of Chestnut Oak Forest may be more subtle and require more attention to extreme rock cover and space beneath the rocks. Many Chestnut Oak Forests have substantial rock content in the soil and may have small rock outcrops but most do not have enough surface boulder cover to affect community composition.

Crosswalks: No NVC equivalent. A new association needs to be created.
Ecological Systems: Southern Appalachian Oak Forest (CES202.886).

Sites: The Boulderfield Subtype may occur on convex, planar, or somewhat concave slopes, generally moderate to steep. It may be on the edges of relict periglacial boulderfields, which tend to be in steeply plunging coves, or it may occur on talus beneath rock outcrops. The boulders in the few known examples tend to be smaller than those in the Rich Cove Forest subtype or in High Elevation Birch Boulderfield, but it is uncertain if this is universally true. Examples should be expected at low to moderate elevations, comparable to the elevational range of other Chestnut Oak Forest subtypes.

Soils: Soil consists of accumulations of organic matter on and among boulders, but patches are generally small and are treated as inclusions in other soil map units.

Hydrology: Conditions are generally dry-mesic due to topography, but moisture may vary drastically at very fine scale. Shallow soil pockets maybe become dry very quickly. Seepage areas are less likely than in more mesic boulderfields. However, roots of large established trees likely extend beneath the boulders and have a greater supply of moisture.

Vegetation: The Boulderfield Subtype canopy is well-developed, either closed or somewhat open. *Quercus montana* may dominate alone or may be mixed with *Quercus rubra*. Other tree species may be present in smaller numbers, including *Betula alleghaniensis, Betula lenta, Carya glabra,* *Carya ovata,* possibly *Tilia americana* var. *heterophylla*, *Acer saccharum,* and at lower elevation, *Ulmus alata*. The understory generally is sparse. *Acer rubrum, Acer pensylvanicum*, or *Nyssa sylvatica* may be present, along with canopy species. The shrub layer is also usually sparse, but *Hydrangea arborescens* dominates patches in some examples. Where observed, shrubs such as *Kalmia latifolia* and *Vaccinium* spp. that are abundant in the surrounding forest are scarce or absent within the boulderfield. The ground cover is generally dominated by vines, including *Isotrema macrophyllum*, *Toxicodendron radicans*, or *Parthenocissus quinquefolia,* but potentially *Smilax rotundifolia*, *Vitis* sp., or others. Herbs are sparse, though lichens may have extensive cover on the rocks. Species that can grow on bare rock or very shallow soil, such as *Polypodium virginianum, Dryopteris marginalis*, and *Sedum ternatum*, are usually the most abundant. A variety of other herbs may occur in soil pockets or favorable microsites. Species observed include *Aralia nudicaulis, Eurybia divaricata, Muhlenbergia tenuiflora, Coreopsis major, Impatiens capensis, Dioscorea villosa, Hylodesmum nudiflorum*, and *Polymnia canadensis*.

Range and Abundance: Unranked but likely G1 or G2. This community is newly recognized, but it is unlikely that more than a handful of examples will be found. It occurs in Tennessee and may possibly occur in adjacent South Carolina, Georgia, or Virginia.

Associations and Patterns: Chestnut Oak Forest (Boulderfield Subtype) occurs with other Mountain Oak Forests, especially other subtypes of Chestnut Oak Forest. It may border or occur close to Rich Cove Forest (Boulderfield Subtype).

Variation: Variation is not fully known. Patches vary in the amount of *Quercus rubra* mixed with *Quercus montana* in the canopy. Distinct variants representing typical acidic and high base conditions may be found.

Dynamics: While stand dynamics presumably are similar to other oak forests, canopy gaps last longer because of the difficulty of tree establishment. Fire may be less of an influence because of the discontinuous leaf litter cover on the surface.

Comments: As with Rich Cove Forest (Boulderfield Subtype), this community is more similar to other Chestnut Oak Forests than is High Elevation Birch Boulderfield to Northern Hardwood Forests, so it is recognized as a subtype rather than a full type. This subtype is one of the most recently recognized communities, added to the 4th Approximation well after the guide was published. Analogous boulderfield subtypes have also been found for Montane Oak—Hickory Forest and High Elevation Red Oak Forest. More work is needed to fully characterize all of these communities. The author has observed multiple examples and several more have been reported. However, some reported examples have proven to be the more mesophytic Boulderfield Subtype of Rich Cove Forest, with a limited oak component.

All of the oak boulderfield forests are expected to be extremely rare and likely of limited extent. However, it should be noted that the Boulderfield Subtype of Rich Cove Forest, while uncommon, proved to be less extremely rare than it appeared when first defined.

Rare species: No rare species are known to be specifically associated with this community.

MONTANE OAK–HICKORY FOREST (ACIDIC SUBTYPE)

Concept: Montane Oak–Hickory Forests are common mountain forests dominated by mixtures of oaks with *Quercus alba* as a significant component. The Acidic Subtype covers the broad range of examples with typical acid-loving herbs and heath shrubs. This subtype lacks indicators of circumneutral soils and also lacks low elevation dry-site species.

Distinguishing Features: All Montane Oak–Hickory Forests are distinguished from other Mountain Oak Forest communities by having a canopy containing significant *Quercus alba* (10% of the canopy or more) mixed with other species in a canopy dominated by oaks and hickories. Chestnut Oak Forest, Low Montane Red Oak Forest, and High Elevation Red Oak Forest have very little or no *Quercus alba*. High Elevation White Oak Forest has a canopy strongly dominated by *Quercus alba* and a dense heath layer; it also occurs at elevations above 4000 feet. Montane Oak—Hickory Forests may occur at similar elevations and may have a dense heath shrub layer, but if so, will have other oaks important in the canopy. Montane Oak–Hickory Forests are distinguished from Oak–Hickory Forests of the Piedmont by having a significant component of montane flora, such as *Castanea dentata, Rhododendron calendulaceum, Kalmia latifolia, Magnolia fraseri*, *Gaylussacia ursina*, and *Gaylussacia baccata*.

The Acidic Subtype is distinguished from the closely related White Pine Subtype by the absence or scarcity of *Pinus strobus* in the canopy. It is distinguished from the Basic Subtype by the absence or scarcity of plants that prefer circumneutral or higher soil pH, species such as *Fraxinus americana, Tilia americana* var. *heterophylla*, *Collinsonia canadensis, Sanguinaria canadensis, Actaea racemosa*, and *Caulophyllum thalictroides*. It is distinguished from the Low Dry Subtype by the absence of more xerophytic species such as *Pinus echinata, Quercus falcata, Quercus stellata*, *Quercus marilandica*, and a number of herbs.

Crosswalks: *Quercus alba - Quercus (rubra, montana) / Rhododendron calendulaceum - (Gaylussacia ursina)* Forest (CEGL007230).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: Montane Oak–Hickory Forest (Acidic Subtype) occurs on ridge tops and on upper to lower slopes, spur ridges, and some valley flats. It occurs over a tremendous range of elevation, from 1000-5800 feet, with examples common over most of that range.

Soils: This community occurs on a broad range of uplands soils, mostly Typic Hapludults such as Chester, Evard and Watauga, or Typic Dystrudepts such as Ashe, Chestnut, Porters, and Stecoah.

Hydrology: Sites are well drained, and conditions generally are dry-mesic to dry.

Vegetation: The Acidic Subtype canopy is dominated by varying combinations of *Quercus alba, Quercus rubra, Quercus montana*, and *Quercus coccinea*. Any of these species may be most abundant, but *Quercus alba* is always present in more than token numbers. *Carya glabra, Carya tomentosa, Quercus velutina, Acer rubrum*, and *Liriodendron tulipifera* are also frequent in the canopy. *Castanea dentata* once dominated or codominated, and sprouts remain highly constant in the understory or shrub layer. Highly constant understory species in CVS plot data include

Oxydendrum arboreum, Sassafras albidum, Nyssa sylvatica, and *Benthamidia* (*Cornus*) *florida*. Also frequent are *Magnolia fraseri, Prunus serotina*, and *Amelanchier arborea*, along with some of the canopy species. The shrub layer is extremely variable. Many examples have open shrub layers with a mix of species that includes *Kalmia latifolia, Rhododendron calendulaceum, Gaylussacia ursina, Rhododendron maximum, Vaccinium pallidum, Vaccinium stamineum*, and *Pyrularia pubera*. Some examples have dense shrub layers strongly dominated by *Kalmia latifolia*, *Gaylussacia ursina*, or *Vaccinium pallidum*. The herb layer generally is low in density and diversity under current conditions. *Chimaphila maculata, Goodyera pubescens*, and *Dioscorea villosa* have high constancy in plots. Other frequent species include *Lysimachia quadrifolia*, *Amauropelta* (*Parathelypteris*) *noveboracensis, Galax urceolata, Hylodesmum nudiflorum, Potentilla canadensis, Viola hastata, Medeola virginica,* and *Gillenia trifoliata*. Under more natural fire regimes, species of the suite of common herbs of dry open sites, described under the Low Dry Subtype, such as *Danthonia spicata, Schizachyrium scoparium, Coreopsis major, Iris verna*, and *Tephrosia virginiana*, likely would be abundant, at least in some examples.

Range and Abundance: Ranked G4G5 but likely G5. This is one of the most extensive communities in the Mountain region of North Carolina, making up a large part of the landscape at low to moderate elevations south of Asheville. It is abundant in most parts of the region, though it is scarce in parts of the Blue Ridge escarpment and in the foothills. The association ranges from Virginia to Georgia.

Associations and Patterns: The Acidic Subtype is a matrix community in many places, making up a significant part of the landscape along with Acidic Cove Forest and Rich Cove Forest, grading to Chestnut Oak Forest and Pine–Oak/Heath on the sharper ridges and grading to High Elevation Red Oak Forest and Northern Hardwood Forest at higher elevations. However, in the foothills and northern Blue Ridge escarpment, it often occurs only in small patches in gaps or upper coves, with Chestnut Oak Forest dominating the landscape. At lower elevations, below 2000 feet, it may grade to the Low Dry Subtype on south- or west-facing slopes. The Acidic Subtype may give way abruptly or gradually to the Basic Subtype where the underlying geology changes.

Variation: Montane Oak–Hickory Forest (Acidic Subtype) is one of the most broadly circumscribed communities, covering a wide range of topography and elevation. Its vegetation is also very variable, though less so than its geographic and physical site range would suggest. The specific canopy dominants often vary over short distances, defying separation, while the same mix can be present from the lowest to the highest elevations. The variation is complex, and quantitative analyses on different data sets have not identified consistent divisions within it. Two variants are tentatively recognized by analogy with the subtypes of Chestnut Oak Forest, with the understanding that it may also be appropriate to create additional variants.

1. Dry Heath Variant has a dense to moderate shrub layer dominated by *Kalmia latifolia, Gaylussacia ursina*, *Vaccinium pallidum*, or other clonal Ericaceous shrubs. It may be appropriate to recognize separate variants for each of these dominants, as is done in Chestnut Oak Forest.

2. Herb Variant has an open shrub layer not strongly dominated by one of the above species, often having *Rhododendron calendulaceum* or other species abundant. Herbs may be sparse or denser.

Dynamics: Dynamics of this community are generally similar to those of Montane Oak Forests as a whole, including regeneration dynamics and an important role for moderate fire.

Following severe canopy disturbance such as logging, examples at present tend to regenerate as successional forests dominated by *Liriodendron tulipifera*, *Acer rubrum*, and *Robinia pseudo-acacia*, often with large numbers of sprouts of understory species. Various oaks often are present, but in much smaller numbers. Carter, et al. (2000), sampling successional forests in the high rainfall area around Highlands, found *Robinia pseudo-acacia*, *Betula lenta*, and *Liriodendron tulipifera* to be common early successional species over a broad range of environments and elevation, but also found some *Carya glabra, Quercus coccinea, Quercus rubra*, and *Quercus alba* present in early successional forests in xeric and intermediate sites at mid to high elevations.

The relationship with the similar White Pine Subtype is somewhat uncertain and needs further investigation. Abella and Shelburne (2003) documented the establishment of *Pinus strobus* and abundance of young pines in an oak forest at Ellicott Rock Wilderness where none had been present before 1900 and only small amounts since 1950. Understory and sapling pines were most strongly correlated with the presence of the few large pines. This would suggest the White Pine Subtype may simply be a fire suppression artifact or some recent alteration. However, in other places an apparently similar history does not lead to pine invasion, and the two subtypes seem more distinct.

Comments: Montane Oak–Hickory Forest was newly recognized with the 3rd Approximation and was not present in earlier editions. A comparable community was not recognized by Whittaker (1956). It apparently is not present in the part of the Great Smoky Mountains where his study concentrated, though it is extensive in the North Carolina portion. Comparable communities were recognized in studies in southern North Carolina, such as those of Racine and Hardin (1975) and Cooper and Hardin (1970). They are recognized in Newell (1997) and, though less common in his study area, by McLeod (1988).

Carter et al. (2000), in their analysis of old-growth plots in the high rainfall area around Highlands, found *Quercus alba* indicative of higher elevations (above 4000 feet) in their data set of old-growth forests, along with *Castanea dentata* and *Gaylussacia ursina*. This is similar to Whittaker's (1956) recognition of white oak forest only at higher elevation. However, the limited remaining legacy of old-growth forests may be misleading in this regard, as mature second growth Montane Oak–Hickory Forest is present throughout the elevational range in the Highlands area. Baranski (1975) emphasized the occurrence of *Quercus alba* throughout the elevation range of oak forests in the North Carolina mountains.

The relationship of higher elevation examples of Montane Oak–Hickory Forest to High Elevation White Oak Forest needs clarification. The Acidic Subtype can range to high elevations and shares many species with High Elevation White Oak Forest. The latter appears to be tied to more extreme sites and to have reduced species richness, but the differences need further investigation. The distinction is confused by the application of Whittaker's (1956) high elevation white oak forest concept to lower elevation mixed forests before the development of the Montane Oak–Hickory Forest concept.

Rare species:
Vascular plants – *Buckleya distichophylla, Calamagrostis porteri, Carex roanensis, Cirsium carolinianum, Dendrolycopodium hickeyi, Fleischmannia incarnata, Fothergilla major, Frasera caroliniensis, Hexastylis contracta, Hexastylis naniflora, Hexastylis rhombiformis, Isotria medeoloides, Liatris microcephala, Lysimachia* (*Trientalis*) *borealis, Lysimachia fraseri, Monotropsis odorata, Rhododendron vaseyi, Shortia galacifolia, Sisyrinchium dichotomum, Smilax hugeri, Spigelia marilandica, Steironema* (*Lysimachia*) *tonsum, Stewartia ovata, Thermopsis fraxinifolia, Thermopsis mollis,* and *Trillium pusillum sensu lato*.

Nonvascular plants – *Sciuro-hypnum populeum* and *Syntrichia* (*Tortula*) a*mmonsiana.*

Vertebrate animals – *Aneides aeneus, Crotalus horridus,* and *Sphyrapicus varius.*

MONTANE OAK–HICKORY FOREST (BASIC SUBTYPE)

Concept: Montane Oak–Hickory Forests are dominated by mixtures of oaks with *Quercus alba* as a significant component. The Basic Subtype encompasses forests of mafic rock or comparable substrates, whose flora contains species typical of higher pH, base-rich sites.

Distinguishing Features: All Montane Oak–Hickory Forests are distinguished from other Mountain Oak Forest communities by having a canopy containing significant *Quercus alba* (10% of the canopy or more) mixed with other species in a canopy dominated by oaks or hickories. The Basic Subtype is distinguished from the Acidic Subtype and the Low Dry Subtype by the combination of limited heath shrub abundance and abundance of typically mesophytic herbs. Characteristic species such as *Pycnanthemum montanum, Tradescantia subaspera, Solidago curtisii, Podophyllum peltatum, Dichanthelium boscii*, and *Brachyelytrum erectum* are often abundant, but species more typical of Rich Cove Forest, such as *Collinsonia canadensis, Arisaema triphyllum, Actaea racemosa, Caulophyllum thalictroides, Sanguinaria canadensis, Adiantum pedatum, Eutrochium purpureum*, and *Philadelphus inodorus* are also usually present. Additional canopy species associated with more mesophytic or more base-rich communities are also usually present, with *Fraxinus americana, Prunus serotina,* and *Magnolia acuminata* especially characteristic. This subtype is potentially confused with Rich Cove Forest (Red Oak Subtype) but can be distinguished by occurring in more topographically exposed settings and having a less mesophytic flora, as well as by having *Quercus alba* as a major component. While a surprising number of herbaceous and woody species are shared with Rich Cove Forests, they represent a distinct subset of rich mesophytic species. Many of the associated species in this community are those of drier sites.

Crosswalks: *Quercus alba - Quercus rubra - Quercus montana / Collinsonia canadensis - Podophyllum peltatum* Forest (CEGL007692).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Basic Subtype occurs in the same range of settings as the Acidic Subtype, including ridge tops and on upper to lower slopes, spur ridges, and some valley flats, but with a substrate of amphibolite, calc-silicate, or other mafic or calcareous rock. It occurs over a tremendous range of elevation, from 1000 feet up to 5200 feet or higher.

Soils: Soils tend to have higher pH, higher base saturation, and higher concentrations of calcium, magnesium, and several other cations, compared to the prevailing soils of the region and to those of the Acidic Subtype. This suite of characteristics is called “basic” by North Carolina ecologists, but rarely if ever is the pH above neutral. Soils mapped for this community include a broad range of upland soils that are not distinguished by their chemical characteristics and are usually shared with other subtypes. Most are Typic Hapludults such as Evard, Cowee, and Fannin, or Typic Dystrudepts such as Ashe, Chestnut, and Porters.

Hydrology: Sites are well-drained, and conditions generally are dry-mesic to dry. As with many communities of mafic rock, some of the flora suggests moister conditions than the topographic position or canopy composition suggest.

Vegetation: The Basic Subtype forest generally is dominated by varying combinations of *Quercus alba, Quercus rubra, Carya glabra*, and less frequently, *Quercus montana*. A significant minority of species characteristic of basic soils is present. Most constant of these species are *Fraxinus americana* and *Prunus serotina*. Other frequent canopy species include *Betula lenta, Quercus velutina, Carya cordiformis*, and less frequently but sometimes abundant, *Carya ovata*, *Acer saccharum, Tilia americana* var. *heterophylla,* or *Juglans nigra*. High constancy understory species in CVS plot data are *Castanea dentata* sprouts, *Acer rubrum, Nyssa sylvatica, Sassafras albidum, Benthamidia* (*Cornus*) *florida,* and *Oxydendrum arboreum*, and other frequent species include *Acer pensylvanicum, Magnolia acuminata*, and *Amelanchier arborea*/*laevis*. Shrubs generally are sparse. *Swida* (*Cornus*) *alternifolia, Corylus americana*, *Calycanthus floridus, Hydrangea arborescens*, and various *Vaccinium* spp. sometimes occur. Vines are not generally extensive, but *Toxicodendron radicans* and *Parthenocissus quinquefolia* are highly constant. The herb layer is usually moderate in density and is diverse. In addition to widespread species such as *Maianthemum racemosum*, *Dioscorea villosa*, *Solidago curtisii*, *Polystichum acrostichoides, Lysimachia quadrifolia*, and *Medeola virginica*, herbs include several of a large suite of base-loving or mesophytic herbs shared with Rich Cove Forest and not generally present in other oak forests. High constancy species in CVS plots are *Amphicarpaea bracteata, Collinsonia canadensis, Uvularia perfoliata, Conopholis americana, Actaea racemosa, Dichanthelium boscii,* and *Galium latifolium*. Other frequent species in plots include *Hylodesmum nudiflorum, Tradescantia subaspera, Eurybia divaricata, Polygonatum biflorum, Goodyera pubescens, Prosartes maculata, Sanguinaria canadensis, Amauropelta* (*Parathelypteris*) *noveboracensis, Eutrochium purpureum, Clintonia umbellula, Chimaphila maculata, Stellaria pubera, Nabalus* sp., *Carex pensylvanica, Ageratina altissima*, and *Pycnanthemum montanum*. Less frequent species that are nevertheless indicative of the Basic Subtype include *Thalictrum dioicum, Phryma leptostachya, Symphyotrichum cordifolium, Phegopteris hexagonoptera, Hylodesmum glutinosum, Adiantum pedatum, Ligusticum canadense, Brachyelytrum erectum, Bromus pubescens*, and *Laportea canadensis*. The Basic Subtype is among the most species rich of mountain communities. CVS plots average 77 species per 1/10 hectare plot. As in other oak forests, the occurrence of more frequent fire would presumably lead to higher cover and diversity of herbs. More of the suite of common herbs of dry open sites, described under the Low Dry Subtype presumably would occur, and a large suite of more shade-intolerant herbs now associated with basic glades might possibly be present.

Range and Abundance: Ranked G3. This community is scattered throughout the Mountain region and the foothills and occupies a significant acreage but is substantially less abundant than the Acidic Subtype. The association ranges southward to Georgia.

Associations and Patterns: The Basic Subtype may occur as small patches amid acidic communities or may occur in large patches where mafic rock substrates are extensive. In such landscapes, it may occur in a mosaic with High Elevation Red Oak Forest (Rich Subtype), Northern Hardwood Forest (Rich Subtype), Rich Cove Forest (Montane Rich Subtype), Montane Cliff (Mafic Subtype), and other basic soil communities and function locally as a matrix community. At the edges of mafic rock substrate, the Basic Subtype often gives way abruptly to other subtypes of Montane Oak–Hickory Forest, but often is bordered instead by Chestnut Oak Forest. It generally grades downslope to Rich Cove Forest. The environmental threshold that separates the Basic Subtype from the Acidic Subtype does not necessarily coincide with that which separates the Montane Rich from Montane Intermediate Subtype of Rich Cove Forest, and either subtype may adjoin.

Variation: The basic subtype is a very variable community, encompassing a broad range of elevation and moisture conditions. Two variants are recognized based on apparent strength of basic conditions as indicated by flora. Additional variants might be warranted based on elevation, topographic moisture levels, or biogeography.

1. Moderately Basic Variant includes the more common examples which lack the species typical of the most basic sites. They have species such as *Fraxinus americana, Prunus serotina, Solidago curtisii, Tradescantia subaspera*, *Sanguinaria canadensis, Actaea racemosa*, and *Brachyelytrum erectum*.

2. Strongly Basic Variant includes examples with a flora that indicates more strongly basic conditions, at least in exposed high topographic settings. In addition to the species of the Moderately Basic Variant, they contain species such as *Tilia americana* var. *heterophylla*, *Juglans nigra, Phryma leptostachya, Adiantum pedatum, Laportea canadensis*, and *Caulophyllum thalictroides*.

Dynamics: Dynamics are similar to those of Mountain Oak Forests in general. Although mesophytic tree species of rich soils are characteristic of this community, they presumably have increased with the lack of fire and the death of chestnuts, as mesophytic trees have in other oak forests. However, it is notable that the proliferation of heath shrubs seen in other oak forests, believed to be caused by lack of fire and death of chestnut trees, has not occurred in the Basic Subtype despite a similar history. Nothing other than soil chemistry appears to be different between the subtypes.

Comments: This community is one of several associated with basic soils and mafic rocks, with a distinctive flora sharing many species that normally are confined to more mesic sites. This distinction is not made in most of the early studies of vegetation, though it was recognized in many site-specific reports and is clear in McLeod (1988) and some other later studies. Ulrey (2002) noted that this may be because many study areas, such as the Great Smoky Mountains, have limited variation in geology. His analysis of CVS data from across the region clearly demonstrated the importance of the soil chemistry gradient as well as of topography. Ulrey (2002) also articulated the curious fact that the chemical differences that seem to drive community patterns are not the nutrients most limiting to plant production.

Rare species:
Vascular plants – *Adlumia fungosa, Allium allegheniense, Bromus ciliatus, Calamagrostis porteri, Carex hitchcockiana, Carex pedunculata, Carex purpurifera, Carex radfordii, Carex roanensis, Celastrus scandens, Collinsonia tuberosa, Collinsonia verticillata, Corallorhiza maculata* var. *maculata, Cypripedium parviflorum* var. *parviflorum, Delphinium exaltatum, Diarrhena americana, Euphorbia purpurea, Fleischmannia incarnata, Frasera caroliniensis, Gillenia stipulata, Hackelia virginiana, Heuchera pubescens, Hexalectris spicata, Hydrastis canadensis, Isotria medeoloides, Liatris microcephala, Liatris turgida, Melica nitens, Polygala senega, Primula meadia, Prunus alleghaniensis* var. *alleghaniensis, Pyrola elliptica, Quercus prinoides,*

Silene ovata, Silphium perfoliatum, Sisyrinchium dichotomum, Smilax hugeri, Smilax lasioneura, Solidago squarrosa, Solidago ulmifolia, Spigelia marilandica, Spiraea corymbosa, Steironema (*Lysimachia*) *tonsum, Symphyotrichum shortii, Thermopsis fraxinifolia, Thermopsis mollis, Tradescantia virginiana, Verbesina walteri, Viola appalachiana,* and *Viola walteri.*

Nonvascular plants – *Syntrichia* (*Tortula*) a*mmonsiana* and *Syntrichia* (*Tortula*) *fragilis.*

Vertebrate animals – *Dendroica cerulea* and *Plethodon welleri*.

Invertebrate animals – *Sphinx chersis*.

MONTANE OAK–HICKORY FOREST (LOW DRY SUBTYPE)

Concept: Montane Oak–Hickory Forests are dominated by mixtures of oaks with *Quercus alba* as a significant component. The Low Dry Subtype covers the distinctive lower elevation examples with flora indicative of drier acidic conditions, including species more common in the Piedmont along with many species characteristic of the Blue Ridge. These communities are usually on dry slope aspects, but they may be associated with a broader range of topography on sandy soils. Fire appears to be particularly important for these communities.

Distinguishing Features: The Low Dry Subtype is distinguished from the other subtypes by the occurrence of characteristic lower elevation species such as *Quercus falcata*, *Quercus stellata*, and *Pinus echinata* in the canopy and a suite of low elevation, fire-tolerant herbs, while lacking species indicative of basic soils. The characteristic tree species are indicators that may be present only in small numbers, though they likely were more abundant in the past. Characteristic fire-tolerant species include *Baptisia tinctoria, Silphium compositum, Solidago odora, Iris verna, Pityopsis graminifolia*, and *Tephrosia virginiana*, along with many others. This subtype lacks any of the richer flora characteristic of the Basic Subtype or Low Dry Basic Subtype, but it shares many heath shrub species with the Acidic Subtype. The Low Dry Subtype is distinguished from the Southern Mountain Pine–Oak Forest by having less pine (though pines are often present in small numbers).

Crosswalks: *Quercus alba - Quercus coccinea - Quercus falcata / Kalmia latifolia - Vaccinium pallidum* Forest (CEGL007691).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Low Dry Subtype typically occurs on convex or planar slopes or spur ridges that face south or west. Examples are at lower elevations, with few getting much above 3000 feet.

Soils: Soils are similar to those in other acidic Mountain Oak Forests. Most are mapped as Typic Hapludults such as Evard, Cowee, and Edneyville. However, the most extensive occurrences are associated with rocky, sandy soils mapped as Ashe (Typic Dystrudept).

Hydrology: Sites are well-drained and drier than other Montane Oak Forests due to low elevation and dry slope aspects.

Vegetation: The forest is dominated by a mix of trees, with *Quercus alba* always present and usually codominant or dominant. *Quercus velutina, Quercus coccinea, Quercus montana, Pinus echinata, Carya glabra*, and *Carya pallida* are also highly constant in plot data and in other observations, and *Pinus rigida* too is frequent. *Quercus falcata* and *Quercus stellata* are characteristic indicator species, usually present in stands but often at low density, so that they are not always found in plot data. Understory species with high constancy include *Nyssa sylvatica, Benthamidia* (*Cornus*) *florida,* and *Sassafras albidum*, all present in all of the relatively few plots. *Acer rubrum, Oxydendrum arboreum*, *Amelanchier arborea/laevis*, and *Magnolia fraseri* are all present in more than half of plots and in most other observations. *Prunus serotina* and *Castanea dentata* are also frequent species in the understory. The shrub layer is open to moderate in density. *Vaccinium pallidum* is most constant and most often dominant. *Kalmia latifolia, Gaylussacia* *baccata*, and *Vaccinium stamineum* are also highly constant, as are the vines *Smilax glauca* and *Smilax rotundifolia*. *Castanea pumila* is also frequent. Though somewhat less frequent, *Arundinaria appalachiana* sometimes is abundant and apparently characteristic. The herb layer ranges from sparse to fairly dense. In plot data, the most constant species are those shared with the Acidic Subtype and other dense acidic forests: *Chimaphila maculata*, *Goodyera pubescens,* and *Dichanthelium* spp., with *Hylodesmum nudiflorum, Solidago curtisii*, *Dichanthelium commutatum*, and *Euphorbia pubentissima* frequent. Most characteristic, however, is a suite of species which respond well to fire and to higher light levels. *Pteridium latiusculum*, *Coreopsis major*, *Iris verna* var. *smalliana*, *Smilax biltmoreana,* and *Solidago odora* are highly constant or at least frequent in plot data and are frequently observed. A suite of other species is less constant but is characteristic, collectively allying this subtype to other dry open communities and distinguishing it from more mesic forests: *Coreopsis major, Danthonia spicata, Piptochaetium avenaceum, Lespedeza procumbens*, several *Desmodium* spp., *Tephrosia virginiana, Schizachyrium scoparium, Andropogon gerardii, Lespedeza virginica, Pityopsis graminifolia, Silphium reniforme, Hypoxis hirsuta, Ionactis linariifolia*, *Sericocarpus asteroides*, and several species of *Helianthus*. A few additional low constancy shrubs indicate similar affinities, including *Vaccinium arboreum, Symplocos tinctoria*, *Robinia hispida*, and *Rhus copallinum*. Plots are fairly diverse under present conditions, averaging 59 species per 1/10 hectare, and likely would be much more diverse if examples were frequently burned.

Range and Abundance: Ranked G2G3. This subtype is rare in North Carolina, with most examples remaining in the vicinity of DuPont State Forest, in Cherokee County, and in the South Mountains. It must once have been more common in lower mountain valleys such as those in Cherokee County, the Asheville Basin, and they upper French Broad valley. The association is not definitely recognized in any other state, but is questionably attributed to Tennessee, Georgia, and South Carolina. It seems particularly likely to occur in Tennessee but similar communities may be treated as a different association there.

Associations and Patterns: The Low Dry Subtype generally occurs in small to large patches, adding up to several hundred acres in the landscape mosaic of a few known sites. It may once have been a matrix community in the landscape of the large valleys. It usually grades to the Acidic Subtype or to Chestnut Oak Forest on nearby slopes and may grade downhill to Acidic Cove Forest or, less often, Rich Cove Forest.

Variation: With the new recognition of the Low Dry Basic Subtype, no variants are recognized.

Dynamics: This subtype is probably more influenced by fire than the other subtypes and other mountain oak forests, with fire maintaining a more open canopy, even less dense understory, and a correspondingly dense herb layer. Given its co-occurrence in landscapes with more mesic forests, the greater influence of fire presumably comes partly from greater fire intensity but also partly from greater ecological effect and slower recovery of woody vegetation in the dry sites. Members of the suite of common herbs typical of dry open sites are likely to have been present in many subtypes of Mountain Oak Forests as well as in Mountain Dry Coniferous Woodlands. Nevertheless, these species are much more frequent, abundant, and diverse in Low Dry Subtype remnants even in the absence of fire, and several often are present at least on roadsides. In contrast, only uncommonly are they found, even on roadsides, in most occurrences of other oak subtypes.

It may be that the common present-day belief that most mountain oak forests were open grassy woodlands is based on historical greater abundance and visibility of the Low Dry Subtype. Most of the acreage likely to have been the Low Dry Subtype was close to areas of denser settlement, and much now supports successional forest or is no longer forested at all. Given the proximity to settlement, its fire frequency may often have been increased above the background frequency more than in other communities. However, the occurrence of recognizable Low Dry Subtype in rugged, less settled areas, in conjunction with other oak forests on less dry sites, suggests it is a natural community driven by distinctive environmental conditions.

At the same time, it is likely that in appropriate low elevation areas, some places that once supported the Low Dry Subtype have become indistinguishable from the Acidic Subtype. Given the low density of indicator species in recognized remnants, they may have been completely lost in other sites. Loss of the characteristic trees to logging, lack of regeneration of them because of the removal of fire, and suppression of characteristic herbs by dense young even-aged canopies may have obscured their identity.

Comments: This is a very distinctive subtype that may be considered as closely related to Southern Mountain Pine-Oak Forest or to Low Mountain Pine Forest as to other subtypes of Montane Oak–Hickory Forest. It was not distinguished in any of the early or later quantitative studies, but no local study has covered an area where it occurs. No examples were known at the time of the 3rd Approximation. It was first recognized in descriptive surveys at what became DuPont State Forest in the 1990s. A small number of plots in the CVS database allows some quantitative description of it.

Rare species:
Vascular plants – *Liatris aspera, Liatris turgida, Helianthus laevigatus*, and *Thermopsis mollis*.

MONTANE OAK—HICKORY FOREST (LOW DRY BASIC SUBTYPE)

Concept: Montane Oak–Hickory Forests are dominated by mixtures of oaks with *Quercus alba* as a significant component. The Low Dry Basic Subtype covers the distinctive, very rare examples that combine flora indicative of drier sites with that indicative of high pH, based-rich soil conditions. Many species more common in the Piedmont are present, along with those characteristic of the Blue Ridge.

Distinguishing Features: The Low Dry Basic Subtype is distinguished from the other subtypes by the occurrence of characteristic lower elevation species such as *Quercus falcata*, *Quercus stellata*, and *Pinus echinata* in the canopy and the presence of the suite of herbs typical of dry open sites, combined with species indicative of basic soils. The characteristic low elevation tree species are indicators that may be present only in small numbers. Characteristic open-site herbs include *Baptisia tinctoria, Silphium compositum, Solidago odora, Iris verna, Pityopsis graminifolia*, and *Tephrosia virginiana*. Characteristic basic soil species include *Fraxinus americana, Fraxinus biltmoreana*, *Cercis canadensis*, *Rosa carolina, Frangula caroliniana, Chionanthus virginiana, Andersonglossum* (*Cynoglossum*) *virginianum, Tragia urticifolia*, and *Scleria oligantha*.

Crosswalks: No NVC equivalent. A new association needs to be created. Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Low Dry Basic Subtype occurs on convex or planar slopes or spur ridges that face south or west, and that have amphibolite or other mafic or calcareous rock substrates. The known range of occurrence is around 1400-1700 feet, but examples should be sought throughout the elevations typical of the Low Dry Subtype, up to 3000 feet or a bit higher.

Soils: Soils presumably are unusually high in pH and base saturation. Known areas are mapped as Evard-Cowee complex (Typic Hapludults).

Hydrology: Sites are well drained and drier than other Montane Oak Forests due to low elevation and dry slope aspects.

Vegetation: The canopy consists of a mix of tree species in which *Quercus alba* usually is dominant or codominant, while *Quercus montana, Carya glabra,* and *Carya pallida* are abundant. Species indicative of low dry conditions, such as *Quercus stellata*, *Quercus falcata*, and *Pinus echinata* are present and likely were more abundant in the past. Species indicative of higher pH conditions, such as *Fraxinus americana* and *Fraxinus biltmoreana*, are characteristic, either abundant or present only at low density. *Quercus velutina* also has high constancy in some known examples. The understory includes frequent *Benthamidia* (*Cornus*) *florida, Diospyros virginiana, Sassafras albidum,* and *Nyssa sylvatica*. Less abundant but characteristic species include *Cercis canadensis, Prunus serotina*, and in one known example, *Prunus alleghaniensis* and *Crataegus uniflora*. The shrub layer varies. *Arundinaria appalachiana* dominates large patches in some known examples. Other areas have sparser shrubs that include some notable species such as *Celtis tenuifolia* (possibly *smallii*), *Amorpha glabra*, *Chionanthus virginicus, Toxicodendron pubescens*, *Rosa carolina*, and *Frangula caroliniana*, as well as more widespread species such as *Vaccinium pallidum* and *Vaccinium stamineum*. Vines, especially *Muscadinia rotundifolia, Parthenocissus* *quinquefolia*, and *Vitis aestivalis* may be abundant on the ground. The herb layer includes large areas dominated by *Piptochaetium avenaceum*. Other high constancy or frequent herbs include *Clitoria mariana, Coreopsis major, Solidago odora, Carex nigromarginata, Chimaphila maculata, Dichanthelium commutatum, Endodeca serpentaria, Galium circaezans, Helianthus divaricatus, Iris verna* var. *smallii*, *Lespedeza repens, Lespedeza violacea, Mimosa microphylla, Scleria oligantha, Solidago petiolaris, Symphyotrichum pratense, Tragia urticifolia*, and *Parthenium integrifolium*. Herb species less frequent in plots but characteristic or indicative include *Agrimonia pubescens, Agrimonia microcarpa, Brickellia eupatorioides, Cunila origanoides, Danthonia sericea, Euphorbia pubentissima, Cynoglossum virginianum, Liatris spicata, Lithospermum virginianum, Phaseolus polystachyos, Silphium reniforme, Tetragonotheca helianthoides, Angelica venenosa, Pityopsis graminifolia, Schizachyrium scoparium*, and *Tephrosia virginiana*. The plot data show high species richness, averaging 77 species per 1/10 ha.

Range and Abundance: Not yet ranked but will be G1. This community is known at fewer than five sites, most in South Mountains but one in the western Mountains. It may be found at other places within the range of the Low Dry Subtype, and in other states, but likely is extremely rare.

Associations and Patterns: This community occurs as small patches. The known examples are associated with other subtypes of Montane Oak–Hickory Forest, including the Low Dry Subtype and Basic Subtype, and with Low Elevation Basic Glade.

Variation: Little is known about variation at present.

Dynamics: As in the Low Dry Subtype, this subtype is presumed to be more influenced by fire than other subtypes and other Montane Oak Forests, with fire maintaining a more open canopy, even less dense understory, and a correspondingly dense herb layer. The abundance of *Arundinaria appalachiana* might also be maintained by fire. Given this community's cooccurrence in landscapes with more mesic forests, the greater influence of fire presumably comes partly from greater fire intensity, though dry site conditions also would increase the likelihood that any ignition would spread through the whole area and might slow the recovery of the woody vegetation.

Comments: This subtype was one of the last to be recognized in developing the 4th Approximation. It was first identified by Kevin Caldwell and Lloyd Raleigh after 2010. Several CVS plots were sampled in one occurrence in 2013, giving some basis for quantitative description, and several smaller and more marginally developed sites were found since then. The sampled site which is the primary basis for the description has a number of unusual floristic characteristics, in other communities as well as in this one. If other examples of the Low Dry Basic Subtype are found, they may be substantially different, but should be recognizable by a combination of flora indicative of warm dry conditions and of basic soils.

Rare species:
Vascular plants – *Arabis patens, Berberis canadensis, Carex eburnea, Helianthus laevigatus, Liatris aspera, Liatris turgida, Matelea obliqua, Prunus alleghaniensis* var. *alleghaniensis, Quercus prinoides, Sceptridium jenmanii,* and *Tradescantia virginiana*.

Invertebrate animals – *Euchloe olympia*.

MONTANE OAK–HICKORY FOREST (WHITE PINE SUBTYPE)

Concept: Montane Oak—Hickory Forests are dominated by mixtures of oaks with *Quercus alba* as a significant component. The White Pine Subtype encompasses examples with a significant component of *Pinus strobus*. Most resemble the Acidic Subtype except for the presence of *Pinus strobus*.

Distinguishing Features: The White Pine Subtype is distinguished by the combination of significant, though not necessarily dominant, *Pinus strobus* in combination with *Quercus alba* under natural conditions. It is distinguished from White Pine Forest by having no more than 75 percent of the canopy cover being *Pinus strobus* under natural conditions. *Pinus strobus* generally provides 25-75% of the canopy cover, but may be less in altered stands. It is distinguished from the White Pine Subtype of Chestnut Oak Forest by having *Quercus alba* as a significant canopy component, though *Quercus montana* may be abundant. The White Pine Subtype should only be used where white pine is believed to be naturally present, not for forests where it has been planted or where it likely spread from nearby plantings. *Pinus strobus* that is abundant as saplings beneath a more mature canopy that lacks it suggests recent invasion and should not be the basis for recognizing the White Pine Subtype unless other evidence points to it. Some *Pinus strobus* may be present in the Low Dry Subtype, which can be distinguished by the presence of more drought tolerant oaks.

Crosswalks: *Pinus strobus - Quercus alba - (Carya tomentosa) / Gaylussacia ursina* Forest (CEGL007517).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The White Pine Subtype occurs on ridge tops and on upper to lower slopes, spur ridges, and some valley flats. It generally occurs at lower elevations, from 1300-3000 feet, but extends up to 3500 feet or higher in the southern mountains.

Soils: This community occurs on a broad range of uplands soils, mostly Typic Dystrudepts such as Edneyville or Ashe, or Typic Hapludults such as Chester and Evard.

Hydrology: Sites are well-drained, and conditions generally are dry-mesic to dry.

Vegetation: The White Pine Subtype canopy is a varying mix in which *Quercus alba* and *Pinus strobus* are both present in significant numbers. They may be codominant, or pines may be a fairly small minority. In CVS plot data, *Liriodendron tulipifera, Carya tomentosa*, and possibly *Acer rubrum* are the only other canopy species with more than 50% frequency. *Quercus montana, Quercus rubra, Carya coccinea*, *Carya glabra*, and *Quercus velutina*, all less frequent in the plot data, are more regularly noted in other site descriptions. The understory may include a wide range of species beyond the canopy species. *Oxydendrum arboreum, Nyssa sylvatica, Benthamidia* (*Cornus*) *florida, Magnolia fraseri*, and *Sassafras albidum* are frequent in drier sites, while *Tsuga canadensis* or *Ilex opaca* can dominate the understory in more mesic occurrences. The shrub layer ranges from sparse to dense. Some examples have moderate density of *Kalmia latifolia, Gaylussacia ursina*, or *Rhododendron maximum*. Other fairly frequent shrubs in plot data include

Vaccinium pallidum and *Symplocos tinctoria*, while *Smilax glauca* and *Smilax rotundifolia* are frequent vines. The herb layer is sparse and indicative of acidic soils, with *Goodyera pubescens, Chimaphila maculata, Polystichum acrostichoides*, and *Amauropelta* (*Parathelypteris*) *noveboracensis* having high constancy in plot data, and *Galax urceolata, Mitchella repens, Lysimachia quadrifolia, Medeola virginica*, and *Viola hastata* being fairly frequent. Overall species richness is low, averaging 35 species per plot.

Range and Abundance: Ranked G3G4. The White Pine Subtype has an odd, discontinuous distribution. It is most abundant in the Blue Ridge escarpment and foothills, but also occurs above the escarpment in several areas. It may be more common in the high rainfall area along the South Carolina border, and it is more abundant in gorges such as Linville Gorge. It is less common than the Acidic Subtype but probably is less uncommon than the number of records suggests. The association ranges to South Carolina, Georgia, and Tennessee, and is questionably attributed to Kentucky.

Associations and Patterns: The White Pine Subtype often is a matrix community where it occurs, forming a substantial part of the landscape mosaic. It can be associated with Montane Oak—Hickory Forest (Acidic Subtype), Chestnut Oak Forest of all subtypes, and Acidic Cove Forest, less often with Rich Cove Forest, Pine—Oak/Heath, rock outcrops, or other communities.

Variation: No variants have been recognized. Examples vary in the relative amount of *Pinus strobus*, but it is unclear when such variation is natural and when it is a result of land use history or alteration of fire.

Dynamics: As with Chestnut Oak Forest (White Pine Subtype), the reason for the occurrence of *Pinus strobus* in this subtype and not in others is not well known. It seems to be something other than the normal gradients of topography, moisture levels, and soil chemistry, since it occurs over a broad range of topography in some places and is absent in others.

Besides occurrence at low elevations, the presence of *Pinus strobus* likely depends on some aspect of dynamics. It is generally regarded as intolerant of fire, though catastrophic fire may favor its regeneration. This community is somewhat associated with gorges and other rugged topography, which may reduce fire frequency while not eliminating it entirely. *Pinus strobus* saplings are fairly tolerant of shade, often persisting in large numbers in the understory in this community, and even around single isolated trees in other communities. The species appears able to take advantage of canopy gaps and to reproduce without fire. The thin-barked saplings are very susceptible to fire, and chronic fire at moderate frequency likely would prevent reproduction of this species. DeYoung (1979), studying on the Tennessee site of the Great Smoky Mountains, found stands of mixed *Pinus strobus* and *Quercus alba* that he interpreted as self-sustaining.

The response of this community to land use is particularly hard to interpret. *Pinus strobus* may potentially be either increased or decreased by past logging. Saplings appear to be invading forests where the species is not abundant in the canopy, and it is unclear if this is a situation of *Pinus strobus* acting as another mesophytic species invading in the absence of fire, or if it is returning to places where it was removed from the canopy in the past. Abella and Shelburne (2003) documented the establishment of *Pinus strobus* and abundance of young pines in an oak forest at Ellicott Rock

Wilderness where none had been present before 1900 and only small amounts since 1950. In their study, and in the author's experience, understory and sapling pines are most strongly correlated with the presence of large pines but can be very abundant where only a few large trees are present.

Abel (1934) noted that *Pinus strobus* suffered little damage from an ice storm that badly damaged oaks. Such storms are common enough that they may help the species coexist with oaks, though this does not appear to explain the variable presence and absence of the species.

Comments: Newell (1997) recognized a *Quercus alba-Pinus strobus/Kalmia latifolia* community in Linville Gorge that clearly is equivalent to this subtype. Callaway, et al. (1987) recognized a white oak-white pine forest which overlapped with other oak forests in ordinations. They described it as being in disturbed areas on limestone, so it is unclear if it is comparable to this natural community.

It is very difficult to distinguish natural occurrence of the White Pine Subtype from successional forests in literature and site descriptions. The discrepancy between vegetation depicted by existing plot data and that often observed in the field may partly result from inclusion of plots in more altered forests. Also, the statistics for CVS data for this subtype are dominated by supplementation of the database by large numbers of plots from focused studies in places where white pine is particularly abundant: Ellicott Rock Wilderness (Patterson 1994) and Thompson River Gorge (Wentworth 1980).

This subtype needs further investigation into its distinctiveness. The recognition of distinct associations for white pine combinations, and the subsequent recognition in the 4th Approximation, may be an example of the "conifer bias" that is frequent in forest ecology, but the fact that the pine is present in some areas and completely absent in others suggests the likelihood that it reflects environmental or biogeographic conditions that would lead to additional differences between the subtypes.

The drivers of this odd distribution of white pine-containing communities are not known. It is apparently of long standing. Pinchot and Ashe (1897) noted: "The woodland in which white pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest, and southern and eastern slopes of the Blue Ridge or on the low hills on the west." They go on to list these areas as the South Fork New River valley of Ashe and Watauga County, the upper valley of the Linville River in Mitchell County, the valley of the French Broad River in Transylvania County, and the southern parts of Macon and Jackson County. They also note the escarpment in Wilkes and McDowell County as a place where both white and yellow pines occur together.

Rare species:
Vascular plants – *Fothergilla major, Liatris turgida, Lysimachia fraseri, Monotropsis odorata,* and *Thermopsis fraxinifolia*.

MONTANE OAK–HICKORY FOREST (BOULDERFIELD SUBTYPE)

Concept: Montane Oak–Hickory Forest (Boulderfield Subtype) communities are forests of well-developed boulderfields, dominated by a mixture of oaks that includes *Quercus alba*, usually along with *Quercus rubra* or *Quercus montana*. Substrates are comparable to High Elevation Birch Boulderfield Forest and Rich Cove Forest (Boulderfield Subtype), but mesophytic trees are present in only small numbers if at all.

Distinguishing Features: The Boulderfield Subtype of Montane Oak–Hickory Forest, like the High Elevation Birch Boulderfield Forest and the Boulderfield Subtype of Rich Cove Forest, is distinguished by occurring on well-developed boulderfields, with nearly complete cover by large rocks, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower vegetation strata substantially influenced by the rock cover. Montane Oak–Hickory Forest (Boulderfield Subtype) is distinguished from boulderfield subtypes of other communities by having canopy composition comparable to other Montane Oak–Hickory Forest subtypes: dominance by a mix of oaks that includes *Quercus alba*.

Because the lower strata, especially the herb layer, are less dense in oak forests than in Rich Cove Forest or Northern Hardwood Forest communities, the recognition of the Boulderfield Subtype of Montane Oak–Hickory Forest may be more subtle and require more attention to extreme rock cover and space beneath the rocks. Many Montane Oak–Hickory Forests are rocky but most do not have enough surface boulder cover to affect community composition.

Crosswalks: No NVC equivalent. A new association needs to be created.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: The Boulderfield Subtype may occur on convex, planar, or somewhat concave slopes, generally moderate to steep. It may be on the edges of relict periglacial boulderfields, which tend to be in steeply plunging coves, or it may occur on talus beneath rock outcrops. The boulders in the few known examples tend to be smaller than those in the Rich Cove Forest subtype or in High Elevation Birch Boulderfield, but it is uncertain if this is universally true. Examples might occur anywhere in the elevational range of Montane Oak–Hickory Forest.

Soils: Soil consists of accumulations of organic matter on and among the boulders, but patches are generally small and are inclusions in soil map units.

Hydrology: Conditions are generally dry-mesic due to topography, but moisture may vary drastically at very fine scale. Shallow soil pockets maybe become dry very quickly. Seepage areas are less likely than in more mesic boulderfields. However, roots of large established trees likely extend below the boulders and have a greater supply of moisture.

Vegetation: The Boulderfield Subtype canopy is well developed, either closed or somewhat open. It is dominated by a mix that includes *Quercus alba* along with *Quercus rubra* or *Quercus montana* or both. Other trees may include *Betula lenta, Betula alleghaniensis, Carya* spp., *Tilia americana* var. *heterophylla*, *Acer saccharum, Fraxinus americana*, or other species. The understory and shrub layer generally are sparse. *Ribes cynosbati* and *Viburnum acerifolium* sometimes occur.

Vines sometimes have extensive cover. *Toxicodendron radicans, Parthenocissus quinquefolia*, or *Isotrema macrophyllum* are the most frequent species. Lichens, or potentially bryophytes, may have extensive cover on the rocks. Otherwise, herbs are sparse. Species characteristic of rock outcrops, such as *Polypodium virginianum, Dryopteris marginalis*, and *Sedum ternatum*, are usually the most abundant. Other species that may occur in small numbers include *Uvularia puberula, Dioscorea villosa, Galium* spp., and a variety of species typical of other subtypes.

Range and Abundance: Unranked but likely G1 or G2. This community is newly recognized, but it is unlikely that more than a handful of examples will be found.

Associations and Patterns: Montane Oak–Hickory Forest (Boulderfield Subtype) occurs with other Mountain Oak Forests. It often is associated with Rich Cove Forest (Boulderfield Subtype).

Variation: Variation is not well known. The known examples occur on amphibolite and have composition suggestive of high base saturation and reduced soil acidity. However, acidic versions may also be found and could be treated as variants.

Dynamics: While stand dynamics presumably are similar to other oak forests, canopy gaps last longer because of the difficulty of tree establishment. Fire may be less of an influence because of the discontinuous leaf litter cover on the surface.

Comments: As with Rich Cove Forest (Boulderfield Subtype), this community is more similar to other Montane Oak–Hickory Forests than is High Elevation Birch Boulderfield to Northern Hardwood Forests, so it is recognized as a subtype rather than a full type. This subtype is one of the most recently recognized communities, added to the 4th Approximation well after the guide was published. Analogous boulderfield subtypes have also been found for Chestnut Oak Forest and High Elevation Red Oak Forest. More work is needed to fully characterize all of these communities. Several more examples are likely to exist, beyond the few observed by the author. . However, some reported examples have proven to be the more mesophytic Boulderfield Subtype of Rich Cove Forest, with a limited oak component.

All of the oak boulderfield forests are expected to be extremely rare and likely of limited extent. However, it should be noted that the Boulderfield Subtype of Rich Cove Forest, while uncommon, proved to be less extremely rare than it appeared when first defined.

Rare species: No rare species are known to be specifically associated with this community.

LOW MONTANE RED OAK FOREST

Concept: Low Montane Red Oak Forest communities are low-to-mid elevation mountain forests dominated by *Quercus rubra*, without appreciable *Quercus alba*, without the distinctive features of Chestnut Oak Forest (Mesic Subtype) or Rich Cove Forest (Red Oak Subtype). The floristic composition suggests intermediate to high soil fertility, lacking the well-developed heath shrub layer of Montane Oak–Hickory Forest (Acidic Subtype) or Chestnut Oak Forest (Mesic Subtype).

Distinguishing Features: Low Montane Red Oak Forest is distinguished from most other oak forests by dominance of *Quercus rubra* without appreciable *Quercus alba* or *Quercus montana*, at low elevations. Chestnut Oak Forest (Mesic Subtype) can be codominated or occasionally dominated by *Quercus rubra*, but it has a composition indicative of very acid soils, with a prominent evergreen heath shrub layer. The distinction from High Elevation Red Oak Forest can generally be made based on elevation, but further clarification is needed for elevations near 3500 feet. The oak in Low Montane Red Oak Forest should be *Quercus rubra* var. *rubra*, while that in High Elevation Red Oak Forest generally is *Quercus rubra* var. *ambigua*, but the varieties have not been widely enough distinguished in literature or plot data to know how reliably this is true near the transition. Low Montane Red Oak Forest lacks species characteristic of higher elevations such as *Betula alleghaniensis, Acer saccharum*, or *Fagus grandifolia*, though the latter two may be present in the transition to Rich Cove Forest. Associated mesophytic species may be absent, but if present, are more likely to be *Liriodendron tulipifera, Betula lenta*, *Halesia tetraptera*, or *Magnolia acuminata*. *Quercus rubra* often is present in all subtypes of Rich Cove Forests and can be abundant enough to appear dominant in a single plot. Low Montane Red Oak Forest should be used only for more extensive stands, but distinguishing individual plots without context may be difficult. The distinction from Rich Cove Forest (Red Oak Subtype) needs further clarification, since *Quercus rubra* can be dominant throughout that community. Most examples of that community have *Tilia americana* var. *heterophylla* as a codominant or abundant tree, while it has not been noted in known examples of Low Montane Red Oak Forest. However, individual plots may be difficult to distinguish, and even some whole stands may prove ambiguous.

Crosswalks: *Quercus rubra - Acer rubrum / Pyrularia pubera / Thelypteris noveboracensis* Forest (CEGL006192).
G015 Southern Appalachian Oak Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).

Sites: Open lower to mid slopes, generally facing north or east or sheltered by topography. Examples occur at low elevations, usually below 3000 feet but possibly up to around 3600 feet.

Soils: Soils are not well known. The known examples are mapped as a variety of widespread series of Typic Hapludults and Typic Dystrudepts.

Hydrology: Moisture conditions apparently are dry-mesic, somewhat moister than most Montane Oak Forests.

Vegetation: Forests are dominated by *Quercus rubra*, sometimes with *Carya glabra*, *Acer rubrum*, or other species codominating but with little or no *Quercus alba* and limited *Quercus* *montana*. Other canopy trees are mainly mesophytic species such as *Liriodendron tulipifera*, *Betula lenta*, or *Halesia tetraptera*. The understory consists of canopy species in combination with widespread understory species such as *Benthamidia* (*Cornus*) *florida, Nyssa sylvatica*, *Oxydendrum arboreum*, and *Castanea dentata* sprouts, and sometimes includes mesophytic species such as *Tsuga canadensis*. The shrub layer generally is open. *Pyrularia pubera* and *Calycanthus floridus* are characteristic. Other species include *Rhododendron calendulaceum, Vaccinium corymbosum*, and less frequently, *Hydrangea arborescens, Hydrangea radiata, Rhododendron minus, Corylus cornuta, Viburnum acerifolium, Hamamelis virginiana*, and other species. The herb layer ranges from moderate to sparse. It may be dominated by a few species, such as *Amauropelta* (*Parathelypteris*) *noveboracensis* or *Athyrium asplenioides;* may have a higher diversity of widely tolerant species such as *Lysimachia quadrifolia, Eurybia divaricata, Goodyera pubescens, Maianthemum racemosum, Medeola virginiana, Carex* spp., and *Hylodesmum nudiflorum*; or it may contain species indicative of richer soils such as *Collinsonia canadensis, Chasmanthium latifolium, Amphicarpaea bracteata, Cynoglossum virginianum, Dichanthelium boscii, Sanguinaria canadensis, Actaea racemosa*, and *Tradescantia subaspera*.

Range and Abundance: Ranked G4? but perhaps rarer. Unclear circumscription makes it difficult to determine abundance, but only a handful of occurrences have been recognized in NHP surveys. Known examples are widely but sparsely distributed in the North Carolina mountains. The association is attributed to South Carolina, Georgia, Tennessee, and Kentucky, but not Virginia.

Associations and Patterns: The community typically occurs as large patches, up to 100 to 300 acres. It is associated with other Montane Oak Forests in drier areas and with Rich Cove Forest in more mesic areas.

Variation: Two variants are recognized:

1. Typic Variant fits most of the description of vegetation above but lacks species of richer soils.

2. Rich Variant contains species typical of richer soils. This variant may be distinctive enough to warrant a separate subtype, analogous to the Basic Subtype of Montane Oak–Hickory Forest and High Elevation Red Oak Forest. Plot data may look similar for it and for Rich Cove Forest (Red Oak Subtype), and the distinction needs further clarification.

Dynamics: Dynamics are presumably similar to those of most Montane Oak Forests, but the dry-mesic sites, at the moist end of the range for oak forests, may imply somewhat reduced influence of fire.

Comments: This community is particularly poorly understood. It was added to the NVC based on plot studies in other states but appears to be comparable to the red oak-pignut forest recognized by Whittaker (1956) in Tennessee. However, conceptual circumscription seems to differ among users, and descriptions and plot assignments vary as a result. Nevertheless, the verified existence of strongly *Quercus rubra*-dominated forests that are not High Elevation Red Oak Forests calls for recognition of something like this community. As defined here, Low Montane Red Oak Forest is narrower than some other uses. Forests with weak predominance of *Quercus rubra* but with significant *Quercus alba* are included in Montane Oak–Hickory Forest instead. The later recognition of Rich Cove Forest (Red Oak Subtype), and variable use of its equivalent association, has further confused the picture and calls for more comparative study.

Day and Monk (1974) found that *Quercus rubra* was the only major tree or shrub species in their Coweeta study other than *Quercus velutina* that wasn't correlated with any of their terrain-based environmental variables. They did not offer an explanation, but it may serve to illustrate the very broad ecological tolerance of the species at the low elevations of their study area.

Quercus rubra is presumed to be the most mesophytic of the Appalachian oaks, and its widespread occurrence in Rich Cove Forest and Acidic Cove Forest supports this idea. *Quercus alba* is also often present in Rich Cove Forests and other mesic sites but tends to be less abundant. Nevertheless, Blackman and Ware's (1982) direct measurements of soil moisture in Virginia found that *Quercus rubra* stands were not always the most mesic oak forests.

Rare species: No rare species are known to be specifically associated with this community.

CALCAREOUS OAK–WALNUT FOREST

Concept: Calcareous Oak–Walnut Forests are very rare low elevation dry-mesic mountain slope forests on dolomite or other calcareous rocks, dominated or codominated by *Quercus muehlenbergii* and/or *Juglans nigra*.

Distinguishing Features: Calcareous Oak–Walnut Forests are distinguished from all other community types by occurrence on dolomite, limestone, or marble; canopies containing abundant *Quercus muhlenbergii* or *Juglans nigra*; and a flora indicative of calcareous conditions. More mesophytic tree species are usually present. but do not predominate as they do in Rich Cove Forest. Montane Oak–Hickory Forest (Basic Subtype), High Elevation Red Oak Forest (Rich Subtype), and the Rich Variant of Low Montane Red Oak Forest and of Chestnut Oak Forest (Herb Subtype) may share many species of basic soils but generally lack *Quercus muhlenbergii* and usually lack *Juglans nigra*.

Crosswalks: *Quercus rubra - Quercus muehlenbergii / Hamamelis virginiana / Polymnia canadensis* Forest (CEGL007215).
G601 South-Central Interior Alkaline Forest & Woodland Group.
Southern Appalachian Oak Forest Ecological System (CES202.886).
Basic Mesic Forest (Montane Calcareous Subtype) (3rd Approximation).

Sites: Calcareous Oak–Walnut Forests occur on lower to mid slopes where the substrate is calcareous rock such as limestone, dolomite, or marble.

Soils: Soils are rocky, presumably high in pH and very high in calcium. Soils are mapped as a wide variety of widespread series of Ultisols and Inceptisols, but they may represent inclusions in these map units.

Hydrology: Sites are dry-mesic to mesic, sheltered by topography but fairly rocky.

Vegetation: Forests are dominated by either *Quercus rubra*, *Quercus muhlenbergii*, or *Juglans nigra*. Other frequent abundant species include *Carya cordiformis*, *Ulmus rubra*, and *Fraxinus americana*. Other trees present in smaller numbers may include *Juglans cinerea, Liriodendron tulipifera, Acer saccharum, Tilia americana* var. *heterophylla*, and other species shared with Rich Cove Forest. The understory consists mainly of the same species, sometimes along with *Benthamidia* (*Cornus*) *florida, Prunus serotina*, or *Swida* (*Cornus*) *alternifolia*. *Ulmus rubra* in particular may dominate the understory. Shrubs are not dense, but *Hamamelis virginiana* sometimes is abundant, and *Celtis* often is present. A few vines may be abundant, especially *Isotrema macrophyllum* and *Toxicodendron radicans*. The herb layer generally is dense, diverse, and includes a number of species recognized as calciphilic as well as more widespread dry-mesic and mesic species. Species that seem to be frequent include *Eurybia divaricata, Amphicarpaea bracteata, Dichanthelium boscii, Dichanthelium commutatum, Arisaema triphyllum, Cubelium concolor, Asplenium resiliens, Pellaea atropurpurea, Actaea racemosa, Maianthemum racemosum, Muhlenbergia tenuiflora, Brachyelytrum erectum*, and *Campanulastrum* (*Campanula*) *americanum*. Other species that may be present and suggest the calcareous conditions include *Adiantum pedatum, Botrypus virginianus, Chasmanthium latifolium, Hylodesmum glutinosum, Eutrochium purpureum*, and *Cystopteris bulbifera*.

Range and Abundance: Ranked G1Q. This community is extremely rare, with only a few sites in North Carolina. The precise range and abundance in North Carolina is complicated by uncertain classification of a couple of possible examples; however, the total number of sites is no more than five. Well-developed examples are known from the Grandfather Mountain Window in the Catawba River valley, with less certain examples from the Hot Springs Window in Madison County and near the Little Tennessee River in Swain County. The association is defined from North Carolina and is not recognized in any other state, though it is questionably attributed to South Carolina. The taxonomic question of the G-rank probably is not warranted, though there should be greater clarification or investigation of calcareous communities in nearby Tennessee that may be similar.

Associations and Patterns: This community sometimes grades into Montane Cliff (Calcareous Subtype) on rocky outcrops contained within the forest. It often grades to Rich Cove Forest on more mesic sites. It abruptly borders various acidic forest communities at the edge of the calcareous rock substrate.

Variation: Each of the few examples is rather different in composition, and most are also heterogeneous.

Dynamics: Because of topographic sheltering and presence of rock outcrops, fire is probably less important than in most Montane Oak Forests. In steep examples, rock falls or soil movement may be important natural disturbances.

Comments: This community is poorly known. No pertinent published literature appears to exist. It was formerly treated as a subtype of Basic Mesic Forest in the 3rd Approximation but has too much montane floristic affinity to retain that treatment. The community appears to be at the mesic end of the moisture range for Montane Oak Forests but ranges to drier conditions. The more mesic parts of some occurrences, with more *Juglans*, do resemble Rich Cove Forest but without fitting any defined subtype.

Although most of the sites for this community have been known for some time, and it was included under a different name in the 3rd Approximation, rarity and limited access have impeded study. A few plots have been sampled by CVS but knowledge remains limited.

Rare species:
Vascular plants – *Anticlea glauca, Arabis patens, Carex eburnea, Hexalectris spicata, Hydrastis canadensis, Oligoneuron (Solidago) rigidum, Stachys cordata,* and *Thaspium pinnatifidum.*

PIEDMONT AND COASTAL PLAIN OAK FORESTS THEME

Concept: Piedmont and Coastal Plain Oak Forests are common upland communities dominated by various species of *Quercus*, with or without *Carya*, and lacking most of the characteristic flora that distinguish Mountain Oak Forests. They are the predominant natural forests of the Piedmont, with the exception of the foothills area, and are limited in extent but widespread in dissected uplands in the Coastal Plain.

Distinguishing Features: Most Piedmont and Coastal Plain Oak Forests may be easily distinguished from Mountain Oak Forests by their geographic location. Only Mountain Oak Forests occur west of the Blue Ridge escarpment, while no Montane Oak Forests occur in most of the Piedmont. In the foothills east of the escarpment, and in a few large monadnock areas such as Hanging Rock and the Kings Mountain ridge, both Piedmont and Coastal Plain Oak Forests and Mountain Oak Forests may occur. They are distinguished by their flora. A large pool of species is typical of the Blue Ridge and these species act as indicators of Montane Oak Forests. They are scarce, or more often absent, in the Piedmont and Coastal Plain Oak Forests of North Carolina. *Castanea dentata*, still present as root sprouts in many occurrences, was once the most important distinguishing species, with very limited Piedmont occurrence. *Rhododendron maximum, Rhododendron catawbiense, Rhododendron calendulaceum, Pyrularia pubera, Pinus strobus*, *Magnolia fraseri, Tsuga caroliniana, Tsuga canadensis, Acer pensylvanicum*, *Pinus pungens*, and *Pinus rigida* are additional species often in Mountain Oak Forests but rarely present in Piedmont communities. *Quercus falcata, Quercus stellata*, and *Pinus echinata* are typical Piedmont species that are usually absent in Mountain Oak Forests but may be present in particular communities.

Piedmont and Coastal Plain Oak Forests are distinguished from Piedmont and Coastal Plain Mesic Forests by the absence of *Fagus grandifolia* in the canopy and by an abundance of oaks more drought tolerant than *Quercus rubra*. *Quercus rubra* may be codominant or locally dominant in either theme, so the communities will need to be distinguished on the basis of associated trees. In recent years, *Fagus grandifolia* has often moved into oak forests but generally remains confined to the understory at present.

A well-developed forest canopy, when not recently disturbed, distinguishes Piedmont and Coastal Plain Oak Forests from Low Elevation Cliffs and Rock Outcrops and other nonforested themes. Piedmont and Mountain Glades and Barrens also generally have very open canopies. However, the Xeric Hardpan Forest communities in this theme, under current conditions, may have substantial canopy and be distinguishable only by the dominance of *Quercus stellata* in the near absence of *Quercus alba*.

Sites: In the Piedmont, oak forests occur on most upland sites, from warm lower slopes to upland ridge tops. In the Coastal Plain, oak forests are restricted to areas with natural sheltering from too-frequent fire. These include bluffs and dissected lands, and occasional isolated ridges surrounded by nonflammable wetlands. Oak Forests are more extensive and occupy more sites in the northernmost Coastal Plain than farther south.

Soils: Oak Forests may occur on almost any upland soil in the Piedmont, and on a wide variety of Coastal Plain upland soils that are not excessively sandy. Most are Hapludults or Kanhapludults.

Hydrology: Piedmont and Coastal Plain Oak Forests occur in all but moist or the most extremely dry upland conditions. Most sites are well drained, but a few may have somewhat restricted drainage owing to shrink-swell clays formed on mafic bedrock.

Vegetation: Piedmont and Coastal Plain Oak Forests are almost always dominated, at least weakly, by some combination of *Quercus alba, Quercus rubra, Quercus velutina, Quercus falcata, Quercus stellata*, and *Quercus montana*. Various species of *Carya* are usually present and sometimes codominant. *Pinus echinata* often is a smaller component, probably more often under more natural conditions, and *Pinus taeda* or *Pinus virginiana* may sometimes be present. These pines, plus *Liriodendron tulipifera*, *Liquidambar styraciflua*, and *Acer rubrum,* often are increased in abundance in the canopy by logging. *Fraxinus americana* may be abundant in some examples with less acidic soil, though it is quickly vanishing under the assault by emerald ash borer (*Agrilus planipennis*). The understory typically includes some combination of *Benthamidia* (*Cornus*) *florida, Nyssa sylvatica, Oxydendrum arboreum*, and *Acer rubrum*, though a number of additional species may be present in the Coastal Plain, in more mesic sites, and in areas with less acidic soil. Shrub layers tend to be open, with species of *Vaccinium* the most typical dominants. Herb layers usually are sparse under present conditions and are limited in diversity. Under past conditions of regular fire, they are believed to have been denser, more diverse, and more dominated by grasses.

Dynamics: Under natural conditions, Piedmont and Coastal Plain Oak Forests are uneven-aged, with numerous old trees present but with trees of a broad range of ages intermixed at a fine scale. No unlogged forests remain in these regions, as they do in the Mountain region. Remnant wood lots that were never clearcut, inaccessible slopes, and the oldest second-growth forests, suggest similar stand dynamics. The newer understandings of the role of fire in these communities, discussed below, do not change this impression (Spooner, et al. 2021). The dominant oaks are among the most long-lived tree species in North Carolina, with several having maximum life spans of 400-600 years, while associated hickories can live 300 years (literature summarized in Loehle 1987). Successful regeneration of canopy trees naturally occurred primarily in small canopy gaps caused by the death of one or a few trees. Trees produce irregular seed crops, with mast years resulting in large numbers of seedlings that survive for several years beneath the canopy. The oaks that establish in canopy gaps generally are from this pool of advanced regeneration.

Ongoing processes such as lightning and severe thunderstorms create individual gaps. Occasional extensive disturbances such as hurricanes create many gaps throughout a stand at one time, but most of the individual gaps are small openings the size of one or a few trees. At a stand scale, old-growth is expected over the vast majority of the landscape, while at a fine scale there is dynamic equilibrium of gaps in different stages of succession. Skeen, Carter, and Ragsdale (1980) argued that even the shade-intolerant *Liriodendron* could reproduce enough in the larger gaps in old-growth forest to persist in the climax Piedmont forests; the same would appear to be true of the pines.

Following severe canopy disturbance such as clearcutting, and even more where land was cleared and farmed, examples tend to regenerate as even-aged successional forests dominated by more ruderal, shade-intolerant species such as *Pinus* spp., *Liriodendron tulipifera*, or *Liquidambar styraciflua*. Various oaks often are present, but in much smaller numbers. In the past, *Pinus* *echinata* was often the dominant successional tree, but in more recent decades, *Pinus taeda* and soft hardwoods have become the predominant successional trees.

There is increased interest in the dynamics of oak forests in general in recent years, and numerous studies have been published in the 2000s and 2010s. Much new information has been added on the role of fire as an important ecological driver in these communities. It is increasingly being recognized that fire likely is a crucial process, and that the near-universal removal of fire is altering forests. Fire in the past presumably led to lower understory density, longer persistence times for canopy gaps, and denser herb layers than we see at present. Longer persistence of gaps would create a more open canopy across stands, allowing shade-intolerant species to be more abundant and more diverse. *Pinus echinata*, the longest-lived and most fire-tolerant of the pines that occur in these communities, was more abundant. The natural, or presettlement, fire regime for these communities is not fully known. Few old trees and fire-scarred logs remain to support fire history studies comparable to those done in the Appalachians. Fire was more frequent than in the Mountain region, but less frequent than prevailed in flatter Coastal Plain uplands. This is in keeping with the intermediate-size fire compartments and lightning rates in the Piedmont, and with the occurrence of Coastal Plain examples in areas with some shelter from fire (Spooner, et al. 2021). Likely these forests burned around every 10 years, an interval that, persisting over a long time, would favor oaks over competing species but would be long enough to allow oak regeneration. However, some authors (e.g. Frost 1998) believed it might be as frequent as 4-6 years.

It is also difficult to tell how much the presettlement fire regime was human-caused versus natural (Spooner, et al. 2021). Earlier historical explorers reported that Native Americans ignited forests regularly. Such travelers tended to follow Indian paths and stay in Indian villages, giving them a severely biased view of how much human influence there was on the land, but it is clear that human-caused fires were common at least in those areas. Less clear is how much their ignition changed the frequency, intensity, and seasonality of fire and how much it preempted fires that would have occurred soon anyway. Though data are sparse, Lafon et al. (2017) did not find evidence that fire frequencies were greater in areas with dense prehistoric human populations than in sparsely populated areas in the Blue Ridge and farther west, nor did frequencies greatly decline in the period after Native American populations were decimated by European diseases but before settlers arrived. The same may have been true in the Piedmont. In any case, increasing the amount of fire by prescribed burning and by allowing naturally ignited fires to burn where possible can be expected to be beneficial to oak forests. It may be noted that burning tends to favor more drought-tolerant species, and that burning is likely to make forests better adapted to future climatic warming and drying.

Most natural and human-caused fires were, and are, low to moderate in intensity. Because the dominant canopy trees are tolerant of such fires, fire likely was not a major cause of canopy gaps. Instead, as suggested by McEwan et al. (2013) for an old-growth oak forest in Kentucky, and generalized by Lafon et al. (2017), fire's primary role was as a filter of the pool of young trees that is present when canopy gaps are formed by wind, lightning, or other natural disturbance. Fire determined what species could regenerate, while the time and location of regeneration of individuals was determined by formation of canopy gaps by wind, lighting, ice, and occasional hotter fires. The dominant oak species tolerate fire better than the associated hardwoods as seedlings and saplings as well as mature trees. Allocation of resources to roots makes them better able to sprout repeatedly if burned, giving them an advantage over most trees.

Frequent burning in the past led to much lower understory density and longer persistence times for canopy gaps, resulting in more open canopies, and denser herb layers than can thrive in the present shady conditions. Forests therefore could support more abundant and diverse shade-intolerant species. These characteristics would make for easier fire spread in these forests. This feedback may have been an important aspect of fire behavior in the past, and this possibility makes it harder to determine natural fire regimes based on the present. The effects of decades of removal of fire are not quickly reversed, because the most important effects are the result of a chronic fire regime. The expected higher diversity consists mostly of conservative species adapted to that regime, species that are slow to colonize and that now have reduced populations and limited seed rain. A single burn often has little effect. More severe prescribed fires and wild fires, or fires accompanied by canopy removal, generally result in the appearance of a few ruderal species in large numbers. These are sometimes mistakenly interpreted as successful restoration of fire-tolerant lower strata, if herbaceous species are not distinguished or if their ecology is not considered.

There has been growing concern in recent decades that oaks are failing to regenerate, both in North Carolina and throughout the eastern deciduous forest region (Loftis and McGee 1993; Rodewald 2003; Knott et al. 2019). While this phenomenon is widespread in the region, details in these sources show substantial variation, including local areas where it does not appear to be occurring. Because the detection of this pattern is at a broad scale, much of the area affected is influenced by ongoing timber management and variation in logging practices as well as other factors. However, it can readily be observed in many Piedmont and Coastal Plain Oak Forests that oaks are scarce or absent in the understory and that other species such as beech and red maple are gradually replacing them in the canopy. Oak seedlings are abundant after mast years, but saplings and understory individuals are scarce. Various shade-tolerant understory tree species have increased in cover. Once a dense understory is established, the forest floor is too shady for oak seedlings to grow to saplings, and the established shade-tolerant trees capture most of the canopy gaps.

The term mesophication has been applied to this process (Nowacki and Abrams 2008), because the tree species that are increasing in most of the eastern United States are regarded as more mesophytic than the oaks. This process is generally blamed on lack of fire. The species that have increased, especially *Acer rubrum* and *Fagus* and, in other regions, *Acer saccharum*, like most other mesophytic species, are not well adapted to fire. *Acer rubrum* stems can be observed to be killed by fires that do not kill oaks of similar size, across a wide range of sizes. Though these species sprout vigorously, so that a single fire would cause little long term change, chronic repeated fire would reduce them drastically. Establishment of mesophytic species is believed to also change the environment within the forest, with humidity increased beneath a dense understory and a thicker duff layer developing. The thin leaves of mesophytic trees pack down on the ground surface more than oak leaves do and hold moisture more effectively. This reduces the flammability of the forest litter, making the forests less able to burn. The higher humidity and thicker duff themselves may also favor mesophytic species; however, given the increased root competition with denser vegetation and the lower water use efficiency of most mesophytic species, moisture may not actually be more available to seedlings.

Though mesophication is believed to result from lack of fire, there are views that subtle climate changes could be contributing. McEwan et al. (2013) and Nowacki and Abrams (2015) cite statistics indicating that the overall region of eastern oak forests was wetter after 1970 than in the earlier 1900s, coinciding with the period of rapid maple increase, and that there were more droughts in the several centuries before 1900. It is very difficult to sort the effects of fire suppression and rainfall shifts from other phenomena, including changes in land use practices and increasing deer populations. Israel (2011), Peet, et al. (2014), and Taverna, et al. (2005) found a widespread decrease in cover in all lower strata, among shade-tolerant and intolerant species, across a wide range of site conditions and successional ages. These studies were in Duke Forest, near Durham, an area with very high deer populations.

Not generally noted in mesophication literature is that the species that are increasing are not universally mesophytic in the sense of being adapted for moister conditions. The understory species with the greatest increase in our area, *Acer rubrum*, actually has a very broad moisture tolerance, and does well in dry sites. More mesophytic species, such as *Fagus grandifolia*, can be seen in the understory of oak forests, but in smaller numbers and over less of the landscape. Other shade-tolerant understory species that have increased are not particularly associated with mesic sites, including *Nyssa sylvatica* and *Oxydendrum arboreum*. These species can reach the canopy, and even in the understory they contribute to shading and thus could help exclude oak saplings. At the same time, one of the most abundant shade-tolerant understory species, *Benthamidia* (*Cornus*) *florida*, has drastically declined due to disease since the 1980s, producing an abrupt reduction in understory shading.

Also generally not noted is that *Acer rubrum*, though shade-tolerant, has ruderal characteristics such as prolific seeding, widespread seed dispersal, and rapid seedling growth in high light, and that these rather than being mesophytic may be the key to its increase. Other species with these characteristics, *Pinus taeda, Liriodendron tulipifera*, and *Liquidambar styraciflua*, have also drastically increased in Piedmont and Coastal Plain forests, and appear to be the species preventing successful oak regeneration after severe disturbances such as logging in many places. The increase in severe disturbance and drastic canopy opening since European settlement, and the proliferation of permanent artificial forest edges with ongoing settlement and fragmentation, have favored all of these species at the expense of oaks in the landscape. The dramatic increase in seed rain of these species, including *Acer rubrum,* could be the primary driver of current oak forest dynamics. Nevertheless, these species would not have become abundant in a landscape with regular fire.

Much attention has been devoted in recent years to shortleaf pine forests. Because *Pinus echinata* was, until recent decades, the primary successional species in abandoned fields and other cleared lands in substantial parts of the Piedmont, much of this loss is due to the loss of these successional stands to harvest, aging, and conversion to other land uses. The displacement of *Pinus echinata* by *Pinus taeda* as the primary successional tree species of abandoned fields, which occurred 1900-1920 in Duke Forest (R.K. Peet, personal communication 2023) and presumably occurred at similar times across the Piedmont, has further contributed to this decline, but such successional stands are additionally much less extensive than after the mass abandonment of farmland in the 1860s and 1930s.

The question of the role of *Pinus echinata* in the prevailing natural communities of the Piedmont is more controversial. It is difficult to determine because the species likely first increased due to logging and other human disturbances, then decreased due to fire suppression and competition with other pines and hardwoods. There has been much belief in, but less careful argument for, the existence of widespread shortleaf pine savannas in the Piedmont analogous to the longleaf pine savannas of the Coastal Plain. The Shortleaf Pine Initiative aims to increase shortleaf pine across many regions, including the Piedmont. There has been a zone recognized in the eastern Piedmont where shortleaf pine is the prevailing pine, but this recognition too was based at least substantially on successional stands. It leaves unanswered the question of how much of the uncultivated landscape was dominated by pine in comparison with oak forests. Pinchot and Ashe (1897) are often cited as a source for widespread abundance of the species. It is worth noting that, at that time, when abandoned farm land and successional forests were widespread on the landscape and fire remained frequent, they stated: "at the present time [ca. 1895], on account of the general distribution of groves of seed-bearing short-leaf pine, this species quickly forms a stand in abandoned fields, ... yet in many [other] portions ..., the short-leaf pine does not rapidly take old fields, from five to ten years or even more being required for a thick stand to be naturally secured." The term "groves" is not generally used for the dominant landscape cover nor for extensive patches. If these groves were sufficient to rapidly seed in abandoned fields in some places, the fact that this did not occur in other places suggests that shortleaf pine seed sources must have been much sparser there. The fact that no other successional species filled old fields before 5-10 years indicates how much less seed rain there was at that time for all early successional tree species. By the 1930s, pines, sometimes *Pinus echinata*, sometimes *Pinus taeda*, filled abandoned fields much more rapidly (Crafton and Wells 1934, Billings 1938, Keever 1950).

In contrast to its occurrence as a dominant of successional forests, the natural behavior of *Pinus echinata* in Piedmont and Coastal Plain Oak Forests appears to be as a frequent minority species, occurring as scattered individuals and small groves. This pattern can be observed in some examples of mature oak forests, suggesting establishment of a clump when a medium size canopy gap coincided with favorable conditions for their seedlings. Such groves likely were more abundant, and scattered individuals likely more frequent between them. How much more abundant they were before European settlement is difficult to judge, because they can be expected to have increased when European settlers began cutting trees in large numbers.

Like the upland oaks, *Pinus echinata* is well suited to fire at moderate frequencies. Its fire ecology is very similar to that of the oaks it co-occurs with. Mature trees survive fire well and, unlike most pines, seedlings retain buds near ground level that allow them to sprout if top-killed by fire. The structure of regularly burned forests, with little understory and higher levels of light on the ground, would allow this species to regularly reproduce in canopy gaps. It is not clear under what circumstances it would be able to supplant oaks as the dominant tree over large areas, and unclear that this happened in North Carolina in typical upland sites.

Comments: The name "oak-hickory forest" is used for most of the communities in this theme, primarily because it is the name in widespread use for these communities. Ware (1992) raised the question of why this name is used when oaks clearly dominate and other genera may be more abundant than hickories. It should be noted that the name applies to a wide range of forests over a broad region, with hickories more abundant in some than others. It may also be noted that maples and mesophytic genera were not as abundant in the past when the name originated. The genus *Carya* is prominent in species lists. Five species are common in the species pool for Piedmont oak–hickory forests, more than any genus other than oak, most large stands have at least two species.

KEY TO PIEDMONT AND COASTAL PLAIN OAK FORESTS

1. Forest dominated by *Quercus montana* (but largely or completely lacking montane species such as *Castanea dentata* and *Rhododendron calendulaceum* that would fit better with Chestnut Oak Forest or Montane Oak–Hickory Forest); forest on an isolated erosional remnant hill or hill group (monadnock), in other very rocky sites, or in the Uwharrie Mountains.
  2. Forest dominated by *Quercus montana* without a significant minority of *Pinus echinata* and without more than scattered *Kalmia latifolia*... **Piedmont Monadnock Forest (Typic Subtype)**
  2. Forest with at least significant minority of *Pinus echinata* or with a shrub layer dominated by *Kalmia latifolia.*
    3. Forest with shrub layer dominated by *Kalmia latifolia*; generally on upper north-facing sides on monadnocks; (mesophytic trees absent or nearly so) ....**Piedmont Monadnock Forest (Heath Subtype)**
    3. Forest with little or no *Kalmia latifolia*; *Pinus echinata* 10% or more of the canopy............ ....**Piedmont Monadnock Forest (Pine Subtype)**
1. Forest not dominated by *Quercus montana*; if the species is present, *Quercus alba* exceeds it in abundance.
  4. Forest consisting of varying combinations of *Quercus hemisphaerica, Pinus taeda, Quercus nigra,* and *Quercus virginiana*; *Quercus alba* generally absent; often containing *Cartrema americana*; community in the Coastal Plain, on small upland areas surrounded by wetlands....... ....**Swamp Island Evergreen Forest**
  4. Forest not containing appreciable, if any, *Quercus hemisphaerica, Quercus virginiana*, or *Cartrema americana*; generally containing abundant *Quercus alba*; if in the Coastal Plain, generally on upland slopes or dissected bluffs, not on small uplands surrounded by wetlands.
    5. Forest dominated by *Quercus alba*, alone or in combination with other species.
      6. Forest containing a substantial amount of both *Quercus phellos* and *Quercus stellata*; evidence of ponded water in low microsites generally present; some wetland herbs or shrubs generally present locally. ....**Mixed Moisture Hardpan Forest**
      6. Forest not containing more than incidental *Quercus phellos*; ponded microsites and wetland herbs or shrubs absent or only incidentally present.
        7. Forest basic, containing multiple species associated with soils with higher base saturation and pH, such as *Fraxinus americana, Fraxinus biltmoreana, Carya cordiformis, Carya ovata, Lindera benzoin, Frangula caroliniana, Symphoricarpos orbiculatus, Rhus aromatica*, *Elymus hystrix, Elymus virginicus*, and *Chasmanthium latifolium*; generally also containing greater abundance of species such as *Cercis canadensis*, *Acer floridanum, Acer leucoderme, Ostrya virginiana*, *Ulmus alata*, and *Carya carolinae-septentrionalis*; *Vaccinium* generally less abundant than *Viburnum* or other shrubs, though it may be present.
          8. Forest dry-mesic in composition, with *Quercus rubra*, or rarely, *Quercus michauxii* or other mesophytic oaks, generally codominant or at least more abundant than the combination of *Quercus stellata, Quercus falcata*, and *Quercus marilandica*.
            9. Forest in the Piedmont, on a substrate of crystalline rock, generally diabase, gabbro, amphibolite, or rarely calcareous sedimentary rock; species indicative of the Coastal Plain, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria* absent or rare; *Quercus rubra* almost always abundant.. .... **Dry-Mesic Basic Oak–Hickory Forest (Piedmont Subtype)**

9. Forest in the Coastal Plain, on a substrate of unconsolidated sediment; containing species indicative of the Coastal Plain, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, or *Symplocos tinctoria*; *Quercus rubra* rarely present, *Quercus michauxii* much more likely; very rare community. ……………………………………………… ……………………**Dry-Mesic Basic Oak–Hickory Forest (Coastal Plain Subtype)**

8. Forest dry in composition, with *Quercus stellata* or *Quercus falcata* abundant in the canopy or at least predominating over *Quercus rubra* ..**Dry Basic Oak–Hickory Forest**

7. Forest not basic, containing few, if any, *Fraxinus americana, Fraxinus biltmoreana, Carya cordiformis, Lindera benzoin, Frangula caroliniana, Symphoricarpos orbiculatus, Rhus aromatica*, *Elymus hystrix, Elymus virginicus*, *Chasmanthium latifolium*, or other indicators of high base status soils; *Vaccinium* spp. generally the predominant shrubs.

10. Forest dry-mesic in composition, with *Quercus rubra*, or rarely, *Quercus michauxii* or other mesophytic oaks, generally codominant or at least more abundant than the combination of *Quercus stellata, Quercus falcata*, and *Quercus marilandica*.

11. Forest in the Coastal Plain, on a substrate of unconsolidated or semi-consolidated sedimentary rock; if geographic location ambiguous, community containing species widespread in the Coastal Plain and not in the Piedmont, such as *Persea palustris, Quercus nigra, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria*. ....**Dry-Mesic Oak–Hickory Forest (Coastal Plain Subtype)**

11. Forest in the Piedmont, on a substrate of crystalline rock or of sedimentary rock older than Cretaceous age; if geographic location ambiguous, community lacking species widespread in the Coastal Plain and scarce in the Piedmont. .... **Dry-Mesic Oak–Hickory Forest (Piedmont Subtype)**

10. Forest dry in composition, with *Quercus falcata* or *Quercus stellata* abundant in the canopy or at least predominating over *Quercus rubra* and *Quercus michauxii*.

12. Forest in the Coastal Plain, on a substrate of unconsolidated or semi-consolidated sedimentary rock; if geographic location ambiguous, community containing species widespread in the Coastal Plain and not in the Piedmont, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria*. .... **Dry Oak–Hickory Forest (Coastal Plain Subtype)**

12. Forest in the Piedmont, on a substrate of crystalline rock or sedimentary rock older than Cretaceous age; if geographic location ambiguous, community lacking species widespread in the Coastal Plain and scarce in the Piedmont. ....**Dry Oak–Hickory Forest (Piedmont Subtype)**

DRY-MESIC OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry-Mesic Oak–Hickory Forests are common Piedmont and Coastal Plain upland hardwood forests of acidic soils, occurring in environments intermediate between the mesic sites of sheltered slopes and the driest sites on ridge tops and upper slopes. They cover the moisture range between that where *Fagus* becomes a significant canopy component and that where *Quercus falcata, Quercus stellata, Quercus marilandica*, or *Quercus montana* become significant components. The Piedmont Subtype covers the extensive examples of the Piedmont region, which lack characteristic Coastal Plain species and lack montane species.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition, and the overall flora. *Quercus stellata, Quercus falcata, Quercus marilandica*, and *Quercus montana* are scarce or absent in Dry-Mesic Oak–Hickory Forest, whereas *Quercus rubra* is largely absent from Dry Oak–Hickory Forest. Dry-Mesic Oak–Hickory Forest is distinguished from Mesic Mixed Hardwood Forest by the absence of more mesic species in the canopy, particularly *Fagus grandifolia* (though such species may be abundantly established in the understory in the absence of fire). It is distinguished from Montane Oak–Hickory Forest by the absence or scarcity of characteristically montane flora, such as *Castanea dentata, Magnolia fraseri, Acer pensylvanicum, Rhododendron calendulaceum*, *Gaylussacia frondosa*, *Gaylussacia baccata*, and *Rhododendron maximum*. Additionally, some species, such as *Kalmia latifolia* and *Hamamelis virginiana*, are widespread in Montane Oak–Hickory Forests but are restricted to more mesic communities in the Piedmont and Coastal Plain.

Dry-Mesic Oak–Hickory Forests are distinguished from Dry-Mesic Basic Oak–Hickory Forests and other basic oak forests by the absence or scarcity of a suite of species indicating high base status, such as *Fraxinus americana, Fraxinus biltmoreana, Cercis canadensis, Brachyelytrum erectum*, *Dichanthelium boscii*, *Symphoricarpos orbiculatus, Frangula caroliniana*, and *Celtis* spp. This distinction may become more difficult in the future, because *Fraxinus* spp., the most frequent indictor species, is rapidly dying out due to introduced insects. Basic indicators also include a set of species that are characteristic of more mesic or floodplain communities but that occur in dry sites with basic soils. These include *Acer floridanum, Carya ovata, Elymus hystrix, Elymus virginicus, Phryma leptostachya*, and *Phegopteris hexagonoptera*. Characteristic species of acidic soils, such as *Oxydendrum arboreum, Vaccinium stamineum, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia frondosa*, and *Chimaphila maculata* may be present in basic communities, but predominate in Dry-Mesic Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences. *Quercus rubra* is largely restricted to the Piedmont Subtype. *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta* are largely restricted to the Coastal Plain Subtype. The Coastal Plain Subtype also tends to have some plants more typical of wetter habitats, such as *Ilex glabra, Osmundastrum cinnamomeum*, and *Lorinseria (Woodwardia) areolata*, presumably associated with very small seepage patches.

Crosswalks: *Quercus alba - Quercus rubra - Carya tomentosa / Vaccinium stamineum / Desmodium nudiflorum* Piedmont Forest (CEGL008475).

G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).
Mesic Mesotrophic and Dry-Mesic Mesotrophic Forest (Peet and Christensen 1980).
White Oak-Red Oak-Black Oak (Oosting 1942).

Sites: Dry-Mesic Oak–Hickory Forests in the Piedmont occupy most mid slopes and low ridges, and sometimes occur on lower or upper slopes, upland flats, or other places where moisture conditions are between dry and mesic. They occur on most substrates, including felsic igneous and metamorphic rocks, most metasedimentary rocks, and most Triassic sediments.

Soils: The Piedmont Subtype occurs on a wide variety of acidic upland soils, most commonly Typic Hapludults and Typic Kanhapludults. The most common map units are Cecil, Pacolet, Georgeville, Tatum, Appling, Madison, and Badin, but 30 or more additional series are associated with occurrences. A few examples are mapped as Alfisols such as Enon and Wilkes, but perhaps represent inclusions or places where the series is not well developed.

Hydrology: Dry-Mesic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests.

Vegetation: The Piedmont Subtype has a well-developed forest canopy with *Quercus alba* generally the most abundant species. *Quercus rubra* is common. Other species frequently present include *Quercus velutina, Carya tomentosa, Carya glabra*, *Carya ovalis*, *Pinus echinata*, *Acer rubrum*, and in the eastern Piedmont, *Pinus taeda*. Examples that have had substantial logging often have more pines and *Acer rubrum*, and *Liquidambar styraciflua* and *Liriodendron tulipifera* may also become abundant in the canopy. The understory most typically consists of *Acer rubrum*, *Oxydendrum arboreum*, *Benthamidia* (*Cornus*) *florida*, and *Nyssa sylvatica*, but may include abundant *Ilex opaca*, *Prunus serotina*, *Liquidambar styraciflua*, and small numbers of other species, as well as canopy species. *Fagus grandifolia* may be present in the understory but not in the canopy. The most characteristic shrubs are *Vaccinium stamineum, Vaccinium pallidum*, and *Euonymus americanus*. *Viburnum rafinesqueanum* or *Vaccinium tenellum* may be abundant in parts of the Piedmont. Trailing *Muscadinia rotundifolia* sometimes may cover significant patches of ground. The herb layer tends to be sparse under present conditions. Common and frequent species include *Chimaphila maculata*, *Goodyera pubescens*, *Hexastylis arifolia*, *Tipularia discolor*, *Hylodesmum nudiflorum*, *Danthonia spicata*, *Dichanthelium* spp., *Carex* spp., and *Uvularia puberula*. Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*.

These forests generally have a closed or nearly closed canopy where not broken by gaps, a moderate-density understory, and a patchy sparse to moderate shrub layer. Canopy gaps are generally present in any sizeable stand and are an important part of the structure. Under past conditions of moderate fire frequency, canopies would have been more open, though still more forest than savanna, and would have had less *Acer rubrum* and more *Pinus echinata*. The forests would have had sparser understory and more cover and diversity of herbs, especially of grasses.

Range and Abundance: Ranked G4G5 but probably should be G5. Dry-Mesic Oak–Hickory Forest occurs throughout the Piedmont, except in the foothill ranges and possibly near the Blue Ridge escarpment. It is one of the most common communities throughout this range. The equivalent association ranges from Georgia to Maryland. Though it is confined to the Piedmont in North Carolina and presumably southward, in northern Virginia the same community composition extends across the Coastal Plain. *Quercus coccinea* is a more important component in Virginia.

Associations and Patterns: Dry-Mesic Oak–Hickory Forest (Piedmont Subtype) is a matrix community, making up much of the typical landscape mosaic in most of the Piedmont. In the topographic moisture gradient, Dry-Mesic Oak–Hickory Forest occurs between Dry Oak–Hickory Forest and Mesic Mixed Hardwoods, often with a very gradual transition. It may also adjoin patches of Piedmont/Coastal Plain Acidic Cliff, Piedmont/Coastal Plain Heath Bluff, Piedmont Monadnock Forest, other upland communities, or floodplain communities. It may be associated with Dry-Mesic Basic Oak–Hickory Forest or other basic communities, sometimes with a sharp boundary at a geologic contact.

Variation: No variants are recognized. Examples vary as expected, with the transition to other communities. Examples transitional to Dry-Mesic Basic Oak–Hickory Forest may have few Ericaceae but lack any definitive species of basic soils.

Dynamics: Dynamics are similar to those of the Piedmont members of this theme in general.

There have been several studies in Duke Forest where Dry-Mesic Oak–Hickory Forest itself has been a major focus. Taverna et al (2005) and Israel (2011) looked at changes in long-term permanent plots. They found ongoing changes, some of which have accelerated in recent years, even in forests that were considered to be in the climax stage. Xi, et al. (2019) examined the complexity of natural disturbance by a severe storm. McDonald, et al. (2003) looked at spatial patterns that suggest that oak regeneration is indeed less abundant near maple understory, but at scales that go beyond simple light competition. Besides the ongoing questions of altered fire regimes and storm damage, very high populations of deer appear to be an important driver of recent changes, which span all successional stages and a wide range of communities, and which involve both shade-intolerant and shade-tolerant species (Israel 2011).

More subtle changes have also occurred. A preliminary analysis of CVS plot data for oak-hickory forests, done by UNC-Chapel Hill ecology students, identified a distinct cluster of plots similar to other Dry-Mesic Oak–Hickory Forests but confined to Duke Forest. This cluster consisted solely of the older plots from Duke Forest, while more recent plots from Duke Forest were similar to other Piedmont plots. The most striking difference in the older Duke Forest plots was abundant *Benthamidia florida* in the understory. *Benthamidia* was often the most abundant understory tree species in Dry-Mesic Oak–Hickory Forest and Mesic Mixed Hardwood Forests within the author's memory, into the 1980s. The introduced dogwood anthracnose fungus (*Discula destructiva*) has reduced it to a minor component and one that is concentrated in a drier part of the moisture gradient than where it once had its peak abundance.

Comments: Befitting its abundance in the landscape near major universities, and especially in university research forests, Dry-Mesic Oak–Hickory Forest has been the subject of many published studies, including several versions of vegetation classification. Most influential for this document has been Peet and Christensen (1980), but numerous others have contributed to the general understanding of this community, including Oosting (1942), Glazier (1967), Nehmeth (1968), Ohmann (1980), and Wells (1974).

Rare Species:
Vascular plants – *Eupatorium saltuense, Eurybia mirabilis, Gillenia stipulata, Helianthemum propinquum, Ilex longipes, Magnolia macrophylla, Orbexilum pedunculatum var. pedunculatum, Pseudognaphalium helleri, Pseudognaphalium micradenium, Pyrola americana, Quercus prinoides, Scrophularia lanceolata,* and *Smilax hugeri*.

DRY-MESIC OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry-Mesic Oak–Hickory Forests are common Piedmont and Coastal Plain upland hardwood forests of acidic soils, occurring in environments intermediate between the mesic sites of sheltered slopes and the driest sites on ridge tops and upper slopes. They cover the moisture range between that where *Fagus* becomes a significant canopy component and that where *Quercus falcata, Quercus stellata, Quercus marilandica*, or *Quercus montana* become significant components. The Coastal Plain Subtype occurs in the Coastal Plain region and contains some species generally not present in the Piedmont.

Distinguishing Features: Dry-Mesic Oak–Hickory Forests are distinguished by natural dominance of a mix of oaks, with or without hickories, in which *Quercus alba* is prominent and more drought tolerant oaks (*Quercus montana, Quercus marilandica, Quercus stellata,* and *Quercus falcata*) are scarce or are outweighed by trees more mesophytic than *Quercus alba*. They are distinguished from Mesic Mixed Hardwood Forest by the absence of more mesophytic species in the canopy, particularly *Fagus grandifolia* and *Quercus michauxii* (though such species may establish in the understory in the absence of fire). The flora in all strata is limited to species tolerant of acidic soils, with species such as *Oxydendrum arboreum*, *Nyssa sylvatica*, *Benthamidia* (*Cornus*) *florida*, and *Vaccinium* spp. common, and species such as *Cercis canadensis*, *Fraxinus americana*, *Ostrya virginiana*, and most mesophytic herbs absent or scarce.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by floristic differences, most prominent in the lower strata. No species of very high constancy distinguish the subtypes, but a suite of species that are present in one but lacking in the other is generally represented. Species of the Coastal Plain Subtype include *Symplocos tinctoria*, and various wetland species such as *Persea palustris*, *Magnolia virginiana*, *Clethra alnifolia*, *Ilex glabra*, *Vaccinium elliottii, Arundinaria tecta*, *Lorinseria areolata*, *Osmundastrum cinnamomeum*, and *Chasmanthium laxum*. Other species sometimes present in the Coastal Plain Subtype but seldom in the Piedmont Subtype include *Gaylussacia frondosa, Morella cerifera* and *Callicarpa americana*. Species frequently found in the Piedmont Subtype but rarely or never in the Coastal Plain Subtype include *Quercus rubra*, *Quercus coccinea*, *Vaccinium pallidum*, *Viburnum rafinesqueanum*, *Viburnum prunifolium*, *Corylus cornuta*, *Carya carolinae-septentrionalis*, and *Chionanthus virginicus.* Herbs are scarce in both subtypes at present. *Chasmanthium laxum* and *Mitchella repens* are among the most frequent herb layer species in the Coastal Plain Subtype but scarce in the Piedmont, while *Hieracium venosum* is frequent in the Piedmont Subtype but largely absent in the Coastal Plain. The Coastal Plain Subtype often has a greater mixture of plants of different moisture tolerance than the Piedmont Subtype.

Crosswalks: *Quercus alba - Carya tomentosa / Oxydendrum arboreum / Gaylussacia frondosa -* Coastal Plain Forest (CEGL004321).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest Ecological System: (CES203.241).

Sites: Dry-Mesic Oak–Hickory Forests in the Coastal Plain occupy upper to lower slopes and other dry-mesic areas that are naturally sheltered from fire. Most examples occur on bluffs or dissected areas, but a few may occur on high river terraces where they are surrounded by wetter communities. Soil texture and drainage as well as topography contribute to where this community occurs.

Soils: Soils apparently are extremely variable or perhaps poorly characterized. In 39 occurrences with soil mapping recorded, 23 series are represented, primarily Ultisols but including Entisols and Inceptisols. The most frequently mapped series are Winton (Aquic Hapludult), Roanoke (Typic Enodaquult), and Baymeade (Arenic Hapludult). Because most occurrences are in dissected topography, their soils may represent small inclusions in other map units.

Hydrology: Dry-Mesic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype has a typical forest canopy dominated by *Quercus alba*, in combination with a variety of species that include *Pinus taeda*, *Carya tomentosa*, *Carya pallida*, and *Quercus velutina*. Species shared with wetter or drier communities are present at lower frequency or abundance, including *Quercus falcata*, *Quercus michauxii*, and *Pinus echinata*. The understory frequently includes abundant *Ilex opaca, Benthamidia* (*Cornus*) *florida*, *Oxydendrum arboreum*, *Acer rubrum*, *Nyssa sylvatica*, *Carpinus caroliniana*, and *Liquidambar styraciflua*. Less frequent but sometimes abundant species include *Magnolia virginiana*, *Stewartia malacodendron*, *Ostrya virginiana*, and *Magnolia tripetala*. Shrubs and ground level vines may be sparse to moderate in cover. *Muscadinia rotundifolia, Symplocos tinctoria*, and *Vaccinium fuscatum* are frequent and abundant, and *Euonymus americanus*, *Vaccinium arboreum, Sassafras albidum*, *Callicarpa americana*, *Smilax rotundifolia*, *Smilax bona-nox*, and *Bignonia capreolata* are also frequent. Less frequent but sometimes abundant species include *Asimina parviflora*, *Clethra alnifolia*, *Styrax grandifolius*, *Vaccinium stamineum*, *Vaccinium tenellum*, *Gaylussacia frondosa*, *Castanea pumila*, *Morella cerifera*, *Ilex glabra*, *Eubotrys racemosus*, and *Arundinaria tecta*. Herbs are sparse to moderate in cover but are generally not diverse. *Mitchella repens* or *Chasmanthium laxum* are frequent and often abundant, and *Polystichum acrostichoides*, *Lorinseria areolata, Osmundastrum cinnamomeum*, and *Chasmanthium sessilifolium* may be abundant in some examples.

Range and Abundance: Ranked G3G4. Dry-Mesic Oak–Hickory Forests occur throughout the Coastal Plain, from the Sandhills Region to bluffs along tidewater rivers and creeks, but they are largely confined to small areas of dissected topography. They did not dominate large parts of the landscape in the past as the Piedmont Subtype did, though they may have been extensive in the northernmost part of the Coastal Plain. The corresponding NVC association is attributed only questionably to South Carolina and Georgia. It might be expected to range through these states. A different comparable association, which shares more Piedmont species, is recognized in Virginia.

Associations and Patterns: The Coastal Plain Subtype appears to naturally be a large patch community. It is common in the small areas of dissected topography but is absent in the prevailing landscapes of the Coastal Plain. It may grade to Dry Oak–Hickory Forest uphill and to Mesic Mixed Hardwood Forest or Piedmont/Coastal Plain Heath Bluff downhill, but patches may be small enough that these communities may not be distinguishable. It may sometimes border floodplain or other wetland communities, occasionally longleaf pine communities.

Variation: No variants are recognized. Northern examples are less sharply differentiated from the Piedmont Subtype. Investigation is needed to determine if some may be more similar to the association recognized in Virginia. Examples also vary with gradation to other communities, including Mesic Mixed Hardwood Forest, Dry Oak–Hickory Forest, and Dry-Mesic Basic Oak–Hickory Forest.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont and Coastal Plain Oak Forests theme in general and to the Piedmont Subtype. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines, while the greater natural fire frequency of the Coastal Plain probably once meant more frequent and intense burning, even in sites with topographic sheltering. This too may contribute to the greater occurrence of pines. Pines, especially *Pinus taeda*, seem to become more abundant in hardwood communities of slopes as one goes southward and also westward across the Gulf Coastal Plain. In the presettlement forests of the Big Thicket of Texas, pines were generally codominant in analogous communities in a way they do not appear to have been in North Carolina before widespread logging (Schafale and Harcombe 1983).

Comments: The transition to the Coastal Plain subtypes of Mesic Mixed Hardwood Forest or Dry Oak–Hickory Forest appears to be more gradual than the comparable transition in the Piedmont. This may be a result of greater disruption of natural fire regimes or may be a result of the nature of Coastal Plain soils. The presence of wetland species, even in these dry upland communities, is presumably related to small areas of seepage.

Though the oak-hickory forests of the Coastal Plain have received less study than those of the Piedmont, Glazier (1967) and Sechrest and Cooper (1970) contributed to earlier understanding of this community.

The NVC has had three additional associations comparable to this subtype. *Quercus alba - Quercus nigra - Ilex opaca / Clethra alnifolia - Arundinaria gigantea ssp. tecta* Forest (CEGL007862) is attributed primarily to North Carolina but is poorly defined. It appears to cover almost the same range of sites and vegetation and to largely overlap the association synonymized with this subtype. It is ranked G4?, an unreasonable rank if it were to be regarded as distinct. *Quercus alba - Carya glabra* / Mixed Herbs Coastal Plain Forest (CEGL007226), formerly attributed to North Carolina, has been clarified as an association of the Gulf Coast. *Quercus alba - Carya tomentosa / Vaccinium elliottii* Forest [Provisional] (CEGL007224) has been dropped from the NVC. The group placement of the primary association synonymized with this subtype, Southern Mesic Beech - Oak - Mixed Deciduous Forest, is problematic. This community is oak-dominated and contains beech only incidentally or as a severe result of fire exclusion.

Rare Species:
Vascular plants – *Clinopodium georgianum, Oplismenus setarius, Solidago villosicarpa,* and *Tridens chapmanii*.

DRY OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry Oak–Hickory Forests are common Piedmont or Coastal Plain upland hardwood forests of acidic soils occurring in the driest typical topographic positions, on south slopes and ridge tops, where *Quercus alba, Q. stellata*, and *Q. falcata* predominate in the canopy. They are the driest sites in typical Piedmont landscapes but are less dominated by xerophytic species than some communities of specialized settings such as montmorillonitic soils or shallow rock. They contain acid-tolerant flora such as *Oxydendrum arboreum, Nyssa sylvatica, Vaccinium stamineum, Vaccinium pallidum*, and *Vaccinium arboreum*, and lack more base-loving plants. The Piedmont Subtype covers typical examples of the Piedmont, which lack significant Coastal Plain flora.

Distinguishing Features: Dry Oak–Hickory Forests are distinguished from Dry-Mesic Oak–Hickory Forests by having *Quercus stellata, Q. falcata*, and other trees more drought tolerant than *Quercus alba* more abundant than *Quercus rubra* and other trees less drought tolerant, though *Quercus alba* usually dominates both. They are distinguished from Xeric Hardpan Forests by a canopy that contains significant *Quercus alba* and other trees that are less xerophytic than *Quercus stellata*.

Dry Oak–Hickory Forests are distinguished from Dry Basic Oak–Hickory Forests by having acid-tolerant plants predominating and by lacking more base-loving plants. Characteristic species in basic communities and typically lacking in acidic communities include *Fraxinus americana, Cercis canadensis, Acer leucoderme*, *Rosa carolina, Clematis ochroleuca*, *Viburnum* spp., and in more base-rich sites, *Frangula caroliniana, Symphoricarpos orbiculatus*, or *Rhus aromatica*. Several additional species are more widely distributed but are more abundant in basic communities, including *Carya carolinae-septentrionalis, Ulmus alata*, and *Acer floridanum*. Acid-tolerant species such as *Oxydendrum arboreum, Vaccinium pallidum, Vaccinium tenellum*, and *Chimaphila maculata* may be present in both communities but are much more likely to predominate in their stratum in Dry Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences, though the dominant species may be the same. Species indicative of the Coastal Plain Subtype include species shared with dry sandy communities, such as *Quercus margaretiae, Quercus incana, Cnidoscolus stimulosus*, and *Gaylussacia dumosa*, as well as species of wetter communities, such as *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta*.

Crosswalks: Quercus falcata - Quercus alba - Carya tomentosa / Oxydendrum arboreum Piedmont Forest (CEGL007927).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).
Oligotrophic Forest, Dry Eutrophic Forest (Peet and Christensen 1980).
White Oak, White Oak-Post Oak (Oosting 1942).

Sites: Dry Oak–Hickory Forests occur on ridgetops, upper slopes, steep south-facing slopes, and other relatively dry upland areas on acidic soils. They occasionally occur on upland flats with somewhat restricted rooting depth, which makes them seasonally dry.

Soils: The Piedmont Subtype may occur on most upland soils. The most common map units are Cecil, Pacolet, Georgeville, Tatum, Appling, Madison, and Badin (all Typic Kanhapludults or Typic Hapludults), but 30 or more additional series are associated with occurrences. A few examples mapped as Alfisols, such as Enon and Wilkes, or Inceptisols, such as Misenheimer, may represent inclusions or incomplete development of these series.

Hydrology: Dry Oak–Hickory Forests occur in the driest environments produced by normal Piedmont topography. Conditions are dry because of runoff from high topographic positions, though a few examples may also have restricted rooting depth.

Vegetation: The Piedmont Subtype forests are dominated by *Quercus alba* in combination with oaks of drier sites, generally *Quercus falcata*, *Quercus stellata*, sometimes *Quercus montana*. *Pinus echinata* may be abundant, sometimes codominant or locally dominant in small groves. Other frequent canopy species include *Carya tomentosa*, *Carya glabra*, *Quercus velutina*, *Quercus coccinea*, *Pinus virginiana*, and, in the eastern part of the range, *Pinus taeda*. Examples that have had substantial logging often have more pines and *Acer rubrum*, and *Liquidambar styraciflua* or *Liriodendron tulipifera* may become abundant in the canopy. Typical understory species, constant or frequent in CVS plot data, are *Oxydendrum arboreum, Acer rubrum, Nyssa sylvatica, Benthamidia* (*Cornus*) *florida*, and *Vaccinium arboreum*. Shrubs range from sparse to dense. The most characteristic shrubs are *Vaccinium stamineum, Vaccinium pallidum*, and *Euonymus americanus*. *Viburnum rafinesqueanum* or *Vaccinium tenellum* may be abundant in parts of the Piedmont. Trailing *Muscadinia rotundifolia* may sometimes cover significant patches of ground. The herb layer tends to be sparse under present conditions. Abundant and frequent species in plots include *Chimaphila maculata*, *Goodyera pubescens*, *Hexastylis arifolia*, *Tipularia discolor*, *Hylodesmum nudiflorum*, *Danthonia spicata*, *Piptochaetium avenaceum*, *Coreopsis major*, *Dichanthelium* spp., *Carex* spp., and *Schizachyrium scoparium*. Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*. With more regular fire, more open understories, and somewhat more open canopies, it is likely that a much greater diversity of herbs occurred. Species of open, burned communities, such as *Tephrosia virginiana, Baptisia tinctoria, Solidago odora, Desmodium* spp., *Lespedeza* spp., *Symphyotrichum* spp., and perhaps some rarer species, probably were widespread.

Range and Abundance: Ranked G4G5. This community occurs throughout the Piedmont, except in the foothill ranges and possibly near the Blue Ridge escarpment. It may once have been the most extensive community in the Piedmont, but because much of its extent is on flat uplands, land use has removed a greater proportion than most other common communities.

The corresponding NVC association is very broad and not precisely defined, extending to Mississippi and Kentucky. It apparently excludes the Atlantic Coastal Plain. It apparently does not occur in Virginia, where drier sites are occupied by an oak/heath forest of more northerly affinities. This concept is almost certainly inappropriately broad. There is no reason to believe this community should have a range so different from the similar Dry Mesic Oak–Hickory Forest, whose equivalent association is limited to a couple of states.

Associations and Patterns: This is the driest community in the typical topographic moisture gradient. It grades to Dry Mesic Oak–Hickory Forest in less dry sites downhill or on different slope aspects. It may be associated with Dry Basic Oak–Hickory Forest or other basic communities, if there is a change in geologic substrate. This transition can sometimes be very gradual but may be abrupt. It is less often associated with Piedmont Monadnock Forest, Xeric Hardpan Forest (Acidic Hardpan Subtype) or Mixed Moisture Hardpan Forest on specialized soils or topography.

Variation: Four variants are recognized:

1. Typic Variant is the most widespread and most fits the description of this community.

2. Hardpan Variant occurs on soils with montmorillonitic clay but which are not extreme enough to support Xeric Hardpan Forest or Mixed Moisture Hardpan Forest. They have some presence of plants suggestive of local or periodic wetness, such as *Quercus phellos*, *Vaccinium corymbosum*, and *Chasmanthium laxum*.

3. Shale Slope Variant is a rare variant occurring on steep slopes with channery soils, where slate, shale, or other rock breaks up into small flat fragments. The accumulation of rock fragments makes these slopes better drained and somewhat unstable. They tend to have more *Pinus virginiana* or *Pinus echinata* in them, and often have some unusual species, such as *Rhus aromatica*, along with more typical acid-tolerant species.

4. Chestnut Oak Variant occurs on rocky ridges where *Quercus montana* is abundant. This variant is transitional to Piedmont Monadnock Forest.

Dynamics: Dynamics are similar to those discussed for the Piedmont members of this theme in general and to those of Dry Mesic Oak–Hickory Forests.

Comments: As in Dry Mesic Oak–Hickory Forest, a number of early studies recognized this community. Peet and Christensen (1980) were particularly influential in the current classification.

Quercus alba – Quercus stellata / Schizachyrium scoparium – Desmodium spp. Woodland (CEGL003722) is an association described in Virginia for extremely frequently burned Piedmont uplands. It appears to be an excessively burned equivalent of Dry Oak-Hickory Forest. Though NVC comments indicate a belief that such vegetation may be quite similar to some pre-European Piedmont vegetation, it likely could only have occurred in similarly extreme human-dominated fire regimes close to denser settlements. It is nevertheless very interesting for its diversity of native herbs, especially Fabaceae and Asteraceae, that are scarce in typical Dry Oak—Hickory Forests. The more natural upland forests, with moderate but regular fire regimes and perhaps lower deer populations, likely contained most of these species and were intermediate between this woodland association and the depauperate Dry Oak—Hickory Forests that exist now without fire.

Pinus echinata – Quercus alba / Vaccinium pallidum / Hexastylis arifolia – Chimaphila maculata Forest (CEGL008427) is an association that is attributed to the Blue Ridge and upper Piedmont, as well as regions to the west. It is more equivalent to Southern Mountain Pine—Oak Forest, though the description is fairly similar to what might be a local area of abundant *Pinus echinata* in Piedmont Dry Oak—Hickory Forests.

Rare Plant Species:
Vascular plants – *Baptisia aberrans, Corallorhiza wisteriana, Fothergilla major, Gillenia stipulata, Helianthus laevigatus, Ilex longipes, Pseudognaphalium helleri, Rhus michauxii, Symphyotrichum georgianum,* and *Thermopsis mollis var. mollis*.

DRY OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry Oak–Hickory Forests are common Piedmont or Coastal Plain upland hardwood forests of acidic soils occurring in the driest typical topographic positions, on south slopes and ridge tops, where *Quercus alba, Q. stellata*, and *Q. falcata* predominate in the canopy. The Coastal Plain Subtype covers Coastal Plain examples, which have a distinct component of species not typical in the Piedmont.

Distinguishing Features: Dry Oak–Hickory Forests are distinguished from Dry-Mesic Oak–Hickory Forests by canopy composition, which has *Quercus stellata, Q. falcata*, and other trees more drought tolerant than *Quercus alba* predominating over trees less drought tolerant. *Quercus alba* tends to be dominant or most abundant in both, though some examples of the Coastal Plain Subtype are more strongly dominated by *Quercus falcata*. Dry Oak–Hickory Forests are distinguished from various sandhill communities by having a closed canopy and lacking the scrub oak understory and characteristic herb layer of longleaf pine communities.

It may be difficult to tell true primary Dry Oak–Hickory Forests of the Coastal Plain Subtype from sandhill communities degraded by fire exclusion, since many characteristic forest species will invade sandhills in the absence of fire. It is unclear how readily *Pinus palustris* would naturally co-occur in these hardwood forests, but a substantial presence presumably indicates that the site was once a sandhill community. Scrub oaks (*Quercus margaretiae, Quercus incana*, and *Quercus marilandica*) may be present in Dry Oak—Hickory Forest but a high abundance of them or any presence of *Aristida stricta* indicates a former sandhill community. The location can also be indicative; fire was frequent on the uplands, and only some kind of natural mitigation of fire frequency or intensity is likely to have allowed the occurrence of oak-hickory forest.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by geography and substrate and by the presence of characteristic Coastal Plain species. *Quercus falcata* and pines are more common, *Quercus coccinea* virtually absent. In the lower strata, predominantly Coastal Plain species such as scrub oaks, *Gaylussacia frondosa*, and species more typical of wetter communities, such as *Ilex glabra* and *Persea palustris*, tend to be present in at last small numbers.

Crosswalks: *Quercus falcata – Quercus stellata – Carya tomentosa / Vaccinium* spp. Coastal Plain Forest (CEGL007246).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest Ecological System: (CES203.241).

Sites: Coastal Plain Dry Oak–Hickory Forests occur on upper slopes and other dry areas that are naturally sheltered from fire. They are usually on bluffs or dissected areas but occur occasionally on high river terraces. Good soil drainage is needed, but the most excessively drained soils support sandhill communities. Soil texture and drainage as well as topography thus contribute to where this community occurs.

Soils: Soils apparently are extremely variable or perhaps poorly characterized. In 21 occurrences with soil mapping recorded, 19 series are represented, primarily Ultisols but including Entisols and Inceptisols. Because most occurrences are in dissected topography, their soils may represent small inclusions in other map units.

Hydrology: Sites are terrestrial and are dry but not excessively drained. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype is a forest generally dominated by *Quercus falcata* and *Quercus alba*, often with abundant *Pinus taeda*, *Quercus stellata*, *Carya tomentosa*, and less frequently *Pinus echinata*, *Pinus palustris*, and *Quercus velutina*. The understory recorded in CVS plots typically includes *Oxydendrum arboreum*, *Benthamidia* (*Cornus*) *florida*, *Acer rubrum*, *Liquidambar styraciflua*, *Nyssa sylvatica*, and less often, *Ilex opaca*, *Persea palustris*, *Prunus serotina*, or *Diospyros virginiana*. The shrub layer may be sparse to dense. *Vaccinium arboreum, Symplocos tinctoria*, and *Gaylussacia frondosa* are frequent in plots. Other shrubs may include *Asimina parviflora*, *Castanea pumila*, *Vaccinium stamineum*, and *Vaccinium tenellum*. Sprawling vines often have substantial cover, especially *Muscadinia rotundifolia*, *Smilax rotundifolia*, *Smilax bona-nox*, and *Gelsemium sempervirens*. Herbs tend to be sparse under present conditions, though patches dominated by *Chasmanthium laxum* occur in some examples. Few other herbs have been recorded in examples, none with high constancy. CVS vegetation plots help characterize this community but don’t represent the range of composition recorded in other examples. With more regular fire, as occurred in the past, these communities likely supported more substantial herb layers, including many of the forb species that occur in Pine/Scrub Oak Sandhill communities.

Range and Abundance: Ranked G4?. In North Carolina, this community occurs throughout the Coastal Plain, from the Sandhills Region to bluffs along tidewater rivers and creeks, but it is largely confined to small areas of dissected topography. It did not dominate large parts of the landscape as the Piedmont Subtype did. The corresponding NVC association ranges to Georgia, Louisiana, and Tennessee, but appears too broadly defined compared to other associations with more limited range. Communities like North Carolina’s can at least be expected to range through South Carolina into Georgia. A different community which shares more Piedmont species is recognized in Virginia.

Associations and Patterns: Dry Oak–Hickory Forests usually grade downhill to Dry-Mesic Oak–Hickory Forest and Mesic Mixed Hardwood Forest on slopes and dissected areas and may occasionally border floodplain communities more directly. Few examples of intact uphill boundaries remain, but this community presumably bordered sandhill or Mesic Pine Savanna communities, though it is unclear if the natural boundary would be sharp or gradual.

Variation: No variants are recognized. Examples vary with latitude, with northern examples less sharply differentiated from the Piedmont Subtype. Substantial variation in the importance of species more characteristic of longleaf pine communities may or may not be natural.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont Subtype and to the dynamics discussed for the theme as a whole. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines. In addition, the greater natural fire frequency of the Coastal Plain probably means more frequent and intense burning, even in sites with topographic sheltering. This too may contribute to the greater occurrence of pines. Unlike in the Piedmont, more frequently burned communities typically occur nearby, and it is possible that climatic cycles that affect fire frequency would cause boundaries of communities to shift over time. Certainly, present fire suppression has allowed vegetation resembling Dry Oak–Hickory Forest to spread farther into flat uplands in some areas.

Comments: *Quercus alba - Quercus falcata - (Carya pallida) / Gaylussacia frondosa* Forest (CEGL006269) is a more northerly Coastal Plain dry oak-hickory forest association that ranges from NJ to VA. It has been questionably attributed to NC but no distinctive northern version of Dry Oak–Hickory Forest that would warrant recognition has been found.

Rare species:
Vascular plants – *Aristida condensata* and *Solidago villosicarpa.*

DRY-MESIC BASIC OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry-Mesic Basic Oak–Hickory Forests are uncommon Piedmont and Coastal Plain forests that occur on less acidic and more base-rich soils than typical, with moisture regimes comparable to Dry-Mesic Oak–Hickory Forests. They fall between Basic Mesic Forest and Dry Basic Oak–Hickory Forest on appropriate substrates. The Piedmont Subtype covers examples in the Piedmont, which lack characteristic Coastal Plain species and lack montane species.

Distinguishing Features: Dry Mesic Basic Oak–Hickory Forests are distinguished from Basic Mesic Forest by a canopy that is dominated by *Quercus alba*, along with other oaks and hickories. There is essentially no *Fagus grandifolia* in the canopy, and *Liriodendron* is scarce in less altered occurrences. Dry-Mesic Basic Oak–Hickory Forests are distinguished from Dry Basic Oak–Hickory Forests by a more mesic flora. The more drought-tolerant oaks such as *Quercus stellata, Quercus marilandica*, and *Quercus falcata* are scarce or absent, and *Quercus rubra* often is abundant.

Dry-Mesic Basic Oak–Hickory Forests are distinguished from Dry-Mesic Oak–Hickory Forests by occurrence of flora indicative of unusually (for North Carolina) high pH and base saturation. Species of basic soils include *Fraxinus americana, Cercis canadensis, Celtis* spp., *Symphoricarpos orbiculatus, Frangula caroliniana, Brachyelytrum erectum*, and *Dichanthelium boscii*. Basic indicators also include a set of species that are characteristic of more mesic or floodplain communities but that occur in dry sites that are less acidic. These include *Acer floridanum, Carya ovata, Elymus hystrix, Elymus virginicus, Phryma leptostachya*, and *Phegopteris hexagonoptera*. Characteristic species of acidic soils, such as *Oxydendrum arboreum, Vaccinium stamineum, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia frondosa*, and *Chimaphila maculata,* may be present, but don't predominate as they do in Dry-Mesic Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences. *Quercus rubra* is largely restricted to the Piedmont Subtype. *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta*, though less frequent than in acidic sites, are largely restricted to the Coastal Plain Subtype compared to the Piedmont Subtype. The Coastal Plain Subtype also tends to have at some least some plants more typical of wetter habitats, such as *Ilex glabra, Osmundastrum cinnamomeum*, and *Woodwardia areolata*, presumably associated with very small seepage patches.

Crosswalks: *Quercus alba - Quercus rubra - Carya (ovata, carolinae-septentrionalis) / Cercis canadensis* Forest (CEGL007232).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).

Sites: Dry-Mesic Basic Oak–Hickory Forests in the Piedmont occur most often on mid slopes and low ridges, and sometimes occur on lower or upper slopes, upland flats, or other places where moisture conditions are dry-mesic.

Soils: The Piedmont Subtype occurs on a variety of upland soils that have high base saturation and less acidic pH than most Piedmont soils. The most common soil series mapped are Enon and Iredell, both Alfisols, with fewer mapped as Mecklenburg, Orange, and Wilkes, also Alfisols. Examples are also mapped on Pacolet and a wide variety of other Ultisols but may represent inclusions in these map units. Though such soils are commonly called basic, it has been noted that few have pH above neutral and some are fairly acidic. Base saturation and availability of individual cations may be more important, and examples have higher values than Dry-Mesic Oak–Hickory Forest.

Hydrology: Sites are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests.

Vegetation: The Piedmont Subtype forests are dominated by combinations of *Quercus alba, Quercus rubra*, *Carya tomentosa*, *Carya glabra*, *Carya carolinae-septentrionalis,* Carya ovata, *Fraxinus americana*, and *Fraxinus biltmoreana*. Other species that may be present include *Quercus velutina*, *Liriodendron tulipifera*, *Carya ovalis*, *Carya ovata*, *Acer floridanum*, and *Juglans nigra*. In examples altered by logging, *Liriodendron tulipifera*, *Pinus taeda*, or *Liquidambar styraciflua* may be abundant or even dominant in the canopy. The understory may be dominated by *Acer floridanum*, *Ulmus alata*, *Acer leucoderme*, *Ostrya virginiana*, *Benthamidia* (*Cornus*) *florida*, or other species. Other frequent or abundant species in CVS plots or site reports include *Juniperus virginiana*, *Carpinus caroliniana*, *Acer rubrum*, *Liquidambar styraciflua*, *Ulmus rubra*, *Ilex opaca*, and *Oxydendrum arboreum*. Shrubs are generally low in density. *Viburnum prunifolium* or *Viburnum rafinesqueanum* may be dense, or there may be a low density mix of shrubs that includes *Symphoricarpos orbiculatus*, *Euonymus americanus*, *Celtis tenuifolia*, *Rosa carolina*, and *Frangula caroliniana*. *Vaccinium* species may be present in small numbers but often are absent. Shrubs of floodplains, such as *Aesculus sylvatica* and *Lindera benzoin*, occasionally are present in small numbers. Vines may form significant cover on the ground, including *Muscadinia rotundifolia*, *Toxicodendron radicans*, *Parthenocissus quinquefolia*, *Lonicera sempervirens*, and, often, the exotic *Lonicera japonica*. Herbs generally are sparse under present conditions, though *Piptochaetium avenaceum* may dominate patches. Frequent herbs in plots or site reports include *Asplenium platyneuron*, *Galium circaezans*, *Endodeca serpentaria*, *Maianthemum racemosum*, and *Hylodesmum nudiflorum*. Widespread species of uplands, such as *Hexastylis arifolia*, *Goodyera pubescens*, and *Danthonia spicata* may be present. Less frequent but characteristic herbs may include *Dichanthelium boscii*, *Brachyelytrum erectum*, *Phegopteris hexagonoptera*, *Actaea racemosa*, *Melica mutica*, *Viola palmata*, *Botrypus virginianus*, *Agrimonia pubescens*, *Phryma leptostachya*, *Polygonatum biflorum* var. *biflorum*, and *Nabalus latissimus.* Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*. With more frequent fire, it is likely that a number of additional herbs which benefit from sunnier conditions would be abundant, including *Tephrosia virginiana, Solidago odora, Baptisia tinctoria, Pteridium latiusculum, Danthonia sericea, Schizachyrium scoparium, Piptochaetium avenaceum, Scleria oligantha*, and *Clitoria mariana*.

Range and Abundance: Ranked G3G4. This community occurs throughout the Piedmont, except in the foothill ranges and near the Blue Ridge escarpment. The corresponding NVC association ranges to Alabama and into Virginia.

Associations and Patterns: Dry-Mesic Basic Oak–Hickory Forest (Piedmont Subtype) is a large patch community. It can be extensive in many areas of mafic rock substrate but does not form a regularly repeating part of the typical Piedmont landscape. In the topographic moisture gradient, Dry-Mesic Basic Oak–Hickory Forest occurs between Dry Basic Oak–Hickory Forest and Basic Mesic Hardwoods, often with a very gradual transition. It may also adjoin patches of Piedmont Cliff, Piedmont/Coastal Plain Heath Bluff, other upland communities, or floodplain communities. It may be associated with Dry-Mesic Oak–Hickory Forest or other acidic communities, if there is a change in geologic substrate. This transition can sometimes be gradual but may be abrupt.

Variation: Two variants are recognized, though the boundary between them will be difficult to define:

1. Typic Variant is the most frequent variant, containing plants of basic soils but lacking the species confined to more strongly basic soils.

2. Strongly Basic Variant contains plants associated only with the most base-rich soils and has a greater diversity and abundance of plants of richer soils. Examples may have *Juglans nigra*, *Tilia americana* var. *caroliniana*, *Frangula caroliniana*, and possibly *Quercus muhlenbergii*. It is much less common than the Typic Variant.

Dynamics: Dynamics are similar to those of Dry-Mesic Oak–Hickory Forest (Piedmont Subtype) and to the theme as a whole. Gap phase regeneration and uneven-aged tree population structure are the natural state, and fire of low to moderate intensity and of moderate frequency is important. Current examples without recent fire sometimes have more grass cover and diversity than their acidic counterparts; it remains to be seen if this will be true of burned examples. If it is, this could lead to somewhat more open canopies, if more abundant grass leads to more intense fires.

Comments: The effect of base-rich soils in producing distinctive communities was recognized by Peet and Christensen (1980) and Oosting (1942). The 3rd Approximation recognized only a single Basic Oak–Hickory Forest community, which spanned the dry and dry-mesic moisture range. The reasoning for the broader moisture range was that the basic-rich soils confused assessment of moisture conditions based on the plants present. As noted, species typical of more mesic sites can be found in drier sites with basic soils, including a number of species considered typical of floodplain in Dry-Mesic Basic Oak–Hickory Forest. However, additional experience has clarified that the dominant trees reflect the moisture gradient in ways similar to acidic soils.

Quercus alba - Quercus rubra - Quercus prinus - Tilia americana var. caroliniana / Ostrya virginiana Forest (CEGL004542) is an association defined by analysis of Uwharrie Mountains CVS data but not recognized here. Five plots were attributed to it (2-151, 2-165, 3-167, 3-168, and 6-151). The plots share a common feature of abundant *Tilia americana* var. *caroliniana*, but vary drastically in canopy dominants and even setting, with one apparently occurring on an alluvial terrace. For the upland sites, it is unclear how they would be distinguished from other Dry-Mesic Basic Oak–Hickory Forests, other than by the abundance of the one species in the suite of basic indicator species. The distinctness of this association needs to be assessed against a broader data set of basic communities, and field relations need to be determined. It is possible that it could represent a facet of the Strongly Basic Variant though not its full scope.

Quercus rubra - Quercus alba - Carya glabra / Geranium maculatum Forest(CEGL007237) is an association described based on a study of old-growth forest plots in a South Carolina Piedmont site and not well distinguished from other Piedmont oak forests. It is questionably attributed to North Carolina. Its description contains some indicators of base-rich soils, suggesting it overlaps the concept of Dry-Mesic Basic Oak—Hickory Forest. It is not clear that there is a basis in enduring characteristics for recognizing it as distinct.

Rare species:
Vascular plants – *Acmispon helleri, Agastache nepetoides, Baptisia aberrans, Berberis canadensis, Buchnera americana, Cirsium carolinianum, Collinsonia tuberosa, Dichanthelium annulum, Eupatorium saltuense, Eurybia mirabilis, Gillenia stipulata, Hexalectris spicata, Pseudognaphalium helleri, Pycnanthemum torreyi, Solidago ptarmicoides (Oligoneuron album*), *Polygala senega, Ruellia purshiana, Silphium terebinthinaceum, Smilax lasioneura, Solidago ulmifolia, Steironema* (*Lysimachia*) *tonsum, Swida* (*Cornus*) *racemosa, Symphyotrichum concinnum,* and *Trifolium reflexum.*

DRY-MESIC BASIC OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry-Mesic Basic Oak–Hickory Forests are uncommon Piedmont and Coastal Plain forests that occur on less acidic and more fertile soils than typical, with moisture regimes comparable to Dry-Mesic Oak–Hickory Forests. They fall between Basic Mesic Forest and Dry Basic Oak–Hickory Forest on the topographic moisture gradient, on appropriate substrates. The Coastal Plain Subtype covers the rare Coastal Plain examples, containing flora characteristic of the Coastal Plain in addition to widespread flora of the type.

Distinguishing Features: Dry-Mesic Basic Oak–Hickory Forests are distinguished from Basic Mesic Forests by a canopy that is dominated by *Quercus alba*, along with other oaks and hickories. There is essentially no *Fagus grandifolia* in the canopy, and *Liriodendron* is scarce in natural occurrences. They are distinguished from Dry-Mesic Oak–Hickory Forests by occurrence of more base-loving flora in association with less acidic substrate. Heaths, at least the more acid-loving ones such as *Oxydendrum arboreum, Vaccinium pallidum*, and *Vaccinium tenellum*, are absent or scarce. *Fraxinus americana, Acer floridanum, Ostrya virginiana, Cercis canadensis*, and *Viburnum* spp. may be abundant. A few examples have distinctive base-loving herbs, but most are more readily distinguished by the woody strata.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by floristic differences, though the dominant canopy species may be similar. *Quercus rubra* is largely restricted to the Piedmont Subtype. *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta*, though less frequent than in acidic sites, are largely restricted to the Coastal Plain Subtype compared to the Piedmont Subtype. The Coastal Plain Subtype also tends to have at some least some plants more typical of wetter habitats, such as *Ilex glabra, Osmundastrum cinnamomeum*, and *Woodwardia areolata*, presumably associated with very small seepage patches.

Crosswalks: *Quercus alba - Carya glabra - Carya tomentosa / Aesculus pavia* Forest (CEGL007225).
G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest Group.
Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest Ecological System: (CES203.241).

Sites: Dry-Mesic Basic Oak—Hickory Forest (Coastal Plain Subtype) communities occur on upper to lower slopes and other dry-mesic areas that are naturally sheltered from fire and that apparently have calcareous material in the soil. Most sites occur on bluffs or dissected areas, but a few may occur on high river terraces that no longer flood. Soil texture and drainage as well as topography contributes to where this community occurs, as very sandy soils tend to support Dry Longleaf Pine Communities instead.

Soils: Soils in this community are not well known. Vegetation suggests they are high in base saturation but this is not reflected in mapped soil series in the few examples. As with many Coastal Plain Basic Mesic Forests, they may be derived from alluvial terrace material. Soil mapping treats most as Winton (Aquic Hapludult), with one example on Suffolk (Typic Hapludult) and one on Wahee (Aeric Endoaquult).

Hydrology: Dry-Mesic Basic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype is dominated by a mix of species of dry-mesic, mesic, and high base conditions, including *Quercus alba, Quercus michauxii, Quercus shumardii, Carya cordiformis, Carya tomentosa, Carya glabra*, and *Fraxinus* spp. *Acer floridanum* is highly constant and often dominant in the understory. Other frequent understory species in CVS plots include *Benthamidia* (*Cornus*) *florida, Morus rubra, Carpinus caroliniana, Cercis canadensis, Asimina triloba, Acer rubrum, Ilex opaca, Ulmus rubra, Nyssa sylvatica, Quercus nigra,* and *Diospyros virginiana.* Shrubs are generally sparse, with *Euonymus americanus* and *Callicarpa americana* most constant. A number of vines are constant or frequent, including *Bignonia capreolata, Muscadinia rotundifolia, Parthenocissus quinquefolia, Toxicodendron radicans, Smilax rotundifolia, Smilax bona-nox, Smilax glauca, Campsis radicans, Lonicera sempervirens*, and the exotic *Lonicera japonica*. The herb layer is moderate to dense. *Polystichum acrostichoides, Chasmanthium laxum*, or *Mitchella repens* may dominate patches. Other frequent species in plots include *Dichanthelium boscii, Podophyllum peltatum, Brachyelytrum erectum, Asplenium platyneuron, Botrypus virginianus, Athyrium asplenioides, Circaea canadensis (lutetiana*), *Carex blanda, Carex laxiflora, Carex grayi, Festuca subverticillata, Galium circaezans, Passiflora lutea, Sanicula canadensis, Scleria oligantha, Viola sororia, Polygonatum biflorum, Gonolobus suberosus, Endodeca serpentaria*, and epiphytic *Tillandsia usneoides*. Additional characteristic herb species in site descriptions include *Melica mutica, Oxalis violacea, Lysimachia quadrifolia,* and *Maianthemum racemosum*.

Range and Abundance: Ranked G4? but probably rarer. In North Carolina only a handful of occurrences are known, all of them small. Most are on bluffs near the Roanoke River, on relict alluvial material, but a couple are widely disjunct. Though not known there, examples may be found along the Cape Fear River. The Coastal Plain Subtype of the Dry-Mesic Basic Oak–Hickory Forest appears to be even rarer than Basic Mesic Forest in the Coastal Plain. The NVC association ranges southward to Georgia and is attributed westward to Mississippi and Tennessee. This is probably too broadly defined, when the analogous acidic Dry-Mesic Oak–Hickory Forest association ranges only to Georgia at the most and perhaps more narrowly. There is no reason to expect basic forests to be floristically or ecologically similar over a broader geographic range than acidic communities.

Associations and Patterns: The Coastal Plain Subtype appears to be a small patch community. The full extent of occurrences is unclear, but all appear to be only a few acres in size. It is unclear if they might have once extended into the flat uplands above the bluffs, areas now occupied by fields, but this seems unlikely, as the calcareous material probably did not extend beyond the slope. Examples probably were naturally bordered by longleaf pine communities above. Below, they may be bordered by Basic Mesic Forest or by floodplain communities.

Variation: Little is known of the natural variation.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont and Coastal Plain Oak Forests theme in general and to the Piedmont Subtype. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines, while the greater natural fire frequency of the Coastal Plain probably once meant more frequent and intense burning, even in sites with topographic sheltering.

Comments: The related NVC association (CEGL007225) is unclearly defined, and it may not fit our examples well. It probably also is too broadly defined relative to other associations.

The placement of this community is G166 Southern Mesic Beech - Oak - Mixed Deciduous Forest is problematic, as it is not as mesic other communities in that group.

No Dry Basic Oak–Hickory Forest community is known in the Coastal Plain. Dry mesic conditions appear to prevail up to the top of the bluff in all known examples.

Rare species: No rare species are known to be associated with this community.

DRY BASIC OAK–HICKORY FOREST

Concept: Dry Basic Oak–Hickory Forests are uncommon Piedmont forests that occur on less acidic and more fertile soils than typical, with moisture regimes comparable to Dry Oak–Hickory Forests. They occur in the driest typical topographic positions such as ridge tops and upper slopes, but more extreme dry conditions can be created by edaphic situations such as clay hardpans, shallow rock, or excessive drainage. No corresponding Dry Basic Oak—Hickory Forest has been found in the Coastal Plain.

Distinguishing Features: Dry Basic Oak–Hickory Forests are distinguished from Dry-Mesic Basic Oak–Hickory Forests by having flora and dominant vegetation indicating drier conditions. As in Dry Oak–Hickory Forest, while *Quercus alba* is usually the most abundant tree species, *Quercus stellata* or *Quercus falcata* are more abundant than *Quercus rubra*. Xeric Hardpan Forests and Xeric Piedmont Slope Woodlands generally are dominated by *Quercus stellata* and have little or no *Quercus alba*. Mixed Moisture Hardpan Forests may also have abundant *Quercus stellata* and sometimes *Quercus alba* but combine them with appreciable amounts of *Quercus phellos* along with some wetland species in lower strata.

Dry Basic Oak–Hickory Forests are distinguished from Dry Oak–Hickory Forests by a suite of plants indicative of high base saturation. *Cercis canadensis, Fraxinus americana, Fraxinus biltmoreana, Acer leucoderme*, and *Viburnum* spp. are scarce in Dry Oak–Hickory Forest and generally abundant in Dry Basic Oak–Hickory Forest, though *Fraxinus* are rapidly dying off due to introduced insects. Stronger basic indicators such as *Frangula caroliniana, Symphoricarpos orbiculatus*, or *Rhus aromatica* are often present. *Carya* spp. and *Juniperus virginiana* are more abundant than in Dry Mesic Basic Oak–Hickory Forest, though less confined to it. As in Dry-Mesic Oak—Hickory Forests, species more typical of floodplains or mesic sites may occur in the basic type, but these are less common due to the dryness. More acid-tolerant species such as *Oxydendrum arboreum, Vaccinium pallidum, Vaccinium tenellum*, and *Chimaphila maculata* may be present in Dry Basic Oak–Hickory Forest but are less predominant than in Dry Oak–Hickory Forest.

Crosswalks: *Quercus alba - Quercus stellata - Carya carolinae-septentrionalis / Acer leucoderme - Cercis canadensis* Forest (CEGL007773).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).
Dry Eutrophic (Peet and Christensen 1980).

Sites: Dry Basic Oak–Hickory Forests occur on ridgetops, upper slopes, south-facing slopes, and other dry topographic settings. They are generally on a substrate of mafic rock but may occur on sedimentary or meta-sedimentary rocks with similar chemistry. They may also occur on upland flats where restricted rooting depth or montmorillonitic soils make them seasonally dry but where conditions are not extreme enough to support Xeric Hardpan Forest.

Soils: Dry Basic Oak–Hickory Forests are supported by a variety of upland soils that are less acidic than most Piedmont soils or are high in base saturation. The most common series mapped are Enon and Iredell, with fewer mapped as Mecklenburg and Wilkes, all Alfisols. Examples are also mapped on Wynott, Georgeville, and other Ultisols, and occasionally on Goldston, a rocky Inceptisol, and Picture, one of the few Mollisols in North Carolina. Though such soils are commonly called basic, it has been noted that few have pH above neutral and some are fairly acidic. Base saturation and availability of individual cations may be more important, and examples have higher values of these than Dry Mesic Oak–Hickory Forest.

Hydrology: Dry Basic Oak–Hickory Forests occur in the driest environments produced by normal Piedmont topography. Conditions are dry because of runoff from high topographic positions, though a few examples may also have restricted rooting depth.

Vegetation: Dry Basic Oak–Hickory Forests are dominated by *Quercus alba* in combination with oaks of drier sites. *Quercus stellata* or, less often, *Quercus falcata* are usually abundant, and one may codominate. Hickories, including *Carya carolinae-septentrionalis*, *tomentosa*, *glabra*, *ovata*, and *ovalis*, are generally also abundant, sometimes codominant. *Fraxinus americana* and *Fraxinus biltmoreana* have been among the most frequent species to indicate base-rich conditions, but current mortality due to invasive insects may soon eliminate them. *Pinus echinata* may be abundant in some examples, sometimes codominating or dominating in small groves. Other species that may be present in the most basic sites include *Juglans nigra* and *Quercus muhlenbergii*. Examples that have been logged may have increased amounts of *Pinus taeda*, *Liriodendron tulipifera*, or *Liquidambar styraciflua*. The understory is variable and may include a diversity of species. *Acer leucoderme*, *Ulmus alata*, or *Acer floridanum* may be dense. *Benthamidia* (*Cornus*) *florida*, *Cercis canadensis*, *Juniperus virginiana*, *Morus rubra*, or less often *Ostrya virginiana* are fairly frequent in plot data and may have high cover. Shrubs are generally sparse. Species may include *Euonymus americanus*, *Viburnum rafinesqueanum*, *Viburnum prunifolium*, *Viburnum rufidulum*, *Viburnum acerifolium*, *Symphoricarpos orbiculatus*, *Celtis tenuifolia*, *Rhus aromatica*, *Frangula caroliniana*, *Rosa carolina*, and sometimes species of mesic forests such as *Aesculus sylvatica* or *Lindera benzoin*. *Vaccinium* spp. may be present in small numbers but often are absent. Herbs are often sparse under present conditions, but *Piptochaetium avenaceum*, *Scleria oligantha*, or *Danthonia spicata* may form denser patches. Other frequent or abundant species in plots include *Endodeca serpentaria, Dichanthelium boscii, Asplenium platyneuron, Galium circaezans*, and *Ruellia caroliniana*. With a more natural fire regime, it is likely many additional herbs would be present. These would include the widespread herbs of more open, burned communities as noted for Dry Oak—Hickory Forest but also grasses such as *Andropogon gerardii* and *Sorghastrum nutans*, and potentially species shared with Xeric Hardpan Forest such as *Tragia urticifolia, Parthenium integrifolium*, and *Clematis ochroleuca*.

Range and Abundance: Ranked G2G3. This community occurs throughout the Piedmont, except in the foothill ranges and near the Blue Ridge escarpment. The corresponding NVC association ranges through South Carolina and Georgia, possibly into Alabama. A different association is recognized in Virginia.

Associations and Patterns: Dry Basic Oak–Hickory Forest (Piedmont Subtype) is a large patch community. It is extensive in some areas of mafic rock substrate but does not form a regularly repeating part of the typical Piedmont landscape. This is the driest community in the typical topographic moisture gradient of base-rich substrates. It grades to Dry Mesic Basic Oak–Hickory Forest in less dry sites downhill or on different slope aspects. It may be associated with Dry Oak–

Hickory Forest or other basic communities, if there is a change in geologic substrate. This transition can sometimes be gradual but may be abrupt. This community also often is associated with Xeric Hardpan Forest, Mixed Moisture Hardpan Forest, or Upland Depression Swamp Forest where montmorillonitic influence on the soil becomes more extreme.

Variation: Four variants are recognized, though the boundaries between them are difficult to define.

1. Typic Variant is the most frequent variant, containing plants of basic soils but lacking the species confined to more strongly basic soils.

2. Strongly Basic Variant is a rarer variant containing plants associated only with the most strongly basic soils and having a greater diversity and abundance of plants of basic soils. Examples may have *Juglans nigra*, *Tilia americana* var. *caroliniana*, *Frangula caroliniana*, and possibly *Quercus muhlenbergii*.

3. Hardpan Variant occurs on soils with montmorillonitic clay but which are not extreme enough to support Xeric Hardpan Forest or Mixed Moisture Hardpan Forest. They have an admixture of plants suggestive of local or periodic wetness, such as *Quercus phellos*, *Vaccinium corymbosum*, and *Chasmanthium laxum*, though not much as in Mixed Moisture Hardpan Forest.

4. Boulderfield Variant occurs in areas with a high cover of large boulders, which leads to a high cover by woody vines and reduced cover by herbs. Earlier drafts of the 4th Approximation recognized it as a provisional subtype, based on an NVC association defined based on several CVS plots: *Quercus alba - Carya glabra - Fraxinus americana / Acer leucoderme / Vitis rotundifolia* Forest (CEGL004541). However, some examples of all Piedmont oak forest communities are rocky and others have high cover of vines. It is unclear that these areas are that distinctive.

The Shale Slope Variant of Dry Oak–Hickory Forest has some species characteristic of basic soils in it, so that it might fit almost as well as a variant of Dry Basic Oak–Hickory Forest.

Dynamics: Dynamics are similar to those of the theme as a whole and to Dry Oak–Hickory Forest (Piedmont Subtype) in particular. The drier sites, often in less dissected topography, likely experienced natural fires that were more intense and more extensive than in the dry-mesic communities. This would produce a more open canopy under natural conditions, though still more forest than savanna in general. Current examples without recent fire sometimes have more grass cover and diversity than their acidic counterparts; it remains to be seen if this will be true of burned examples. If it is, this could lead to somewhat more open canopies, as the grass would fuel more intense fires.

With more fire, it is possible that the boundaries between Dry Basic Oak–Hickory Forest and Xeric Hardpan Forest would shift. It is possible that some former Xeric Hardpan Forests have become indistinguishable from Dry Basic Oak–Hickory Forests. A dendrochronology at Picture Creek Diabase Barrens, a predominantly Xeric Hardpan Forest site, found an abrupt and complete shift from regeneration of *Quercus stellata* and *Pinus echinata* to regeneration of *Quercus alba* and *Pinus taeda* in the site, corresponding to a change in ownership that presumably brought an end to burning (Sigmon-Chatham 2015).

Comments: No examples of Dry Basic Oak–Hickory Forest are known in the Coastal Plain; if any are found, they would be covered by this type but probably would warrant a new subtype.

Quercus montana - Quercus stellata - Carya glabra / Vaccinium arboreum - Viburnum rufidulum Forest (CEGL004416) is an association attributed to North Carolina which has a somewhat confusing description and is not recognized in the 4th Approximation. It probably is more related to Piedmont Basic Glade or possibly represents a basic version of Xeric Piedmont Slope Woodland, but it bears some resemblance to Dry Basic Oak—Hickory Forest.

Rare species:
Vascular plants – *Acmispon helleri, Agastache nepetoides, Baptisia aberrans, Berberis canadensis, Borodinia missouriensis, Buchnera americana, Callitriche terrestris, Cirsium carolinianum, Desmodium ochroleucum, Dichanthelium annulum, Fleischmannia incarnata, Gillenia stipulata, Helianthus laevigatus, Hexalectris spicata, Parthenium auriculatum, Polygala senega, Pseudognaphalium helleri, Pycnanthemum torreyi, Ruellia purshiana, Silphium terebinthinaceum, Smilax lasioneura, Solidago ptarmicoides* (*Oligoneuron album*), *Solidago radula, Solidago ulmifolia, Symphyotrichum concinnum, Symphyotrichum georgianum,* and *Tridens chapmanii*.

PIEDMONT MONADNOCK FOREST (TYPIC SUBTYPE)

Concept: Piedmont Monadnock Forests are very rocky, highly acidic forests of isolated erosional remnant hills, occasionally of bluffs or other very rocky sites, in the eastern and central Piedmont. They are dominated by *Quercus montana*, occasionally codominated by *Quercus coccinea*, but lack most of the characteristic montane species of Chestnut Oak Forests. The Typic Subtype covers the most common examples, which lack an appreciable component of either *Pinus echinata* or *Kalmia latifolia*.

Distinguishing Features: Piedmont Monadnock Forests may be distinguished from most Piedmont communities by the dominance of *Quercus montana*. Some Dry Oak–Hickory Forests that are transitional to this type may have abundant *Quercus montana*, but it does not dominate. Piedmont Monadnock Forests may be distinguished from Chestnut Oak Forests by a more limited flora that completely or largely lacks the characteristic montane species, such as *Castanea dentata, Rhododendron calendulaceum, Pyrularia pubera, Gaylussacia ursina, Magnolia fraseri, Carex pensylvanica*, and *Maianthemum racemosum*. Piedmont species such as *Quercus falcata* and *Quercus stellata* are more often present, though they may also be present in some foothill examples of Chestnut Oak Forest.

The Typic Subtype is distinguished by the absence of a significant admixture of *Pinus echinata* (5% of cover or basal area) or *Kalmia latifolia*.

Crosswalks: *Quercus montana - Quercus alba / Oxydendrum arboreum / Vitis rotundifolia* Forest (CEGL006281).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).

Sites: Piedmont Monadnock Forests usually occur on isolated erosional remnant hills, known as inselbergs or monadnocks. The substrate usually is dacite, rhyolite, quartzite, pyrophyllite or other highly weathering-resistant rocks. A few examples occur on bluff tops or other sites where there is an abundance of quartz veins that contribute a high rock content to the soil, and one example is on a terrace gravel in the fall zone.

Soils: Soils are very rocky, well-drained, and generally extremely acidic. Peet and Christensen (1980) suggested that aluminum toxicity might be an important stress factor at the pH values they measured. The most frequently mapped soil series are Georgeville (Typic Kanhapludult), Tatum, and Uwharrie (Typic Hapludults). Other frequent series include Herndon and Badin (Typic Kanhapludults) and Goldston (Typic Dystruept), but a wide variety of other Typic Hapludults and Typic Kanhapludults also are mapped.

Hydrology: Sites are dry to xeric due to high topographic position. The high rock content in the soil may contribute to dry conditions by limiting available rooting volume.

Vegetation: The Typic Subtype forest is strongly dominated by *Quercus montana*. *Quercus alba, Quercus velutina, Quercus coccinea, Carya glabra*, and *Carya tomentosa* occur with high constancy in CVS plots but in small numbers. *Quercus falcata* and *Quercus stellata* are less frequent, as are small numbers of *Pinus echinata* or *Pinus virginiana*. The understory is generally dominated by *Oxydendrum arboreum*, and *Nyssa sylvatica a*nd *Acer rubrum* are usually present. Also highly constant in plots, though in small numbers, are *Diospyros virginiana, Sassafras albidum, Prunus serotina*, and *Benthamidia* (*Cornus*) *florida*. The shrub layer may be sparse to moderate in density. *Vaccinium pallidum* usually dominates, and *Vaccinium stamineum* is highly constant and often abundant. Other frequent shrubs are *Vaccinium tenellum* and *Vaccinium arboreum*. *Gaylussacia baccata*, in a disjunct population, dominates the shrub layer of one well-known example (Occoneechee Mountain). *Muscadinia rotundifolia* often covers large areas on the ground, more often than in other oak forests, and *Smilax glauca* and *Smilax rotundifolia* are frequent. The herb layer is very sparse, at least under current conditions. *Chimaphila maculata* is the only highly constant species in CVS plots. Other characteristic species, less frequent in plot data but often observed, include *Danthonia spicata, Hieracium venosum, Clitoria mariana, Schizachyrium scoparium*, *Goodyera pubescens*, *Hylodesmum nudiflorum*, *Pteridium latiusculum,* and *Tephrosia virginiana*. With more frequent fire, additional herb species likely would be found, but, given the extreme soil conditions, it is unclear how diverse or abundant herbs could be even with regular burning.

Range and Abundance: Ranked G3G4. Piedmont Monadnock Forests occur throughout the Piedmont, except in the foothills, and are most abundant in the Uwharrie area. They are rare in the northeastern Piedmont. The equivalent association ranges to Georgia and Alabama. They are much less extensive than the typical oak-hickory forests, and G3 may be an appropriate rank.

Associations and Patterns: Piedmont Monadnock Forests may occur as large or small patches. They usually grade downhill to Dry Oak–Hickory Forest, but sometimes give way directly to more mesic communities. In the Uwharrie area, where Piedmont Monadnock Forests are the most extensive and diverse, the Heath Subtype occurs on north-facing slopes of the hills, the Pine Subtype on west and south slopes, and the Typic Subtype on the tops. Xeric Piedmont Slope Woodland or Piedmont Acidic Glade often also occurs on the south slopes. Where the felsic volcanic rocks give way to mafic volcanic rocks, Dry Basic Oak–Hickory Forest replaces these communities.

Variation: The low diversity makes for less variation than is present in many community types. The few examples that occur on mafic rock monadnocks should be examined for differences that could be recognized as a variant.

Dynamics: The dynamics of Piedmont Monadnock Forests are similar to those of Piedmont oak forests as a whole. The topographic exposure of monadnocks makes them particularly susceptible to lightning and wind. They are also particularly susceptible to fires spreading uphill, which produces increased intensity, though they may also be the starting point for more numerous lightning fires than most places. Nevertheless, tree dynamics appear to be dominated by small to medium size canopy gaps, and forests naturally exist as old-growth, multi-aged stands. As in other Piedmont forests, the dominant trees tolerate fire, and most fires would kill few canopy individuals. The abundance of both small rock outcrops and loose rock in these forests may disrupt fire behavior. But, as with other Piedmont oak forests, it is presumed that more regular fire would once have supported more grass cover and more herb diversity. The high cover of *Muscadinia* *rotundifolia* that occurs in many examples might be less with more frequent fire, but this species is capable of quickly recovering its cover.

Comments: Peet and Christensen (1980) recognized monadnock forests as distinct in their analysis of Piedmont vegetation, and they appear to have originated the name. They suggested a combination of elevation, dryness, nutrient-poor soil, and extreme acidity, possibly including aluminum toxicity, as the cause of their distinctive character. Because most examples stand only a few hundred feet above surrounding lands and less than 1000 feet above sea level, elevation itself is unlikely to be significant. While dryness is clearly important, the subordinate role of *Quercus stellata* and *Q. marilandica* and the absence of *Q. montana* in other dry sites suggests that soil physical and chemical characteristics are more important. However, a few examples occur on monadnocks composed of mafic rock, which presumably do not have highly acidic soils. Not all high hills support Piedmont Monadnock Forest, and a few examples occur in sites other than monadnocks. These exceptions may be instructive. They occur where cobble size rocks are very abundant in the soil, on relict terrace gravels and in places with a high density of quartz veins. It thus appears likely that abundance of rock itself may be an important driver of the dominance of *Quercus montana* and the distinctive character of this community.

Piedmont Monadnock Forest was tentatively treated as a subtype of Chestnut Oak Forest in early drafts of the 4th Approximation guide. The recognition of several subtypes within it suggests it would be better treated as a distinct type. While floristically depauperate, it appears to be as distinct from montane Chestnut Oak Forest as Montane Oak–Hickory Forest is from Piedmont oak-hickory forests.

Piedmont Monadnock Forests are generally quite distinctive in the eastern Piedmont where they reach their best development near the summits of monadnocks. In the Uwharrie Mountains area, erosional remnants are larger and Piedmont Monadnock Forests are interspersed with Dry Oak—Hickory Forests of the Chestnut Oak Subtype, as the abundance of *Quercus montana* varies more continuously. In the foothills area, Piedmont Monadnock Forests are replaced by mountain Chestnut Oak Forest communities. The precise location of this transition needs clarification.

Except in the Uwharrie Mountains, monadnocks represent a small portion of the Piedmont landscape. However, since they are usually too rocky and steep to farm and are less accessible than most areas for wood cutting, many examples have escaped total destruction in the past. While cutting and livestock foraging has been universal, a number remain in good condition.

Rare species:
Vascular plants – *Fothergilla major, Monotropsis odorata,* and *Thermopsis mollis*.

PIEDMONT MONADNOCK FOREST (PINE SUBTYPE)

Concept: Piedmont Monadnock Forests are *Quercus montana*-dominated forests of isolated erosional remnant hills and other very rocky sites in the eastern and central Piedmont. The Pine Subtype covers examples where *Pinus echinata* is naturally present in more than small numbers (and presumably was once more abundant), though it may not codominate. The Pine Subtype occurs primarily in the Uwharrie area and occasionally on monadnocks elsewhere.

Distinguishing Features: Piedmont Monadnock Forests may be distinguished from most communities by the dominance of *Quercus montana*. They are distinguished from Chestnut Oak Forests by a more limited flora that lacks or largely lacks the characteristic montane species, such as *Castanea dentata, Rhododendron calendulaceum, Pyrularia pubera, Gaylussacia ursina, Magnolia fraseri, Carex pensylvanica*, and *Maianthemum racemosum*. The Pine Subtype is distinguished from the Typic Subtype by having an apparently natural, persistent significant component of *Pinus echinata* (greater than 10% under present conditions).

Crosswalks: *Quercus montana - Pinus echinata / Vaccinium pallidum* Piedmont Monadnock Forest (CEGL004148).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).

Sites: Piedmont Monadnock Forests generally occur on isolated erosional remnant hills composed of weathering-resistant rock. The Pine Subtype usually occurs on west- or south-facing slopes of the hills.

Soils: Soils are similar to those of the Typic Subtype and are very rocky, well drained, and generally extremely acidic.

Hydrology: Sites are dry to xeric due to high topographic position. The high rock content in the soil may contribute to dry conditions by limiting rooting volume.

Vegetation: The Pine Subtype is dominated by *Quercus montana*, similarly to the other subtypes. *Pinus echinata* may be codominant or may be a minority component but naturally makes up at least 10% of the canopy. *Quercus velutina, Quercus alba, Carya glabra, Carya tomentosa*, *Quercus coccinea*, *Quercus stellata*, and *Quercus falcata* are often present in small numbers. The understory generally includes abundant *Nyssa sylvatica, Oxydendrum arboreum,* and *Acer rubrum*, and smaller numbers of *Diospyros virginiana*, *Prunus serotina*, and other species. The shrub layer is sparse to moderate and usually is dominated by *Vaccinium pallidum*. *Vaccinium stamineum* is frequent, and *Vaccinium arboreum, Vaccinium tenellum*, and other species occur occasionally. *Muscadinia rotundifolia* may cover large areas on the ground, and *Smilax glauca* and *Smilax rotundifolia* are frequent. The herb layer is sparse under current conditions. *Chimaphila maculata* is the only highly constant species. Other species that are frequent in the few CVS plots in this subtype include *Tephrosia virginiana, Pteridium latiusculum, Danthonia sericea, Hieracium venosum, Schizachyrium scoparium, Piptochaetium avenaceum, Dichanthelium commutation, Scleria oligantha*, and *Clitoria mariana*.

Range and Abundance: Ranked G2. This subtype appears to be much less common in North Carolina than the Typic Subtype, but it may be overlooked, or examples may have lost their characteristic *Pinus echinata*. This community may occur in South Carolina and Georgia but is not confirmed.

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Associations and Patterns: The Pine Subtype occurs as small patches. It tends to occur on the west and south slopes of monadnocks, sometimes on the east slopes, with the Typic Subtype on the top, but it is absent from many isolated monadnocks. It tends to give way to the Heath Subtype on north slopes, and sometimes to the Xeric Piedmont Slope Woodland or Piedmont Acidic Glade on south slopes. Examples grade downhill to Dry Oak–Hickory Forest or sometimes directly to more mesic forests.

Variation: Details of variation are not known.

Dynamics: The dynamics of Piedmont Monadnock Forests are similar to those of Piedmont oak forests as a whole, and the Pine Subtype is similar to the Typic Subtype in dynamics. The steeper slopes in the Pine Subtype may make fires more intense in it, and this may support the persistence of *Pinus echinata*. If pine is present in appreciable amounts, the greater flammability of its litter may also contribute to greater fire intensity.

Comments: The Pine Subtype is much less well documented than other subtypes. While the vegetation description above is based on CVS plot data, only a handful of plots have been sampled. The impression of constancy and of minor species present could change substantially with more data.

The Pine Subtype is one of the least distinct of communities in the Fourth Approximation, and though it is recognized in the NVC, further study may suggest it should be merged with the Typic Subtype. *Pinus echinata* is naturally a frequent but minority component of most Piedmont oak forests, occasionally dominating local groves. No other oak forests have a recognized subtype, or even a variant, based on its presence or absence. The abundance of *Pinus echinata* appears to have been modified more than for most trees, sometimes reduced by the removal of fire, sometimes increased by logging or land clearing. At present, it is generally impossible to know if the presence, absence, or particular abundance of this species in a given oak forest is natural. The argument for recognizing the Pine Subtype of Piedmont Monadnock Forest is that the presence of pine appears to be less modified in it, that it distinctly is present in some examples and not others, and that its presence appears tied to a distinctive landscape position.

Rare species: No rare species are known to be specifically associated with this community.

PIEDMONT MONADNOCK FOREST (HEATH SUBTYPE)

Concept: Piedmont Monadnock Forests are *Quercus montana*-dominated forests of very rocky isolated erosional remnant hills in the eastern and central Piedmont. The Heath Subtype covers examples with a dense shrub layer of *Kalmia latifolia*, generally occurring on north-facing side slopes.

Distinguishing Features: The combination of a *Quercus montana*-dominated canopy, without mesophytic trees, along with a dense *Kalmia latifolia* shrub layer, occurring in the eastern or central Piedmont, distinguishes this subtype from all other communities. Communities with only sparse *Kalmia latifolia* should not be classified as this subtype. In the western Piedmont and Blue Ridge, Chestnut Oak Forest (Dry Heath Subtype) may be locally dominated by the same combination of species but typically is more diverse and contains other characteristic montane species such as *Gaylussacia baccata, Gaylussacia ursina, Rhododendron calendulaceum*, or *Castanea dentata*. This subtype sometimes grades into Piedmont/Coastal Plain Heath Bluff on lower slopes, where more mesic canopy appears over the dense *Kalmia* shrub layer. However, in most places the Heath Subtype and Heath Bluff do not co-occur.

Crosswalks: *Quercus montana - Quercus alba / Oxydendrum arboreum / Kalmia latifolia* Forest (CEGL004415)
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).

Sites: Piedmont Monadnock Forests generally occur on isolated erosional remnant hills composed of weathering-resistant rock. The Heath Subtype occurs on north-facing slopes of monadnocks.

Soils: Soils are similar to those of the Typic Subtype and are very rocky, well drained, and presumably extremely acidic.

Hydrology: Sites are well drained and dry but are cooler and more moist than other Piedmont Monadnock Forests because of the northerly slope aspect.

Vegetation: The Heath Subtype, like other Piedmont Monadnock Forests, has a canopy strongly dominated by *Quercus montana*. Other species, including *Quercus alba, Quercus velutina*, *Quercus coccinea*, and *Carya tomentosa*, are often present in small numbers. The understory is generally dominated by *Oxydendrum arboreum*, and *Nyssa sylvatica, Acer rubrum, Ilex opaca*, *Diospyros virginiana, Sassafras albidum*, *Amelanchier arborea*, and *Benthamidia* (*Cornus*) *florida* are frequent. The shrub layer is dense and is dominated by *Kalmia latifolia*. *Vaccinium stamineum* and *Vaccinium pallidum* have high constancy in plots and site reports. Other frequent shrubs include *Symplocos tinctoria*, and *Vaccinium arboreum*, and a few examples have *Hamamelis virginiana* or *Fothergilla major*. *Smilax rotundifolia* is frequent. The herb layer is sparse under current conditions. *Chimaphila maculata* is the only high constancy species in plots. Other species noted include *Epigaea repens, Uvularia sessilifolia, Danthonia spicata, Polygonatum biflorum*, and *Galax urceolata*. Given the dense shrub cover, which appears to be natural, herbs may not be substantially more abundant or diverse in landscapes with more frequent fire, but this is unsure.

Range and Abundance: Ranked G3. In North Carolina, this subtype occurs primarily in the Uwharrie area. The equivalent association ranges southward to Alabama. Unless it is more abundant in some other state, its rank probably should be G2.

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Associations and Patterns: The Heath Subtype often exists in association with other subtypes. It occurs on the north slopes of monadnocks, with the Typic Subtype uphill of it and on top, and the Pine Subtype occurs on west, south, and sometimes east slopes. The Heath Subtype sometimes grades downhill to Piedmont/Coastal Plain Heath Bluff on more mesic slopes but more often gives way to Mesic Mixed Hardwood Forest or is bordered below by a floodplain community.

Variation: No pattern of variation is known.

Dynamics: Dynamics of the Heath Subtype probably are intermediate between the typical dynamics of Piedmont oak forests and of mesic forests. The north-facing slopes likely lead to lower fire intensity and frequency, but the exposed upper slope position still allows fire to occur. The prevalence of *Kalmia latifolia* suggests reduced fire frequency and intensity compared to most oak forests, but some fire probably is necessary for *Quercus montana* to remain dominant in the long run. As in Piedmont/Coastal Plain Heath Bluff, the presence of *Kalmia* probably is relict from the cooler Pleistocene climate but has persisted as much because of natural sheltering from fire as of the cooler microclimate.

Comments: This subtype is largely confined to the Uwharrie Mountains, with only a handful of examples known elsewhere. It is compositionally related to the oak-heath forests of the Virginia Piedmont, which cover large expanses of the landscape there, as well as to the Chestnut Oak Forests of the mountains. *Symplocos tinctoria* can be an important shrub component.

Rare species:
Vascular plants – *Fothergilla major.*

MIXED MOISTURE HARDPAN FOREST

Concept: Mixed Moisture Hardpan Forest is a community with a mixture of tree species typical of hydric and xeric conditions, occurring on sites with clay-rich soils that have restricted internal drainage or shrink-swell properties. Typically, *Quercus phellos* is mixed with *Quercus alba, Quercus stellata*, or *Carya carolinae-septentrionalis* in the canopy, but is not predominant as it is in Upland Depression Swamp Forest. This community type is intermediate between Upland Depression Swamp Forest and Xeric Hardpan Forest.

Distinguishing Features: Mixed Moisture Hardpan Forest is distinguished by the co-occurrence of wetland and upland oak and hickory species, generally including both *Quercus phellos* and *Quercus stellata* in significant numbers, without segregation into distinct Xeric Hardpan Forest and Upland Depression Swamp communities. *Quercus alba* and other dry-mesic species are also generally abundant but may be scarce. Sites typically show evidence of shallow ponding of water but only in limited microsites.

Crosswalks: *Quercus phellos - Quercus (alba, stellata) - Carya carolinae-septentrionalis* Hardpan Wet Forest (CEGL004037).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: Mixed Moisture Hardpan Forests occur on unusually flat upland areas of the Piedmont, generally associated with diabase, gabbro, or other mafic rock but potentially with clay-rich metasedimentary rocks.

Soils: This community occurs on montmorillonitic or other clay-rich soils that restrict water penetration and interfere with roots through their density or shrink-swell behavior. The most common soil series mapped in occurrences is Iredell (Vertic Hapludalf), with some mapped as Enon (Ultic Hapludalf) or Lignum (Aquic Hapludult) and a few as Orange (Albaquic Hapludalf), Misenheimer (Aquic Dystrudept), or other series.

Hydrology: Sites appear to be alternately wet and dry, with water pooled on part of the ground surface at times but dry most of the time. Moisture conditions are not comparable to any position on the normal upland moisture gradient. However, dry and wet conditions are more moderate than in Xeric Hardpan Forest or Upland Depression Swamp Forest respectively.

Vegetation: Mixed Moisture Hardpan Forest has a canopy with a mix of trees that includes species of wet, mesic, and dry sites. *Quercus phellos* and *Quercus stellata* co-occur. Other highly constant species in CVS plots include *Carya glabra, Liquidambar styraciflua, Ulmus alata, Quercus alba, Quercus falcata, Carya tomentosa*, and *Fraxinus americana*. *Carya ovata, Ulmus americana, Quercus velutina, Pinus echinata*, and *Pinus virginiana* also are frequent. The understory includes *Acer rubrum, Nyssa sylvatica, Benthamidia* (*Cornus*) *florida, Prunus serotina, Juniperus virginiana, Ilex opaca*, and *Diospyros virginiana*, as well as canopy species. Also frequent are *Oxydendrum arboreum, Crataegus marshallii*, and *Morus rubra*. The shrub layer is sparse to moderate in density. *Ilex decidua, Viburnum prunifolium, Vaccinium pallidum, Rosa carolina,* and *Hypericum hypericoides* occur with high constancy in plots. Other frequent shrubs include

Vaccinium stamineum and *Vaccinium fuscatum*. Additional species noted in whole-site surveys include *Eubotrys racemosus* and *Vaccinium tenellum.*

Vines are prominent in portions. *Smilax rotundifolia* may form tangles, and *Muscadinia rotundifolia* may have substantial cover on the ground. *Parthenocissus quinquefolia, Toxicodendron radicans, Lonicera sempervirens, Campsis radicans*, and the introduced *Lonicera japonica* are highly constant, and *Smilax bona-nox* is frequent. The herb layer is sparse to moderate under current conditions and often is very patchy. *Danthonia spicata* is in all plots and may have moderate cover. Other highly constant or frequent species in plots include *Dichanthelium laxiflorum, Scutellaria integrifolia, Stylosanthes biflora, Endodeca serpentaria, Potentilla canadensis, Asplenium platyneuron, Eupatorium rotundifolia, Euphorbia pubentissima, Galium circaezans, Lespedeza repens, Lespedeza virginica*, and *Clematis ochroleuca*, along with collectively frequent *Carex* spp. Additional notable species reported in site surveys include *Chasmanthium laxum, Hexastylis lewisii, Coreopsis major, Cunila origanoides, Iris verna,* and *Sericocarpus linifolius*.

Range and Abundance: Ranked G2?, but possibly G3. Examples are scattered through the central and eastern Piedmont, with one anomalous possible occurrence in the Coastal Plain. The equivalent association occurs in Virginia and possibly South Carolina.

Associations and Patterns: Mixed Moisture Hardpan Forests occur as large to small patches. Occurrences may be associated with Upland Depression Swamp Forest or Xeric Hardpan Forest, but more often are surrounded by oak–hickory forests.

Variation: Variation is not well known, but two variants are recognized to encourage further investigation of differences.

1. Basic Variant occurs over mafic rock and presumably has soil with relatively high pH and base saturation. *Fraxinus americana*, *Clematis ochroleuca*, *Rosa carolina* and other species more typical of higher pH soil are likely to be present.

2. Acidic Variant occurs on other substrates which produce more typically acidic soils with lower base saturation. The above species are likely to be absent, and *Oxydendrum arboreum*, *Vaccinium pallidum*, *Chimaphila maculata*, and other acid tolerant species are more likely to be present. This variant is less common than the Basic Variant.

Dynamics: The natural dynamics of Mixed Moisture Hardpan Forest are expected to be fairly similar to other Piedmont oak-hickory forests. The difficult rooting environment may make the trees more susceptible to wind throw, but most canopy gaps still appear to be small. This community would naturally be exposed to fire as frequently as the surrounding upland matrix. It would likely burn almost as frequently, but occasional fires might occur during times of wet ground and have little effect on the community. Like the various oak-hickory forests, it probably would be more grassy and more open with regular burning but less so than in oak-hickory forests and much less than in Xeric Hardpan Forest.

It is not known if seasonal or ephemeral aquatic animal communities are present in the small pools of Mixed Moisture Hardpan Forests, but they should be sought.

Comments: There has been uncertainty about the recognition of this community. Mixed Moisture Hardpan Forest appears to be conceptually transitional between Xeric Hardpan Forest and Upland Depression Swamp, in a way that may or may not reflect an important conservation target of its own. Arguments for its recognition include that it often occurs in patches of several acres and that it often occurs without one or both of the communities it is intermediate between. Though not well known, its dynamics may be distinct and not intermediate. This community type is more narrowly defined than other oak forests, perhaps more comparable to a subtype, but there is no type that it can reasonably be nested within. It can be difficult to recognize Mixed Moisture Hardpan Forests in secondary sources. The combination of closely associated patches of Xeric Hardpan Forest and Upland Depression Swamp Forest will sound similar if mixed together in a site description.

Communities with comparable unusual mixtures of wet and dry soil conditions and of wetland and xerophytic plants are known in other parts of the Southeast and are sometimes known by the term "xerohydric." The piedmont gabbro upland depression forest in Georgia described by Sewell and Zomlefer (2014) is a similar hardpan setting. The overall species list suggests a similarly mixed, but much more diverse, community, containing *Quercus michauxii, Quercus shumardii*, and *Quercus oglethorpensis*. However, passing mention of "dry phase" or "wet phase" suggests the presence of segregated communities that are not distinguished. It is unclear if a mixed xerohydric community is also present.

No published literature is known that addresses North Carolina's Mixed Moisture Hardpan Forests, though they may be implicit in some of the limited literature on Xeric Hardpan Forest. They were initially described in several Natural Heritage Program county and regional inventory reports, under the name of "mesic hardpan forest." The placement of it in the Piedmont and Coastal Plain Oak Forests theme is not entirely satisfactory, since communities that are arguably most closely related to it, Xeric Hardpan Forest and Upland Depression Swamp Forest, are in other themes. But because it is intermediate between them, it clearly does not fit in either of those themes. It is in this theme because the combination of xerophytic and wetland vegetation "averages" mesophytic but it is dominated by oaks. True mesophytic species are scarcer than those of either extreme. The vegetation description above is based primarily on CVS plot data, but only five plots represent this community. The constancy values therefore may be of limited accuracy.

Rare species:
Vascular plants – *Swida* (*Cornus*) *racemosa.*

SWAMP ISLAND EVERGREEN FOREST

Concept: Swamp Island Evergreen Forests are evergreen hardwood or hardwood-pine communities occurring on sandy upland islands surrounded by swamps. They are dominated by *Quercus hemisphaerica* and *Pinus taeda,* sometimes *Quercus nigra*, and contain several species otherwise found in North Carolina only in maritime and coastal fringe forests. Natural isolation from fire is thought to be an important determinant of these communities. They are similar to Coastal Fringe Evergreen Forest and could almost as easily fit in the Maritime Upland Forest theme but occur well inland of any maritime community.

Distinguishing Features: Swamp Island Evergreen Forests are distinguished from the various oak-hickory forest types, as well as from Mesic Mixed Hardwood Forest and other inland communities, by the abundant presence of hardwoods more typical of the coastal fringe in North Carolina, most commonly *Quercus hemisphaerica* and *Cartrema americana*, but sometimes including *Quercus virginiana, Quercus geminata*, and other species. They are distinguished from Coastal Fringe Evergreen Forest and Maritime Evergreen Forests by their inland location, and also by the lack of certain characteristic maritime species, such as *Ilex vomitoria* and *Prunus caroliniana*. Swamp Island Evergreen Forests sometimes grade into Pine/Scrub Oak Sandhill, from which they are distinguished by a denser canopy, lack of evidence of present or past abundance of *Pinus palustris*, and scarcity of shade-intolerant species. This distinction may become blurred by logging and long absence of fire.

Crosswalks: *Quercus hemisphaerica - Pinus taeda - (Quercus nigra) / Osmanthus americanus var. americanus / Ilex glabra* Forest (CEGL007022).
G790 Southeastern Evergreen Oak Forest Group.
Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest Ecological System: (CES203.241).
Coastal Fringe Evergreen Forest (Third Approximation).

Sites: Swamp Island Evergreen Forests occur on locally high areas on floodplain terraces, surrounded by wetter floodplain communities. All known examples are associated with medium to large blackwater rivers.

Soils: Soils in all known examples are sandy and well drained. A few are mapped as Aquic Paleudults (Foreston, Johns) or Aquic Quartzipsamments (Pactolus), and many are not distinguished from the map units of the surrounding floodplain, such as Johnston (Cumulic Humaquept) and Dorovan (Typic Haplosaprist).

Hydrology: Moisture levels appear to be dry-mesic to dry, grading to mesic on the edges. The sites are not flooded, though exceptional floods might inundate them briefly. Soils are well drained, but the water table presumably is not deep.

Vegetation: The Swamp Island Evergreen Forest canopy may be dense or somewhat open. *Quercus hemisphaerica* or *Pinus taeda* dominate or codominate. *Quercus nigra* may be abundant, occasionally codominant. No other large trees occur with high frequency, but *Fagus grandifolia, Acer rubrum, Liquidambar styraciflua*, and *Quercus virginiana* occur in some examples. The understory is often dominated by *Quercus hemisphaerica* or *Cartrema americana*. *Ilex opaca,* *Acer rubrum*, and *Persea palustris* are frequent in occurrences. Both wetland species such as *Carpinus caroliniana* and upland species such as *Sassafras albidum* may occur occasionally. The shrub layer is highly variable among examples, and often includes a mix of species typical of both dry and wet habitats. Most frequent in occurrences are *Gaylussacia frondosa, Ilex glabra, Lyonia lucida*, *Vaccinium arboreum*, and *Clethra alnifolia*. Less frequent but notable species include *Asimina parviflora* and *Ilex coriacea*. No vine species appear to be frequent in site descriptions, but *Muscadinia rotundifolia, Parthenocissus quinquefolia*, *Toxicodendron radicans*, and *Smilax* spp. may be present. Herb diversity generally is very low in present examples. *Pteridium pseudocaudatum* and *Mitchella repens* are most frequent and are sometimes mentioned as dominant. *Hexastylis arifolia* is present in multiple sites.

Range and Abundance: Ranked G2G3. In North Carolina, this community is known only in the southern part, associated with the Lumber, Waccamaw, and Northeast Cape Fear rivers and their large tributaries such as Juniper Creek and Big Swamp. The equivalent association is attributed to South Carolina and Georgia, with the redundant association mentioned below extending to the Florida panhandle. Because the characteristic species are more widespread farther south, and because there are larger rivers, this community may be more abundant in those states.

Associations and Patterns: Swamp Island Evergreen Forests occur as small, occasionally large, patches. Most are in the highest locations, but a few grade uphill to sandhill vegetation. They grade downhill to Blackwater Bottomland Hardwoods or Cypress–Gum Swamp.

Variation: No variants are recognized. Examples often are heterogeneous or show a gradient with elevation. Nevertheless, some have more wetland species while others appear very dry and seem transitional to sandhills.

Dynamics: The dynamics of this community have not been studied. It occurs in locations that are sheltered from fire spread by wet, nonflammable vegetation, and this presumably is crucial to their distinctive character. Comparable soils in better connected uplands would support longleaf pine communities. Nevertheless, they may naturally burn occasionally, and this may be important to their dynamics. The coexistence of shade-tolerant *Quercus hemisphaerica* and shade-intolerant *Pinus taeda* may depend on periodic disturbance. It is possible that some examples may be unrecognized former longleaf pine communities, occurring in places where natural fire was barely adequate to maintain their dominance in the past, or possibly where anthropogenic fire was frequent and consistent enough to support them in the past.

The sandy soils also suggest the possibility of excess drainage and drought stress as a source of natural disturbance and contributor to coexistence of species.

Comments: No published literature appears to cover this rare community type, at least in North Carolina. It was recognized in natural heritage site surveys over the last several decades and was only more recently distinguished from Coastal Fringe Evergreen Forest. Besides containing species that are otherwise found only near the coast in North Carolina, Swamp Island Evergreen Forests also share with maritime communities a tendency to contain an unusual mix of species of wet and dry sites, though the dominant species have broad moisture tolerance.

Beyond sheltering from fire, the cause of the distinctive character of the community is not clear. It is unclear why species that are otherwise confined to within a few miles of the coast in North Carolina are able to persist in disjunct inland populations in these sites. Their sites are all in the southernmost part of the state, which is also the only part with large blackwater river floodplains.

Pinus taeda - Quercus hemisphaerica / Osmanthus americanus / Ilex glabra Woodland (CEGL003619) is another swamp island association in the NVC that is attributed to North Carolina. It appears to be largely, if not completely, redundant with the association crosswalked here, other than ranging into the Florida panhandle.

Rare species: No rare species are specifically known to be associated with this community.

HIGH ELEVATION ROCK OUTCROPS THEME

Concept: High Elevation Rock Outcrops are sparsely or patchily vegetated communities of exposed bedrock occurring at higher elevations in the Mountain Region. They have less vegetation, less continuous soil, and more bare rock than Piedmont and Mountain Glades and Barrens, and, though they may contain local wet seepage areas, they lack the distinctive characteristics of the bedrock wetlands of Spray Cliff and Low Elevation Seep (Bedrock Subtype).

Distinguishing Features: High Elevation Rock Outcrop communities are distinguished from Low Elevation Cliffs and Rock Outcrops by the floristic differences associated with elevation. They often contain distinctive species confined to higher elevations, such as *Sibbaldiopsis tridentata, Carex brunnescens, Rhododendron (Menziesia) pilosum, Picea rubens*, and the suite of rare species such as *Houstonia montana*. They are more likely to have some additional species such as *Bryodesma* (*Selaginella*) *tortipilum, Danthonia compressa, Geocarpon* (*Mononeuria, Arenaria*) *groenlandicum*, and *Rhododendron catawbiense*. Other species such as *Toxicodendron radicans, Gelsemium sempervirens, Rhododendron minus, Vaccinium arboreum, Vaccinium stamineum, Pinus virginiana, Juniperus virginiana*, and most *Quercus* species are more likely to occur on low elevation outcrops. All High Elevation Rock Outcrops occur in exposed topographic positions, on mid slope or higher; they may include vertical cliffs or more gently sloping surfaces. The transition from low to high elevation communities is different for the different communities, occurring around 3000 feet for High Elevation Granitic Dome but 4000 feet for High Elevation Rocky Summit.

High Elevation Rock Outcrops are distinguished from Piedmont and Mountain Glades and Barrens and Grass and Heath Balds, as well as from all forest and woodland themes, by their sparse vegetation, limited soil, and large amount of bare rock. High Elevation Rock Outcrops may have patches of denser herbaceous or woody vegetation, but these cover only a minority of the community extent, usually a small minority.

Within the theme, communities are divided into rocky summit and granitic dome communities based on rock structure and its effect on vegetation. Granitic Domes are distinguished by smooth exfoliation surfaces with limited fractures and irregularities. Vegetation is therefore confined to unanchored shallow soil mats, without appreciable deeper crevices or pockets. Rocky Summits usually have substantial irregularities and fractures, though they may include areas of continuous smooth rock formed by bedding or foliation planes or massive beds. A few subtypes may consist largely of these smoother surfaces.

Sites: High Elevation Rock Outcrop communities occur on outcrops of rock that have very little soil cover, because of steepness, high topographic position, and resistance to weathering. They tend to be of weathering-resistant kinds of rock, such as quartzite, granite, gneiss, rhyolite, or related rocks but can also be of mafic or calc-silicate rocks. While High Elevation Granitic Domes are smooth and uniform, High Elevation Rocky Summits tend to be extremely heterogeneous at a fine scale, with expanses of rock often broken by ledges, chutes, overhangs, deep crevices, soil pockets, and aisles between slumped slabs of rock. Small accumulations of fallen boulders are common at the base of steeper outcrops, but larger areas of open talus are rare.

Soils: Soil is limited to shallow mats or accumulations on smooth surfaces or in local small depressions, and to occasional deeper accumulations in crevices. It presumably consists of a combination of marginally weathered rock and organic matter, perhaps with the addition of dust trapped by the vegetation and, potentially, material washed in from above.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. However, moisture availability is extremely heterogeneous on a fine scale. Seepage areas may create small patches of wetland conditions. Slope aspect may also be important in determining moisture status of plants, as is the presence of overhangs. Overhangs and grottos can result from differential strength of rock layers. The climate of high elevations reduces drought stress, as evaporation is lower, rainfall is higher, and fog often bathes many sites. As in spruce-fir forests, fog may be a significant source of moisture, though rocks and herbs may not be as efficient at straining water from it as conifer branches are (Praskievicz and Sigdel 2023).

Vegetation: All rock outcrop communities have limited cover of vascular plants, but their vegetation structure and composition tend to be extremely heterogeneous within occurrences as well as variable among the different communities and among their examples. Moister outcrops and sheltered microsites may have substantial cover of bryophytes, while drier outcrops may have substantial cover of crustose lichens, umbilicate lichens, or more xerophytic mosses. On the bare rock, vascular plants tend to be sparse. A suite of species that can grow on bare rock or minimal soil occurs across many of the communities. It includes several species of *Heuchera, Micranthes (Saxifraga), Asplenium, Bryodesma (Selaginella)*, and *Polypodium*. A further suite of herbs capable of surviving in shallow soil occurs on many outcrops, including drought-tolerant graminoids such as *Danthonia compressa, Schizachyrium scoparium*, and *Carex misera*, forbs such as several *Houstonia* species, *Krigia montana, Sibbaldiopsis tridentata*, and *Geocarpon* (*Mononeuria*) *groenlandicum*, and highly specialized species such as *Liatris helleri* and *Solidago spithamaea*. Other herbs of more general open habitats may be present, such as *Agrostis perennans, Angelica triquinata,* and *Solidago* spp., as well many species shared with surrounding forests. Herbs typical of Low Elevation Rocky Summits, such as *Campanula divaricata, Carex umbellata, Lysimachia quadrifolia,* and *Galax urceolata*, may occur but with lower frequency and mainly in lower elevation or more southerly examples. Trees or shrubs often take root in crevices or other areas with deeper soil. In more fractured outcrops, they may form substantial patches interspersed with the open rock. They may be of any species typical of the high elevations, but *Rhododendron catawbiense* is particularly characteristic. Granitic domes have distinctive vegetation representing stages of primary succession from *Grimmia laevigata* and *Bryodesma (Selaginella) tortipilum* to small herbs to larger grassy patches and eventually to shrubs and small trees.

Dynamics: Most rock outcrop communities appear stable for long time periods, but they are undergoing a slow primary succession as rock weathers, soil accumulates, and plants establish. Outcrops tend to occur where these processes are particularly difficult and slow, due to resistant rock, steepness, and high erosion. Chemical weathering and plant growth are both slower in the cool climate at high elevation, slowing succession, but physical weathering by frost wedging enhances fracturing of rock. Resetting of weathering and primary succession may occur in some outcrops as rare collapse, breaking, or spalling exposes fresh rock. This is particularly important in granitic domes, where exfoliation leads to spalling of the surface. Granitic domes also have a distinctive dynamic because soil mats are not well anchored on the smooth rock and may easily fall, restarting primary succession. Though less dramatic than at lower elevations, maintenance of open rock may also be aided by drought, which can kill established plants with limited rooting depth.

Fire is unlikely to be an important natural influence in most High Elevation Rocky Outcrop communities because of the sparse vegetation. Most are also surrounded by Spruce–Fir Forests or Northern Hardwood Forests, communities that do not naturally burn effectively. However, some are surrounded by High Elevation Red Oak Forest or other oak forests, and these might be exposed to fire more often.

There has been some concern raised by botanists monitoring rare plants that cover of woody vegetation has increased at the expense of rare herbs. It is not clear, however, that a natural process that would control woody growth is missing in most examples. With the exception of the minority that were readily exposed to fire, natural disturbances seem unaltered. Some disturbances, such as human trampling, have increased in many examples. Johnson (1995) found that rare plants on outcrops do suffer from competition with woody plants and that competition seems to be what confines them to the rock outcrop. Johnson (1995) noted that high light levels are considered important, but that high elevation outcrops are frequently in fog, and some rare plants grow in microsites that are shaded by rock. He noted that dryness of outcrops is emphasized, but that rare species occur in the wettest as well as the driest microsites of rock outcrops. He also noted that herbs seem to suffer less from overhanging vegetation than from woody plants rooted in the same patch and suggested root competition may be more important than light competition. This appears reasonable, given the limited rooting volume.

The long-term dynamics of High Elevation Rocky Summit communities are interesting, in that many of their species appear to be remnants from an alpine tundra community that was widespread in the Southern Appalachians during the Pleistocene (Wiser 1993). Many of the rare species associated with them, both endemic and disjunct from the north, likely were once widespread alpine species in North Carolina. See the High Elevation Rocky Summit (Typic Subtype) for more details.

High Elevation Rock Outcrop communities are particularly sensitive to trampling and can be seriously harmed by even light foot traffic or technical climbing. Roots and soils accumulations themselves can be destroyed along with stems and flowering stalks of plants, and regrowth is slow in the harsh environment. Many plant populations are very small, confined to limited microsites. Easy public access is often the greatest threat to High Elevation Rock Outcrop communities.

Comments: High Elevation Rock Outcrops are better studied than most sparsely vegetated communities, thanks to a comprehensive quantitative classification study (Wiser et al. 1996).

KEY TO HIGH ELEVATION ROCK OUTCROPS

1. Community on exfoliated granitic gneiss, granite, or related massive rocks; surface smooth, often curving from gentle to steep, with few or no deep fractures or crevices; vegetation, other than lichens and mosses on bare rock, consisting largely of plants in shallow soil mats, with *Bryodesma (Selaginella) tortipilum* usually dominant. Larger plants, where present, also rooted in shallow soil mats. (Consider also Low Elevation Granitic Dome if near 3000 feet elevation)............................ ………………………………………………………………….. **High Elevation Granitic Dome**

1. Community not on exfoliated gneiss, granite, or related massive rocks; if surface smooth and with limited deep fractures or crevices, then rock of other types and the surface a bedding plane or foliation surface, not smoothly curving; vegetation not consisting primarily of plants in shallow soil mats; vegetation a patchy mix of herbaceous and woody species rooted in deeper crevices and soil pockets along with plants on bare rock, or vegetation consisting solely of umbilicate lichens on bare rock.

  2. Vegetation sparse overall but generally patchy, with lichens, bryophytes, sparse herbs on bare rock, herbs in shallow soil mats, and herbs and woody species rooted in limited deeper soil patches; rock outcrop generally fractured and heterogeneous, and with abundant crevices, fractures, ledges, and other microsites, but possibly a smooth surface of amphibolite or related mafic rock with few fractures.

    3. Rock outcrop a smooth, relatively unfractured surface of amphibolite or related rock; aspect generally south or west; vegetation containing a mix of typical high elevation rocky outcrop species such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*, with species typical of lower elevations, such as *Schizachyrium scoparium* and *Coreopsis major*. (Consider High Elevation Mafic Glade if vegetation cover is high over the whole community) ....**High Elevation Rocky Summit (Little Bluestem Basic Subtype)**

    3. Rock outcrop heterogeneous, generally moderately or highly fractured, with crevices, fractures, ledges, and other varying microsites; any type of rock and any aspect

      4. Rock outcrop occurring at elevations above 5500 feet, or somewhat lower but with a limited flora that lacks species of lower elevations; typically dominated by *Heuchera villosa, Carex misera, Micranthes petiolaris*, *and* species shared with Spruce–Fir Forests................ ....**High Elevation Rocky Summit (High Peak Subtype)**

      4. Rock outcrop occurring at elevations below 5500 feet, or if somewhat higher, containing at least some plant species typical of lower elevations, such as *Kalmia latifolia, Amelanchier arborea, Vaccinium pallidum, Danthonia spicata, Krigia montana,* and *Dichanthelium acuminatum*.

        5. Rock outcrop a steep slope or cliff facing north or east; composed of amphibolite; with vegetation containing abundant *Physocarpus opulifolius, Packera plattensis*, and *Phlox subulata* .... **High Elevation Rocky Summit (Ninebark Basic Subtype)**

        5. Rock outcrop steep or gentle; composed of any kind of rock; vegetation generally with a mix of species and growth forms, but without *Physocarpus, Packera*, and *Phlox* predominant; species of base-rich conditions are limited …………………………….. ……………………………………..**High Elevation Rocky Summit (Typic Subtype)**

  2. Rock outcrop vegetation consisting almost solely of the lichens *Lasallia papulosa* and *Lasallia caroliniana* on bare rock; vascular plants extremely limited or absent in most of the community; rock outcrop a smooth surface with few fractures, generally occurring on highly acidic rock such as quartzite ..... **High Elevation Rocky Summit (High Peak Lichen Subtype)**

HIGH ELEVATION ROCKY SUMMIT (TYPIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations, generally above 4000 feet. Vegetation of Rocky Summits is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The Typic Subtype covers most examples, lacking the distinctive characteristics of other subtypes. Their substrates range from felsic to mafic but they lack a strong component of flora associated with basic soils or with the highest elevations.

Distinguishing Features: High Elevation Rocky Summits are distinguished from forests, shrublands, and grasslands by a structure of sparse vegetation or herbaceous vegetation of moderate cover with extensive bare rock. Patches of shrub cover are generally present on edges or in pockets of deep soil, but large areas of shrub dominance should be considered Heath Balds. High Elevation Rocky Summits are distinguished from High Elevation Granitic Domes by having abundant fractured rock, in contrast to the largely smooth exfoliated bedrock of the domes. Montane Cliff communities generally occur at lower elevation than 4000 feet; they also are distinguished not by steepness but by a more topographically sheltered setting, below mid slope or protected by gorge walls or other topography.

High Elevation Rocky Summits are distinguished from Low Elevation Rocky Summits by the general absence of low elevation plants such as *Diodia teres, Phemeranthus (Talinum) teretifolius, Bryodesma (Selaginella) rupestre*, and *Quercus montana*. High elevation plants that are generally absent in Low Elevation Rocky Summits include *Sibbaldiopsis tridentata, Trichophorum cespitosum, Carex brunnescens, Geum radiatum, Liatris helleri, Solidago spithamaea, Houstonia montana, Rhododendron (Menziesia) pilosum, Abies fraseri, Picea rubens*, and *Sorbus americana*.

The Typic Subtype is distinguished from the High Peak Subtype by the presence of plants generally absent at the highest elevations. These include *Kalmia latifolia, Amelanchier arborea, Vaccinium pallidum, Danthonia spicata, Krigia montana, Carex umbellata*, and *Dichanthelium acuminatum*. The Typic Subtype is distinguished from the Little Bluestem Basic Subtype by the absence or minor role of warmer site plants characteristic of that subtype, such as *Schizachyrium scoparium* and *Coreopsis major*; it also has more typical cool site plants such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*. It is distinguished from the Ninebark Basic Subtype by the absence or scarcity of *Phlox subulata ssp. subulata, Packera plattensis* (*Senecio*) *plattensis*, and *Physocarpus opulifolius*.

Crosswalks: *Saxifraga michauxii - Carex misera - Danthonia spicata - Krigia montana* Rocky Summit (CEGL004279).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: High Elevation Rocky Summits of the Typic Subtype occur on peaks, ridge tops, upper slopes, and potentially mid slopes that are not topographically sheltered. They may consist of any kind of rock. The rock lacks the continuous smooth surface created by exfoliation. It generally is fractured or irregular, but areas of smooth surface created by bedding planes, foliation, or joints may occasionally be extensive. Fractures and varying hardness of rock layers can create complex structure, including surfaces that are flat, sloping, vertical, or overhanging, and microsites such as ledges, crevices, chutes, and pockets of deeper soil.

Soils: Soil is limited to local small depressions and to occasional deeper accumulations in crevices or pockets. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may locally include soil washed in from above.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. However, moisture availability is extremely heterogeneous on a fine scale. Local microsites may concentrate or trap rainwater and runoff, creating moist conditions. Seepage areas may create small patches of wetland conditions. Overhangs may create humid microsites even in exposed sites and these may or may not be blocked from direct rainfall. The climate of high elevations reduces drought stress, as evaporation is lower, rainfall is higher, and fog often bathes many sites.

Vegetation: High Elevation Rocky Summit vegetation tends to be patchy and mixed in structure. The extensive rock areas may include herbs able to root on bare rock and species of shallow soils. Deeper soil patches and deep crevices often have shrubs or even trees. Herbs found by Wiser et al. (1996) to have moderate to high constancy in one or both of the clusters that are equivalent to the Typic Subtype include *Micranthes (Saxifraga, Hydatica) petiolaris, Athyrium asplenioides, Danthonia spicata, Carex misera, Hylotelephium telephioides, Sibbaldiopsis tridentata, Heuchera villosa, Krigia montana, Polypodium appalachianum, Agrostis perennans, Rumex acetosella,* and *Angelica triquinata*. Site reports show largely the same set of species occurring frequently. Several rare species are also fairly high in frequency, at least in examples in the northern part of the state, including *Houstonia montana* and *Geum radiatum*. Other species that may occur with lower frequency include *Solidago glomerata, Deschampsia cespitosa* ssp. *glauca, Danthonia compressa, Oreojuncus trifidus, Sanguisorba canadensis, Geocarpon* (*Mononeuria, Minuartia) groenlandicum, Liatris helleri,* and *Trichophorum cespitosum*. Herbs typical of Low Elevation Rocky Summits, such as *Schizachyrium scoparium, Campanula divaricata, Carex umbellata, Lysimachia quadrifolia,* and *Galax urceolata*, may occur but with lower frequency and mainly in lower elevation or more southerly examples. Shrubs that occur with at least fairly high frequency include *Rhododendron catawbiense, Sorbus americana, Vaccinium corymbosum, Vaccinium erythrocarpum*, *Rhododendron pilosum*, and *Diervilla sessilifolia.* Less frequent are *Physocarpus opulifolius, Aronia arbutifolia, Hypericum buckleyi, Viburnum cassinoides, Clethra acuminata, Gaylussacia baccata*, and species shared with lower elevations such as *Kalmia latifolia*. What trees are present also reflect the high elevation, with *Sorbus americana* and *Betula alleghaniensis* having high frequency and *Picea rubens* and *Abies fraseri* occurring if there is a seed source nearby. *Pinus* spp., *Quercus* species other than *rubra*, and other species of lower elevations are uncommon.

Range and Abundance: Ranked G2. Examples are scattered in the higher mountain ranges of North Carolina but are more abundant in the northern mountains of the state. This community also occurs in Tennessee but is not known in the other Southern Appalachian states. Different associations represent the rocky summits in Virginia.

Associations and Patterns: High Elevation Rocky Summits are small patch communities. Most examples of the Typic Subtype are a few acres at most, but larger complexes may add up to more than 10 acres. They may be associated with Heath Bald or Grassy Bald communities, but otherwise are surrounded by high elevation forests of the Spruce-Fir Forests and Northern Hardwood Forests themes, or by High Elevation Red Oak Forest or the highest extents of Montane Oak–Hickory Forest.

Variation: Three variants are recognized, to call attention to a distinctive specialized environment that needs further study and may warrant higher level recognition. Further variants may need to be recognized.

1. Typic Variant has the characteristics described above. It remains heterogeneous and may warrant further subdivision. It includes two plot clusters recognized by Wiser, et al. (1996) as *Paronychia-Polypodium* and *Deschampsia-Angelica*. Both are associated with mafic rock but do not have flora suggestive of strong basic influence. Additional examples of the Typic Variant, not sampled by Wiser or not distinguished in analysis, occur on felsic rock, including several that are transitional to Low Elevation Rocky Summit and have a component of lower elevation species. These could potentially be recognized as variants.

2. Anakeesta Variant occurs in the Great Smoky Mountains and is believed to be tied to outcrops of the Anakeesta slate, a rock that is not only felsic but often sulfidic. It was distinguished by Wiser, et al. (1996) as the *Calamagrostis cainii-Rhododendron carolinianum* community; it was later recognized in NVC as the *Saxifraga michauxii - Carex misera - Calamagrostis cainii* Grassland association CEGL004278). The rhododendron has since been recognized as a distinct species: *Rhododendron smokianum*. The published description includes mention of *Rugelia nudicaulis*, another species endemic to the Great Smoky Mountains, as well as of very high elevation species such as *Abies fraseri*. This variant may well warrant recognition as a subtype. It is unclear if the properties of Anakeesta slate or the biogeography of the Great Smoky Mountains is most important in its character. Its relationship to other subtypes there needs further investigation.

3. Ice/Rock Fall Variant is a distinctive open community that rarely forms at the base of vertical Rocky Summit or Granitic Dome cliffs where substantial amounts of ice form in the winter and fall to the base of the cliff. This variant is analogous in ecological process to the ice pond community of South Carolina (Hill 1999) but is much higher in elevation and consequently is rather different floristically. Its environment is a relatively level terrace of fallen boulders and soil at the base of the cliff, with small areas of water impounded by the accumulation of the terrace. Its flora includes boulderfield and wetland species as well as typical Rocky Summit species, some of which apparently established after falling from the rock above. It may warrant recognition as a distinct subtype, with further study.

Dynamics: High Elevation Rocky Summits are generally among the most stable of rocky outcrop communities. They are less likely to experience undercutting and collapse than cliffs, though some examples are still prone to it. With their deep rooting sites in crevices and deeper soil pockets, they are less likely to have vegetation mats slough off than are granitic domes. They are subject to stress and potential mortality of established vegetation caused by drought, though less so than lower elevation rock outcrops. Extreme cold and ice are distinctive potential disturbances. In the Ice/Rock Fall Variant, and potentially in lower parts of some Typic Subtype examples, battering by falling material may be a chronic or intermittent disturbance.

High Elevation Rocky Summits are interesting for their potential long-term dynamics. The Southern Appalachians are believed to have had a broad alpine tundra zone during the Pleistocene glaciation, with a timberline around 4400 feet (Delcourt and Delcourt 1985, 1988). Wiser (1993) noted that the tree line likely would have been lower in highly exposed sites. The 4000 foot lower elevation range for High Elevation Rocky Summit corresponds to this. Her analysis of biogeographic affinities and growth forms suggests that 17% of the 288 vascular plant species she found on high elevation rock outcrops are likely relicts of alpine tundra that has otherwise been replaced by forests. This includes a number of species shared with northern alpine communities, such as *Deschampsia cespitosa* and *Oreojuncus trifidus*, and endemic species such as *Carex misera, Carex biltmoreana, Solidago glomerata*, and *Geum radiatum*. Many of these species are now confined to High Elevation Rocky Summits, while others occur largely in them in combination with Grassy Balds or High Elevation Boggy Seeps. The exceptionally large number of rare species associated with High Elevation Rocky Summits is at least partly a result of this history and of their role as refugia for once-abundant species of alpine tundra.

Comments: This subtype encompasses two plot clusters distinguished by quantitative analysis by Wiser (1993). However, the two clusters are the most closely related in the analysis, and most of the highly constant species in each are also at least frequent in the other. A third cluster, called *Aronia/Kalmia* appears to represent more shrubby zones in the Typic Subtype, and is described as transitional to Heath Bald.

Aronia melanocarpa - Gaylussacia baccata / Carex pensylvanica Shrubland (CEGL008508) is a G1? rock outcrop association defined in Virginia and stated to potentially be in North Carolina. It is described as a mosaic of shrub patches, herb patches, and bare rock. If something like it occurs, it might fit as a subtype of High Elevation Rocky Summit or might be a kind of glade.

In addition to the large number of rare plants and handful of rare animals listed below, High Elevation Rocky Summits may share with Spruce-Fir Forests a number of globally rare beetle species in genera such as *Trechus* and *Arianops*, some of them endemic to single North Carolina mountain ranges.

Rare species:
Vascular plants – *Agrostis mertensii, Allium allegheniense, Betula cordifolia, Calamagrostis cainii, Calamagrostis canadensis* var. *canadensis, Campanula rotundifolia, Cardamine clematitis, Chelone cuthbertii, Clematis occidentalis, Crocanthemum bicknellii, Crocanthemum propinquum, Cystopteris fragilis, Dendrolycopodium dendroideum, Geocarpon* (*Minuartia*) *groenlandicum, Geum radiatum, Gymnocarpium appalachianum, Houstonia montana, Huperzia appressa* (*appalachiana*), *Koeleria spicata* var. *spicata*, *Liatris helleri, Lilium grayi, Lilium philadelphicum* var. *philadelphicum, Micranthes caroliniana, Oreojuncus trifidus, Phlox subulata, Polygala senega, Rhodiola rosea, Rhododendron vaseyi, Robinia hispida* var. *kelseyi, Solidago spithamaea, Triantha glutinosa, Trichophorum cespitosum, Woodsia appalachiana,* and *Woodsia ilvensis*.

Nonvascular plants – *Barbilophozia barbata, Barbilophozia hatcheri, Bazzania nudicaulis, Bryoerythrophyllum ferruginascens, Campylopus atrovirens, Cetraria arenaria, Cirriphyllum piliferum, Didymodon tophaceus, Diplophyllum taxifolium* var. *mucronatum, Ephebe americana, Gymnoderma lineare, Lecanora anakeestiicola, Leptodontium flexifolium, Melanelia stygia, Metzgeria violacea, Mylia taylorii, Polytrichastrum alpinum, Porpidia contraponeda, Rhytidium rugosum, Scapania mucronata, Sphagnum capillifolium, Sphagnum pylaesii, Sphagnum subsecundum, Sphagnum tenellum, Sphenolobus saxicola, Tritomaria exsectiformis* ssp. *exsectiformis,* and *Xanthoparmelia monticola*.

Vertebrate animals – *Falco peregrinus anatum* and *Neotoma magister*.

HIGH ELEVATION ROCKY SUMMIT (HIGH PEAK SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. Vegetation is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The High Peak Subtype covers examples in topographically exposed settings at the highest elevations, where even mid-elevation species are largely absent. Most are above 5500 feet.

Distinguishing Features: The High Peak Subtype is distinguished from other subtypes of High Elevation Rocky Summit and from all other open communities by occurring at the highest elevation locations, generally above 5500 feet, surrounded by Spruce–Fir Forests or Heath Balds, combined with a limited flora that lacks species of lower elevation rock outcrops. Species typically completely lacking in this subtype include *Kalmia latifolia, Amelanchier arborea/laevis, Vaccinium pallidum, Danthonia spicata, Krigia montana,* and *Dichanthelium acuminatum*, while a small number of rock outcrop species such as *Heuchera villosa, Carex misera, Micranthes petiolaris*, and species shared with Spruce–Fir Forests are prominent.

Crosswalks: *Saxifraga michauxii - Carex misera - Oclemena acuminata - Solidago glomerata* Rocky Summit (CEGL004277).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: The High Peak Subtype occurs near the tops of peaks and ridge tops, at elevations generally above 5500 feet. The rock is generally highly resistant felsic rock or quartzite. In known examples the rock tends to be highly fractured.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter.

Hydrology: This subtype may be less dry than most rock outcrops. The high elevation locations are subject to frequent fog as well as high rainfall and have limited evaporation in the cool temperatures. The fractured rock also may provide places for water to accumulate or be retained.

Vegetation: Vegetation of the High Peak Subtype is the typical mix of sparse vegetation on bare rock with patches of shrubs and trees in deeper soil pockets. Herbs with high constancy in Wiser, et al. (1996) include *Micranthes* (*Hydatica*, *Saxifraga*) *petiolaris, Carex misera, Oclemena acuminata, Solidago glomerata*, and *Heuchera villosa*. Other fairly frequent species include *Houstonia serpyllifolia, Athyrium asplenioides, Chelone lyonii, Angelica triquinata, Polypodium appalachianum,* and *Carex brunnescens*. Shrubs and trees with high constancy include *Sorbus americana, Rhododendron (Menziesia) pilosum,* and *Abies fraseri*, while *Vaccinium erythrocarpum* is fairly frequent. Only a few other species were found in the plots, including *Vaccinium corymbosum, Rhododendron catawbiense, Aronia arbutifolia, Rubus strigosus* (*idaeus*)*, Phegopteris connectilis, Trichophorum cespitosum, Eurybia cordifolia,* and *Houstonia serpyllifolia*.

Range and Abundance: Ranked G1. This community is limited to a handful of occurrences on high peaks, primarily on Grandfather Mountain, Roan Mountain, and in the Black Mountains. It also occurs in the Tennessee, probably solely at Roan Mountain and the Great Smoky Mountains.

Associations and Patterns: The High Peak Subtype is a small patch community. Though individual patches are mostly small, larger clusters may add up to 10 acres or more. It is generally surrounded by Fraser Fir Forest, Red Spruce–Fraser Fir Forest, or Heath Bald.

Variation: The High Peak Subtype is a relatively narrowly defined community with limited variation.

Dynamics: The dynamics of the High Peak Subtype are probably similar to the Typic Subtype and to High Elevation Rocky Summits in general.

Comments: The High Peak Subtype was distinguished from the Typic Subtype by quantitative analysis in Wiser (1993). Besides the primary cluster that is equivalent to this subtype, called *Aster acuminatus/Menziesia pilosa*, there was a woody-dominated cluster that appears to represent shrub patches in this subtype, called *Picea rubens/Leiophyllum buxifolium*.

Rare species:
Vascular plants – *Agrostis mertensii, Calamagrostis cainii, Geocarpon* (*Minuartia*) *groenlandicum, Geum radiatum, Houstonia montana, Huperzia appressa* (*appalachiana*), *Koeleria spicata* var. *spicata*, *Liatris helleri, Oreojuncus trifidus, Phegopteris connectilis, Rhodiola rosea, Rubus strigosus* (*idaeus*), *Solidago spithamaea,* and *Trichophorum cespitosum.*

Nonvascular plants – *Gymnoderma lineare, Leptodontium flexifolium, Mylia taylorii, Plagiochila sullivantii, Rhytidium rugosum, Sphenolobus saxicola,* and *Polytrichastrum alpinum*.

Vertebrate animals – *Desmognathus wrighti.*

HIGH ELEVATION ROCKY SUMMIT (LITTLE BLUESTEM BASIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations, generally above 4000 feet. The Little Bluestem Basic Subtype is a very rare community on southern or western exposures of base-rich rock — amphibolite, other mafic rock, or other basic substrates or influenced by base-rich seepage. While not strongly calciphilic, the flora contains species not otherwise common in High Elevation Rocky Summits. The warm exposure allows some lower elevation plants to mix with high elevation species. It thus shares characteristics with both High Elevation Mafic Glade and Low Elevation Rocky Summit.

Distinguishing Features: High Elevation Rocky Summits are distinguished from forests, shrublands, and grasslands by a structure of sparse vegetation or herbaceous vegetation of moderate cover with extensive bare rock. Patches of shrub cover are generally present on edges or in pockets of deep soil but are limited. High Elevation Rocky Summits are distinguished from High Elevation Granitic Domes by having abundant fractured rock, in contrast to the largely smooth exfoliated bedrock of the domes. Montane Cliff communities generally occur at lower elevation, below 4000 feet; they also are distinguished not by steepness but by a more topographically sheltered setting, below mid slope or protected by gorge walls or other topography.

The Little Bluestem Basic Subtype is distinguished from other subtypes of High Elevation Rocky Summit by the occurrence of abundant *Schizachyrium scoparium, Coreopsis major*, and other species more typical of lower elevations. It is distinguished from Low Elevation Rocky Summit and Low Elevation Basic Glade by the presence of typically high elevation species such as *Sibbaldiopsis tridentata, Angelica triquinata*, and *Sorbus americana*. It is distinguished from High Elevation Mafic Glade by lower vegetation cover and more extensive bare rock. While the flora suggests basic soil conditions and research has shown soils to be high in base cations, not all examples are on mafic rocks. Some occur on normally acidic rocks which have some seepage, presumably because the seepage brings higher concentrations of base cations.

Crosswalks: *Schizachyrium scoparium - Saxifraga michauxii - Coreopsis major* Rocky Summit (CEGL004074).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: The High Peak Subtype occurs on ridgetops or uppermost slopes. Examples are known from 4100 to over 5000 feet. Most examples known are in the Amphibolite Mountains area in the northwestern corner of the state. Outcrops are generally surfaces of slab-like fractured rock that slope to face south or west. While fractures are more abundant than in High Elevation Granitic Domes, there is fairly extensive continuous rock. The rock is usually amphibolite, but other kinds of rock in the vicinity of amphibolite can support the community, apparently influenced by movement of cation-rich water from the amphibolite.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter. Soils sampled in Wiser (1993) plots were higher in pH, magnesium, and manganese than other High Elevation Rocky Summits.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. The extensive continuous rock surface limits the amount of water accumulation and seepage, and the dry slope aspect of the Little Bluestem Basic Subtype makes it drier than other subtypes. However, small seepage areas with saturated conditions may still be present.

Vegetation: Vegetation of the Little Bluestem Basic Subtype is a mix of sparse vegetation on bare rock, herb-dominated shallow soil mats, and some woody vegetation in deeper pockets or crevices. More of the vegetation is herbs than in other subtypes. The flora includes both species common to most High Elevation Rocky Summits and species shared with Low Elevation Rocky Summits. Herbs with constancy over 50% in Wiser (1993) and Wiser et al. (1996) plots are *Schizachyrium scoparium, Coreopsis major, Krigia montana, Dichanthelium acuminatum, Danthonia spicata, Paronychia argyrocoma*, and *Micranthes* (*Hydatica*) *petiolaris*. Other herbs with fairly high frequency include *Allium cernuum, Viola sagittata, Solidago bicolor, Campanula divaricata, Houstonia caerulea, Carex umbellata, Hylotelephium telephioides, Heuchera villosa, Polypodium appalachianum, Avenella (Deschampsia) flexuosa,* and *Agrostis perennans*. Less frequent but notable herbs include *Danthonia sericea, Sibbaldiopsis tridentata, Houstonia longifolia* var. *glabra, Carex brunnescens, Carex misera,* and *Asplenium montanum*. Seeps may contain species such as *Sanguisorba canadensis, Oxypolis rigidior, Thalictrum clavatum*, and *Drosera rotundifolia*. The highest constancy woody species, all generally with low cover in plots, are *Rhododendron catawbiense, Kalmia latifolia*, and *Quercus rubra*, while *Physocarpus opulifolius, Vaccinium pallidum*, and *Vaccinium corymbosum* also are frequent. Additional high elevation species such as *Betula alleghaniensis* and *Sorbus americana* may occur.

Range and Abundance: Ranked G1. The Little Bluestem Basic Subtype is largely limited to the Amphibolite Mountains in Ashe County but may be found in a few other places. Only a handful of well-developed occurrences is known. The NVC association is also attributed to Tennessee.

Associations and Patterns: The Little Bluestem Basic Subtype is a small patch community. Occurrences may be up to a few acres in size. They may occur near other subtypes of High Elevation Rocky Summit. They are usually surrounded by High Elevation Red Oak Forest (Rich Subtype) or Northern Hardwood Forest (Rich Subtype).

Variation: This is a narrowly defined community. It varies primarily in transitions to adjacent communities.

Dynamics: The dynamics of the Little Bluestem Basic Subtype are similar to High Elevation Rocky Summits in general. Because of their drier site conditions, drought may be an important natural disturbance. Fire may be a natural influence in the peripheral parts, but fire is unlikely to carry through the sparse vegetation.

Comments: This subtype was distinguished in analysis by Wiser (1993). It was the most distinct cluster in her analysis, but likely would appear less distinct if Low Elevation Rocky Summits had been included. It appears only marginally distinct from High Elevation Mafic Glade, but the lower plant cover and greater importance of bare rock tie it to High Elevation Rocky Summit. The influence of higher base richness makes it somewhat analogous to the Basic Subtype of Low Elevation Rocky Summit.

Rare species:
Vascular plants – *Allium allegheniense, Calamagrostis canadensis* var. *canadensis, Campanula rotundifolia, Clematis occidentalis* var. *occidentalis, Cystopteris fragilis, Geum radiatum, Gymnocarpium appalachianum, Houstonia montana, Huperzia appalachiana, Liatris aspera, Liatris helleri, Lilium grayi, Micranthes caroliniana, Phlox subulata, Trichophorum cespitosum, Woodsia appalachiana,* and *Woodsia ilvensis*.

Nonvascular plants – *Campylopus atrovirens, Cetraria arenaria, Gymnoderma lineare,* and *Rhytidium rugosum*.

HIGH ELEVATION ROCKY SUMMIT (NINEBARK BASIC SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. Vegetation is sparse or patchy, with substantial amounts of bare rock, and is generally characterized by a mix of growth forms or by predominantly forbs and sparse woody vegetation. The Ninebark Basic Subtype encompasses very rare examples on vertical amphibolite cliffs of cool slope aspect, with sparse vegetation dominated by *Physocarpus opulifolius, Phlox subulata*, and *Packera (Senecio) plattensis*. This subtype lacks many of the typical Rocky Summit plants and is conceptually transitional to Montane Cliff. It is known from Bluff Mountain, and this may be the only well-developed example.

Distinguishing Features: The Ninebark Basic Subtype is distinguished by amphibolite substrate and sparse vegetation dominated by *Physocarpus opulifolius, Packera plattensis*, and *Phlox subulata*.

Crosswalks: *Physocarpus opulifolius / Campanula divaricata - Tradescantia subaspera* - (*Packera plattensis)* Cliff Sparse Vegetation (CEGL004759).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: The known Ninebark Basic Subtype occurrence is on steep, cliff-like outcrops of amphibolite, on upper slopes, facing north or east. It is unclear if the vertical orientation or the slope aspect is crucial for its occurrence.

Soils: Soil is limited to local small depressions and to deeper accumulations in fractures. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may include some material washed in from above.

Hydrology: The Ninebark Basic Subtype has extensive dry area because of the lack of soil, but the northerly slope aspect reduces evaporation and creates less xeric conditions than in most High Elevation Rocky Summits. Some seepage areas may be present.

Vegetation: Vegetation in the Ninebark Basic Subtype is sparse overall, but may have patches dominated by herbs or shrubs, both as shallow soil mats on flatter surfaces and plants rooted in fractures. Herbs include *Tradescantia subaspera, Packera plattensis, Phlox subulata*, *Houstonia purpurea, Houstonia longifolia* var. *glabra*, *Deschampsia cespitosa* var. *glauca, Carex misera, Capnoides* (*Corydalis*) *sempervirens, Campanula divaricata, Coreopsis major, Polygala senega, Arabidopsis lyrata* ssp. *lyrata*, *Schizachyrium scoparium, Helianthus divaricatus, Danthonia compressa, Solidago bicolor*, and *Polygala senega*. Woody species include *Physocarpus opulifolius, Kalmia latifolia, Rhododendron catawbiense*, and *Tsuga caroliniana*.

Range and Abundance: Ranked G1? but the G1 status is clearer than many other communities. No more than a handful of examples exist, perhaps only one. The NVC association, however, is attributed to Tennessee as well as North Carolina.

Associations and Patterns: The Ninebark Basic Subtype is a small patch community, with patches potentially up to several acres. They may have more vertical surface than horizontal. The well-known example is associated with Carolina Hemlock Forest and Montane Oak-Hickory Forest, but other forest communities are possible.

Variation: This is a very narrowly defined community. Nothing is known about variation other than the normal heterogeneity of rock outcrop communities.

Dynamics: Nothing specific is known about the dynamics of this subtype. The steepness presumably makes it more susceptible to rock falls.

Comments: This community type is not well understood, and it is included only provisionally because the basis for its distinctness is not entirely clear. It was recognized as an association in the NVC, clearly based on the Bluff Mountain occurrence, but it is now attributed to Tennessee as well. Wiser (1993) did not find it distinct; with only two plots in it, data may not have been sufficient. The plots clustered with the Little Bluestem Basic Subtype. However, its vegetation reflects the cooler microclimate of the northeast-facing slope.

Rare species:
Vascular plants – *Allium allegheniense, Calamagrostis canadensis* var. *canadensis, Campanula rotundifolia, Geocarpon* (*Minuartia*) *groenlandicum, Geum radiatum, Houstonia montana, Liatris aspera, Liatris helleri, Micranthes caroliniana, Muhlenbergia glomerata, Packera paupercula var. appalachiana, Phlox subulata,* and *Woodsia ilvensis.*

Nonvascular plants – *Campylopus atrovirens* var. *atrovirens*, *Dichodontium pellucidum, Leptodontium flexifolium, Lejeunea cavifolia,* and *Rhytidium rugosum*.

HIGH ELEVATION ROCKY SUMMIT (HIGH PEAK LICHEN SUBTYPE)

Concept: High Elevation Rocky Summits are communities of flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings, at high elevations. The High Peak Lichen Subtype covers rare examples of steep to gently sloping, dry, smooth outcrops at high elevations, where shallow soils mats are nearly absent and vegetation consists almost entirely of the umbilicate lichens *Lasallia papulosa* or *Lasallia caroliniana*, along with crustose lichens. They are conceptually intermediate between High Elevation Rocky Summit and High Elevation Granitic Dome in having smooth, minimally fractured rock surfaces.

Distinguishing Features: The High Peak Lichen Subtype is distinguished from all other communities by the dominance of *Lasallia papulosa* or *Lasallia caroliniana*, the scarcity of vascular plants, and the absence or near absence of both crevices and shallow soil herb mats.

Crosswalks: *Lasallia papulosa - Lasallia caroliniana* Nonvascular Vegetation (CEGL004386).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).
High Elevation Granitic Dome (High Peak Lichen Subtype) (earlier 4^{th} Approximation drafts).

Sites: The High Peak Lichen Subtype occurs on outcrops that are relatively continuous and unfractured but that are not exfoliated granitic rock. They occur on upper slopes or spur ridges at high elevations. The rock is quartzite in known examples, but other kinds of rock are possible.

Soils: Almost no soil is present. Even shallow accumulations of material in crevices or pockets are scarce or absent.

Hydrology: The High Peak Lichen Subtype is dry because of the lack of soil and exposure to wind and sun. However, the cool moist climate, high rainfall, and frequent fog at high elevation ameliorates the dry conditions to some degree. Generally little or no seepage is present.

Vegetation: The High Peak Lichen Subtype is vegetated almost solely by the lichens *Lasallia papulosa* and *Lasallia caroliniana* growing on bedrock. Vascular plants are largely absent.

Range and Abundance: Ranked G2? but probably rarer. The number of occurrences is not well known, and depends on uncertainties of circumscription, but no more than a handful of occurrences are likely. The NVC association is also attributed to Tennessee.

Associations and Patterns: The High Peak Lichen Subtype is a small patch community. Because some examples are steep, their vertical extent may be greater than their map extent. Associations are not well known. This subtype may occur in association with other subtypes. Otherwise, it may be surrounded by various kinds of high elevation forests, or potentially Heath Bald.

Variation: This is a narrowly defined community that has little known variation.

Dynamics: Nothing specific is known of the dynamics of the High Peak Lichen Subtype. They likely are very stable. The lichens are extremely vulnerable to trampling, so any examples that are not steep and are accessible may be among the most sensitive of communities to visitation.

Comments: The High Peak Lichen Subtype remains one of the most poorly understood of the communities in the 4th Approximation. It is not well known to the author and is not well described in site reports. Only a single CVS plot is known to represent it; Wiser (1993) and CVS did not generally distinguish lichen species. The limited number of people who can distinguish and who report on the different species of umbilicate lichens makes collecting information difficult.

This subtype was treated as a subtype of High Elevation Granitic Dome in early drafts, based on its NVC characterization as occurring on exfoliation slopes. But it was initially defined on Grandfather Mountain and indicated to likely occur in the Roan Mountain area. Neither mountain has well-developed granitic domes, though smooth dip slope surfaces that resemble exfoliation faces are locally present. Additional vertical, smooth quartzite cliffs covered with umbilicate lichens in the Black Mountains may also be this community. While the large High Elevation Granitic Domes farther south in the mountains sometimes have extensive faces dominated by umbilicate lichens, these do not represent this community, which is confined to higher peaks north of Asheville. The move from High Elevation Granitic Dome remains somewhat uncertain, but the association with rocky summits and higher elevation appear to make it a better fit.

Rare species: No rare species are known to be specifically associated with this community.

HIGH ELEVATION GRANITIC DOME

Concept: High Elevation Granitic Domes are communities of large, smooth, exfoliation surfaces of granitic rock, occurring at higher elevations than Low Elevation Granitic Domes, generally above 3000 feet. Vegetation consists primarily of lichens on bare rock or of shallow mats generally dominated by *Bryodesma (Selaginella) tortipilum*.

Distinguishing Features: High Elevation Granitic Domes are distinguished from Low Elevation Granitic Domes by elevation and vegetation. The elevational boundary is around 3000 feet, but the types may overlap somewhat. Species that occur in High Elevation Granitic Domes but seldom in Low Elevation Granitic Domes include *Carex misera, Carex biltmoreana, Trichophorum cespitosum, Danthonia compressa, Hypericum buckleyi, Packera millefolium,* and *Robinia hartwigii*. Species that occur in Low Elevation Granitic Domes but seldom or less often in High Elevation include *Bryodesma rupestre, Danthonia spicata, Hypericum gentianoides, Hexasepalum (Diodia) teres, Phemeranthus teretifolius, Phlox nivalis ssp. hentzii, Rhododendron minus, Chionanthus virginicus, Juniperus virginiana*, *Pinus virginiana*, and *Carya* spp.

Granitic Domes are distinguished from other rock outcrop communities by a near absence of crevices and deep soil pockets, so that the vegetation is strongly dominated by shallow mats. In contrast, glades have extensive areas of slightly deeper, though still shallow, soil where herb or shrub cover is high. Rocky summits may have local areas of shallow soil mats, but also support substantial plant cover rooted in crevices or deeper pockets. Low Elevation Rocky Summit (Quartzite Ledge Subtype) can have substantial shallow soil mats but occurs on quartzite and has distinctive vegetation with abundant *Kalmia (Leiophyllum*) *buxifolia* and *Rhododendron carolinianum*. Cliffs are located in more topographically sheltered situations, generally on lower slopes or gorge walls, and generally also are more fractured. Smooth, exfoliated rock faces that extend onto lower slopes or gorge walls should be treated as High Elevation Granitic Domes if the rock is largely free of fractures and the vegetation is similar to that described above.

High Elevation Granitic Domes may grade conceptually into higher elevation examples of Low Elevation Basic Glade (Montane Subtype), which have a different threshold for low versus high elevation types. Glades are distinguished by more continuous soils and vegetation, though their soils are still shallow and their vegetation of low stature and often of similar composition. Often glades are on rocks that appear to be exfoliation surfaces that are more irregular, with undulating surfaces and more weathering pits. Both communities can contain patches that resemble the other, and in such cases, classification may need to be decided by the preponderance of cover. Only if there are substantial contiguous areas of both should both types be recognized on a single outcrop complex.

Despite apparently contradictory names, two other communities may occasionally occur on the same rock outcrops as High Elevation Granitic Domes. Low Elevation Seep (Bedrock Subtype) is a wetland community that occurs where seepage areas are extensive and have well-developed bryophyte mats or distinctive wetland flora. Low Elevation Acidic Glade (Biltmore Sedge Subtype) is a dense graminoid-dominated community, generally of *Carex biltmoreana*. Both of these communities should be recognized only for large, well-developed patches, while small seeps and patches of *Carex biltmoreana* should be treated as part of the Low Elevation Granitic Dome community.

High Elevation Granitic Domes sometimes have zones along their edges with vegetation that resembles Heath Bald or Pine–Oak/Heath. These areas should be considered part of the Granitic Dome community unless they cover a substantial area or extend far from the rock outcrop.

Crosswalks: *Selaginella tortipila - Krigia montana - Houstonia longifolia* Granitic Dome (CEGL004283).
G671 Piedmont-Blue Ridge Dome & Flatrock Group. Group.
Southern Appalachian Granitic Dome Ecological System (CES202.297).

Sites: High Elevation Granitic Domes occur on outcrops of exfoliated massive rocks, usually granite or related rocks or granitic gneiss. Examples are known from 2900 feet to 4900 feet in elevation. Slopes may be gentle or steep, but large examples often curve gradually from nearly flat to nearly vertical. Domes are usually in upper slope positions and most often face south.

Soils: Soils are generally absent, except for patchy mats of shallow organic or mineral matter, usually of a sandy texture. Shallow continuous soils occur at the periphery. Wiser et al. (1996) noted that soils tended to be lower in major cations and micronutrients than all the different subtypes of High Elevation Rocky Summit.

Hydrology: High Elevation Granitic Domes tend to be xeric overall. With little soil, rainfall runs off immediately, leaving the rock dry most of the time. However, many examples occur in areas with high rainfall. The cooler temperatures and greater frequency of fog at higher elevations also makes them somewhat less xeric. Small seeps are common on the edges of domes, where moisture percolating through forest soil meets the bare rock. Occasionally a more persistent small stream may flow down the rock. Where domes have flatter tops, they may have small weathering pits that can trap water for a while after rains.

Vegetation: High Elevation Granitic Domes include large areas of rock that is bare or covered with crustose lichens. Areas of *Umbilicaria* sp. or *Lasallia papulosa* may be present. Mosses described as important by Oosting and Anderson (1939) include *Bucklandiella* (*Racomitrium*) *heterosticha, Grimmia laevigata, Polytrichum* spp., and, in seeps, *Sphagnum* spp., *Andreaea rupestris*, and *Hedwigia ciliata*. Also often present are *Cladonia* spp. lichens. Vegetation mats of *Bryodesma tortipilum* dominate the portion of the community with vascular vegetation. Wiser et al. (1996), a larger set of CVS plot data, and site descriptions don't consistently identify any other plant species as highly constant, but a number of herbs are at least fairly frequent in one or more of these sources. These include *Krigia montana*, *Houstonia longifolia* var. *glabra*, *Danthonia compressa, Danthonia sericea, Andropogon virginicus*, *Carex umbellata, Dichanthelium acuminatum, Solidago puberula, Danthonia spicata, Avenella flexuosa, Schizachyrium scoparium*, *Capnoides* (*Corydalis*) *sempervirens, Micranthes* (*Hydatica*) *petiolaris, Eurybia surculosa*, *Solidago simulans*, and *Viola* spp. Additional notable herbaceous species that occur less frequently include *Sibbaldiopsis tridentata, Heuchera villosa, Carex misera, Agrostis perennans, Andropogon gerardii, Carex biltmoreana, Lobelia spicata,* and *Pycnanthemum* spp. Woody species occur primarily on the edges, though they may be present on thicker soil mats. Fairly frequent shrub species include *Kalmia latifolia, Diervilla sessilifolia, Vaccinium pallidum* (some *Vaccinium altomontanum*), *Gaylussacia baccata, Vaccinium corymbosum,* and *Hypericum buckleyi*. Frequent trees include *Acer rubrum, Amelanchier arborea/laevis*, *Quercus rubra, Quercus montana*, *Pinus pungens*, and *Pinus strobus*.

Range and Abundance: Ranked G2G3 but perhaps G3. North Carolina examples are concentrated in Jackson and Macon counties, with only a few examples scattered elsewhere in the Mountains. This community extends to South Carolina and Georgia and is questionably attributed to Tennessee, but a large majority of occurrences are in North Carolina.

Associations and Patterns: High Elevation Granitic Domes are best considered small patch communities, but the largest complexes can exceed 100 acres in size. They tend to be bordered by various oak forests or by Pine–Oak/Heath. Lower edges may grade to Acidic Cove Forest or other mesic communities. Patches of the rare Low Elevation Seep (Bedrock Subtype) or Low Elevation Acidic Glade (Biltmore Sedge Subtype) may be associated with them.

Variation: Examples vary with configuration of the rock. Steeper outcrops have more bare rock while gentler slopes have more developed soil mats. Relative amounts of bare rock and vegetation mats may also vary with time and with amount of visitation. Two variants are recognized, to call attention to a distinct zone that is present in some examples.

1. Typic Variant covers most parts of all examples and fits the description above.

2. Ice/Rock Fall Variant is a distinctive open community that forms rarely at the base of vertical Granitic Dome faces where substantial amounts of ice form in the winter and fall from the cliff. This variant is analogous in ecological process to the ice pond community of South Carolina (Hill 1999) but is at somewhat higher elevation. More study is needed to characterize this variant, which was reported by Ed Schwartzman in the course of county natural area inventories. It appears as a relatively level terrace of fallen boulders and soil at the base of the cliff, with small areas of water impounded by the accumulation of the terrace. It has a cold and wet microclimate created by accumulation of fallen ice and has chronic disturbance that keeps forests from developing. Its flora includes boulderfield and wetland species as well as typical High Elevation Granitic Dome and Rocky Summit species, some of which apparently survive after falling from the rock above. This variant may prove distinctive enough to warrant a subtype or even a full type. However, occurrences are apparently all small, very heterogeneous, and seem to be tightly associated with High Elevation Granitic Domes.

Dynamics: Granitic Dome communities are primary successional communities like other rock outcrops, but they display a distinctive kind of successional dynamics (Oosting and Anderson 1937). Bare rock is colonized by mosses, particularly *Grimmia laevigata*, and by *Bryodesma tortipilum*. These pioneer mats trap sand grains and wind-blown dust, and accumulate organic matter, forming shallow soil that eventually can be colonized by other plants. As mats expand at their edges and become thicker, larger herbs, and eventually shrubs and trees, can root in them. Because the mats are not well anchored to the smooth rock beneath, most mats slough off under their own weight before they become very old. This tendency is greater on the steeper slopes and is exacerbated both by the death of the shallowly rooted trees and shrubs and by saturation of the mats during heavy rains. This cyclic succession maintains a predominance of bare rock and early successional mats despite the occurrence of most examples in areas with very high rainfall. Spalling of the rock surface may also occasionally renew the unweathered rock surface. The overall complex of vegetation zones appears relatively stable over time. However, flatter upper edges of domes are less susceptible to sloughing, and a more continuous zone of shallow soil shrubland can develop there. Most of the sparse vegetation of the community would not carry fire and probably is little affected by fire in surrounding communities. However, it is possible that the upper edge may shift in response to fire dynamics or climatic cycles.

Comments: Plot analysis by Wiser (1993) found a distinct cluster representing High Elevation Granitic Domes, which was called *Selaginella/Carex umbellata*. The most closely related cluster was one called *Aronia/Kalmia*, which appears to be more closely related to High Elevation Rocky Summit (Typic Subtype).

Earlier drafts of the 4th Approximation included a High Peak Lichen Subtype within High Elevation Granitic Dome. This poorly known community has been moved to treatment as a subtype of High Elevation Rocky Summit. Though that community occurs on smooth rock surfaces, its locations more resemble rocky summit conditions.

Rare species:
Vascular plants – *Coreopsis grandiflora* var. *grandiflora, Crocanthemum bicknellii, Crocanthemum propinquum, Danthonia epilis, Dendrolycopodium dendroideum, Huperzia porophila, Juniperus communis* var. *depressa, Lysimachia fraseri, Packera millefolium, Rhododendron vaseyi, Robinia hartwigii, Solidago simulans, Solidago uliginosa* var. *uliginosa*, and *Trichophorum cespitosum*.

Nonvascular plants – *Bryoerythrophyllum ferruginascens, Campylopus atrovirens* var. *atrovirens, Campylopus paradoxus,* and *Melanelia stygia*.

Vertebrate animals – *Aneides aeneus* and *Plestiodon anthracinus*.

Invertebrate animals – *Bleptina sangamonia*.

LOW ELEVATION CLIFFS AND ROCK OUTCROPS THEME

Concept: Low Elevation Cliffs and Rock Outcrops are sparsely vegetated communities of bedrock or occasionally of talus. They have less vegetation, less continuous soil, and more bare rock than Piedmont and Mountain Glades and Barrens. They lack the distinctive characteristics of Granitic Flatrocks, Coastal Plain Marl Outcrops, and the bedrock wetlands of Spray Cliff and Low Elevation Seep (Bedrock Subtype). They occur in the Piedmont, Coastal Plain, and low-to-moderate elevations in the Mountains. The rock may be fractured bedrock, loose talus, or sloping smooth exfoliated granitic rock, but flat-lying exfoliated granitic rock is contained in the Granitic Flatrocks theme instead. Cover of all vegetation is low in the community as a whole. It may consist wholly of herbs, bryophytes, and lichens, or may include limited patches or individual stems of shrubs and stunted trees.

Distinguishing Features: Low Elevation Cliffs and Rock Outcrops communities are distinguished from High Elevation Rock Outcrops by the floristic differences associated with lower elevation. They lack the distinctive species confined to higher elevations, such as *Sibbaldiopsis tridentata, Carex brunnescens, Rhododendron (Menziesia) pilosum, Picea rubens*, and the suite of rare species such as *Houstonia montana*. They are less likely to have some additional species such as *Bryodesma* (*Selaginella*) *tortipilum, Danthonia compressa, Geocarpon* (*Mononeuria*) *groenlandicum*, and *Rhododendron catawbiense*. They are more likely to have species of lower elevations, such as *Toxicodendron radicans, Gelsemium sempervirens, Rhododendron minus, Vaccinium arboreum, Vaccinium stamineum, Pinus virginiana, Juniperus virginiana*, and most *Quercus* species.

Low Elevation Cliffs and Rock Outcrops are distinguished from Piedmont and Mountain Glades and Barrens, as well as from all forest and woodland themes, by their sparse vegetation and limited soil. The predominance of bare rock distinguishes them from most other naturally non-forested communities such as those of beaches and excessively drained sands. However, the boundary of the theme is more complex where several rock-dominated communities are placed in different themes and where several specialized kinds or rock outcrops are treated as different themes. Along rivers and streams, where regular flooding or intermittent flood scouring become a strong influence, bedrock and loose rock are treated as Rocky Bar and Shore communities in the Piedmont and Mountain Floodplains theme. Rock kept wet by spray or extensive perennial seepage are included in the Upland Seepages and Spray Cliffs theme.

Several other sets of rock-dominated communities are treated as different themes because of their distinctive characteristics. Flat-lying exfoliated granitic rock sites are placed in the Granitic Flatrocks theme, and outcrops of limestone in the Coastal Plain are the Coastal Plain Marl Outcrops theme. One exception to the predominance of rock in the Low Elevation Cliffs and Rock Outcrops theme is the Coastal Plain Cliff community, which consists of vertical or near-vertical unconsolidated sediment.

Within the theme, communities are primarily divided into rocky summit, granitic dome, cliff, and talus communities. As in the High Elevation Rock Outcrops theme, rocky summits are distinguished by an exposed topographic position and by fractured rock rather than smooth exfoliation surfaces. They generally occur on ridge tops or upper slopes but may occur on mid slopes where there is no topographic sheltering. They may be steep and cliff-like or more gently sloping. Fractures provide sparse but deep rooting sites for plants. Granitic domes generally are in similarly exposed topographic situations, but the rock is a smooth exfoliation surface. Without deep crevices, plants are confined to shallow soil mats that are not well anchored to the rock surface. Cliffs are distinguished by a sheltered topographic position, generally lower slope, but potentially mid or, rarely, upper slope where adjacent landforms shelter them. They generally are steep, often vertical or overhanging, but may have a flatter top and may have ledges and other horizontal surfaces. The rock is generally fractured, offering at least some rooting sites. Talus consists of a deep surface cover of boulders, with little or no soil accumulation. Open, sparsely vegetated talus is extremely rare in North Carolina, where most accumulations of boulders support forest communities.

Sites: Low Elevation Cliffs and Rock Outcrop communities occur on outcrops of rock that have very little soil cover, because of resistance to weathering or rapid erosion. Outcrops on higher topography tend to be more weathering-resistant kinds of rock, such as quartzite, granite, gneiss, rhyolite, or related rocks. Cliffs may be of a broader range of rock types, even unconsolidated sediment, with the outcrop created or maintained by undercutting and collapse. Outcrops tend to be extremely heterogeneous at a fine scale, with cliffs and rocky summits often broken by ledges, chutes, overhangs, deep crevices, soil pockets, and aisles between slumped slabs of rock. Small accumulations of fallen boulders are common at the base of steeper outcrops, but larger areas of open talus are extremely rare.

Soils: Soil is limited to shallow mats or accumulations on smooth surfaces or in local small depressions and to occasional deeper accumulations in crevices. It presumably consists of a combination of marginally weathered rock and organic matter, perhaps with the addition of dust trapped by the vegetation.

Hydrology: Rock outcrop communities tend to be xeric overall, due to the lack of soil. Most rainfall runs off immediately, leaving the rock dry shortly afterward. However, moisture availability is extremely heterogeneous on a fine scale. Cliffs often have small, sometimes larger, zones of seepage emerging from fractures in the rock or from the edge of the soil cover above. Granitic domes too can have seepage areas on the edge of the soil of the adjacent forest. Even rocky summits may have microsites that concentrate or store water running off the bare rock, and deep crevices may provide substantial moisture for plants rooted in them. Slope aspect is also very important in determining microsite moisture status for plants, as is the presence of overhangs. Overhangs and grottos can result from differential strength of rock layers but also often appear to be formed by sapping by ground water discharge.

Vegetation: All rock outcrop communities have limited cover of vascular plants, but their vegetation structure and composition tend to be extremely heterogeneous within occurrences as well as variable among them. Moister outcrops or microsites may have substantial cover of bryophytes, while drier outcrops may have substantial cover of crustose lichens, umbilicate lichens, or more xerophytic mosses. On the bare rock, vascular plants tend to be sparse. A suite of species that can grow on bare rock occurs across many of the communities. It includes several species of *Heuchera, Micranthes (Saxifraga), Asplenium, Bryodesma (Selaginella)*, and *Polypodium*. A further suite of herbs capable of surviving in shallow soil occurs on many outcrops, including drought-tolerant grasses such as *Danthonia* spp. and *Schizachyrium scoparium*, and forbs such as several *Houstonia* species, *Krigia* spp., *Hypericum gentianoides,* and *Phemeranthus teretifolius*. Additional more specialized rock outcrop species occur in particular communities. Species more typical of forests or deep-soil open communities may occur in small numbers where there are favorable microsites. Though limited, they may make up a significant part of the species list for a site, because of the limited number of specialist species present. Trees or shrubs often take root in crevices. They may be of any species, but more often are drought-tolerant species such as *Juniperus virginiana, Pinus echinata, Pinus rigida, Pinus pungens, Quercus stellata, Quercus montana, Ulmus alata, Kalmia latifolia,* or *Vaccinium arboreum*. On ledges or flatter tops, patches of vegetation similar to glades may occur, with grasses or xerophytic sedges dominant. Granitic domes have distinctive vegetation representing stages of primary succession from *Grimmia laevigata* and *Bryodesma (Selaginella) rupestre* to small herbs to larger grassy patches and eventually shrubs and small trees.

Dynamics: Most rock outcrop communities appear stable for long time periods, but they are undergoing a slow primary succession as rock weathers, soil accumulates, and plants establish. They tend to occur where these processes are particularly difficult and slow, due to resistant rock and steepness. Nevertheless, the continued long-term existence of rock outcrops clearly depends on primary succession being interrupted or reset. Where succession is not checked, they presumably develop into glades and ultimately into forests. Resetting may occur as rare collapse, breaking, or spalling of rock, which produces a fresh bare rock surface. Sapping by groundwater, undercutting by streams, or undermining by slope creep, as well as exfoliation or parallel jointing, promote this in some examples. On granitic domes, where soil/vegetation mats are not well anchored, they eventually simply fall when they become too large and heavy. Maintenance of open rock may also be aided by droughts, which can kill established plants in the harsh environment. The author has observed many cases of well-established trees on outcrops dying during droughts. Heavy rains may also wash accumulated soil from some parts of outcrops and promote the falling of unanchored soil mats.

Comments: Steep outcrops such as cliffs and many granitic domes are extremely difficult to study quantitatively. Many of the intensive local vegetation analysis studies have focused exclusively on forest vegetation and did not address rock outcrops at all. Where they were sampled in local studies, such as Newell (1997), the number of plots is few. Wiser, et al. (1996) was a comprehensive study of High Elevation Rocky Summits, but no similar study has occurred for most of the Low Elevation Cliffs and Rock Outcrops. Elsewhere, what plot data exist may be biased or misleading, as sampling often must be confined to the flatter portions or edges, which may not characterize the community as a whole. Several early studies with a floristic focus have provided published descriptions of various other rock outcrop communities (e.g., Taggart 1973, Dumond 1970, Cooper and Hardin 1970, and the particularly thorough focused study of Oosting and Anderson 1937).

KEY TO LOW ELEVATION CLIFFS AND ROCK OUTCROPS

1. Community in an exposed topographic position, on an upper to mid slope without sheltering topography; if facing north, nevertheless exposed to drying winds; in the Mountains or mountainous foothills.
   2. Community on exfoliated granitic gneiss, granite, or related massive rocks; surface smooth, often curving from gentle to steep, with few or no deep fractures or crevices; vegetation, other than lichens and mosses on bare rock, consisting largely of plants in shallow soil mats, with *Bryodesma (Selaginella) rupestre* usually dominant. Larger plants, where present, also predominantly rooted in shallow soil mats; in the Mountains or mountain-like foothills. (Consider also High Elevation Granitic Dome if near 3000 feet elevation)…………………….. ……………………………………………………………..**Low Elevation Granitic Dome**
   2. Community not on exfoliated granite-like rocks; rock generally substantially fractured and offering some deep crevices or soil pockets; smoother only where bedding planes or edges of massive beds are exposed.
      3. Community on exposed bedding planes of quartzite; vegetation dominated by mats of *Bryodesma (Selaginella) tortipilum, Carex umbellata, Kalmia (Leiophyllum) buxifolia*, and *Rhododendron carolinianum*, often with *Hudsonia montana*; extremely rare community possibly confined to the east rim of Linville Gorge …………………………………………… ……………………………. **Low Elevation Rocky Summit (Quartzite Ledge Subtype)**
      3. Community not both on bedding planes of quartzite and dominated by the above species, though possibly on quartzite or with some of these species may be present.
         4. Community containing multiple species indicative of higher pH and high base saturation, such as *Myriopteris (Cheilanthes) lanosa, Myriopteris tomentosa, Hylotelephium (Sedum) telephioides, Aquilegia canadensis*, *Pycnanthemum incanum*, *Philadelphus inodorus*, *Philadelphus hirsutus, Celtis tenuifolia*, and *Ptelea trifoliata* ……………………………. ... ……………………………………………**Low Elevation Rocky Summit (Basic Subtype)**
         4. Community containing few or no species indicative of higher pH and high base saturation; flora largely or exclusively of acid-tolerant plants; *Kalmia latifolia, Vaccinium* spp., and other members of the Ericaceae often prominent ………………………………… ………………………………………**Low Elevation Rocky Summit (Acidic Subtype)**

1. Community in a topographically sheltered setting, on a lower slope, or if higher upslope, in a narrow gorge or facing north; in any region.
   5. Community in the Coastal Plain; substrate of unconsolidated or marginally consolidated sediments .... **Coastal Plain Cliff**
   5. Community not in the Coastal Plain; substrate igneous, metamorphic, or consolidated sedimentary rock.
      6. Community on talus or loose piles of boulders with extensive open space between and beneath them; in the Mountains (but note that talus or boulderfields with substantial tree cover are treated as forest communities.) . ... **Talus Vineland**
      6. Community not on talus or loose boulders; in either the Mountains or Piedmont.
         7. Community in the Piedmont outside of the mountainous foothills; containing little or no montane flora (though occasional disjunct populations of montane species may be present); species not characteristic of the Mountains, such as *Quercus stellata, Ulmus alata, Vaccinium arboreum, Piptochaetium avenaceum*, and *Gelsemium sempervirens,* present and usually abundant and diverse; associated with Piedmont communities.

8. Community containing indicators of high base saturation and higher pH, such as *Aquilegia canadensis, Myriopteris (Cheilanthes) lanosa, Asplenium trichomanes, Asplenium rhizophyllum, Adiantum pedatum, Asarum canadense*, and species shared with basic forests or floodplain forests .... **Piedmont Cliff (Basic Subtype)**

8. Community containing few or no species suggesting high base saturation; flora almost exclusively of acid-tolerant species. ....**Piedmont Cliff (Acidic Subtype)**

7. Community in the Mountains or mountain-like foothills area; montane flora such as *Micranthes* (*Hydatica*) *petiolaris, Heuchera villosa, Polypodium appalachianum, Carex biltmoreana, Rhododendron maximum, Tsuga canadensis,* and *Betula lenta* relatively abundant and diverse; associated with Mountain communities.

9. Community containing multiple species indicative of higher pH and high base saturation, such as *Aquilegia canadensis, Asplenium rhizophyllum, Asplenium resiliens, Micranthes careyana, Cystopteris* spp., *Philadelphus* spp., and *Hydrangea arborescens*; substrate mafic or calcareous rock or apparently influenced by base-rich rock.

10. Substrate of calcareous rock such as limestone, dolomite, marble, or occasionally calc-silicate; species of strongly calcareous conditions present, such as *Asplenium resiliens, Cystopteris bulbifera, Asplenium ruta-muraria, Pellaea atropurpurea*, or *Sedum glaucophyllum* present; other species indicative of high base saturation more numerous..**Montane Cliff (Calcareous Subtype)**

10. Substrate of mafic rock such as amphibolite, hornblende gneiss, or possibly calc-silicate, or apparently influenced by such rocks; species indicative of higher pH and high base saturation abundant but less so, species of strongly calcareous conditions absent..... ....**Montane Cliff (Mafic Subtype)**

9. Community containing few or no species indicative of higher pH and high base saturation; flora consisting largely or exclusively of acid-tolerant species; substrate felsic or other acidic rock. ....**Montane Cliff (Acidic Subtype)**

LOW ELEVATION ROCKY SUMMIT (ACIDIC SUBTYPE)

Concept: Low Elevation Rocky Summits are flat-to-vertical outcrops of fractured rock on ridge tops, upper to mid slopes, or other topographically exposed settings at low to mid elevations, generally below 4000 feet. Vegetation of Low Elevation Rocky Summit communities is sparse or patchy in density and is generally characterized by a mix of growth forms, including forbs, graminoids, shrubs, and trees. The Acidic Subtype is the widespread community of felsic rocks, quartzite, or other acidic rocks, lacking plants that indicate higher pH conditions and also lacking the distinctive characteristics of the Quartzite Ledge Subtype.

Distinguishing Features: Low Elevation Rocky Summits are distinguished from High Elevation Rocky Summits, which have similar site configuration and vegetation structure, by an elevation generally below 4000 feet. Near the transition elevation, they are distinguished by flora. Characteristic low elevation species include *Bryodesma (Selaginella) rupestre, Danthonia spicata, Danthonia sericea, Chimaphila maculata, Rhododendron minus, Quercus montana, Pinus virginiana,* and *Pinus echinata*. Characteristic high elevation species that seldom occur in Low Elevation Rocky Summit include *Bryodesma tortipilum, Carex brunnescens, Sibbaldiopsis tridentata, Rhododendron (Menziesia) pilosum, Picea rubens, Sorbus americana*, and a number of rarer plant species such as *Liatris helleri*. However, a few species more typical of higher elevations are found in Low Elevation Rocky Summits, including *Rhododendron catawbiense*, *Danthonia compressa*, and *Geocarpon* (*Mononeuria, Arenaria, Minuartia) groenlandicum*

Low Elevation Rocky Summits are distinguished from Montane Cliffs by occurring in topographically exposed situations. Both may be steep to vertical, though Rocky Summits are usually less steep. Cliffs are confined to lower slopes, gorges, or other topographically sheltered environments. Low Elevation Rocky Summits are distinguished from Low Elevation Granitic Domes by rock structure and vegetation. Rocky Summits have fractured rock which offers some deeper rooting sites and greater stability to at least some plants. Granitic Domes have smooth exfoliated rock surfaces where vegetation is confined to shallow soil mats.

Low Elevation Rocky Summits are distinguished from various Piedmont and Mountain Glades and Barrens, as well as from forests, by having less continuous vegetation and soil. Though shrub and tree patches may be present, the predominant ground cover in Low Elevation Rocky Summits is bare rock or lichen. Small Low Elevation Rocky Summits can be difficult to distinguish from small, shaded rock outcrops that are regarded as part of a forest. To be classified as a Low Elevation Rocky Summit, an outcrop should be large enough to create a persistent gap in the canopy, and it should have multiple species typical of bare rock or open sunny conditions.

The Acidic Subtype is distinguished from the Basic Subtype by the lack or near lack of plants preferring higher pH conditions, such as *Myriopteris (Cheilanthes) lanosa, Hylotelephium (Sedum) telephioides, Sedum glaucum, Aquilegia canadensis*, and *Pycnanthemum incanum*. Given the typically sparse vegetation of Rocky Summits, these species may be limited in abundance even in the Basic Subtype. The Quartzite Ledge Subtype is distinguished from Low Elevation Rocky Summit by a distinctive configuration of flat-lying quartzite beds with vegetation intermediate between Rocky Summit and Granitic Dome, as well as intermediate between low and higher elevation communities. *Bryodesma (Selaginella) tortipilum* is abundant in it, and *Kalmia*

(Leiophyllum) buxifolia, Hypericum densiflorum, Xerophyllum asphodeloides, and *Tsuga caroliniana* are characteristic.

Crosswalks: *Saxifraga michauxii* Rocky Summit (CEGL004524).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: Low Elevation Rocky Summits occur on ridge tops or on upper to mid slopes exposed to sun and wind. The rock tends to be somewhat fractured, offering at least a few deeper crevices and soil pockets. The rock may be relatively flat-lying or may include cliffs that are vertical or even overhanging. The rock structure may be very heterogeneous, with a flat top, jagged crags, vertical faces, ledges, chutes, overhanging faces, and grottos potentially present. The rock in the Acidic Subtype tends to be quartzite, granite, gneiss, or other acidic rocks.

Soils: Soil is limited to local small depressions and to occasional deeper accumulations in crevices. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may locally include soil washed in from above.

Hydrology: Low Elevation Rocky Summits tend to be xeric overall. With little soil, rainfall runs off immediately, leaving the rock dry most of the time. Seeps are rare in Rocky Summits, but small ones may occur. Local microsites may concentrate or trap rainwater and runoff, creating moist conditions.

Vegetation: The vegetation on Low Elevation Rocky Summits is sparse but with a patchy structure that may include small denser areas. Large areas are bare rock with only crustose lichens. Other lichens, including *Umbilicaria* spp. or *Lasallia papulosa* may be present in patches of steep rock, while *Cladonia* spp. may dominate areas of flatter rock. *Grimmia laevigata*, *Polytrichum* spp., and other mosses may dominate patches. Herbs of bare rock or extremely shallow soil, such as *Heuchera villosa, Bryodesma rupestre, Micranthes (Saxifraga, Hydatica) petiolaris, Campanula divaricata*, and *Hypericum gentianoides* occur with moderate frequency. Less frequent such species in site descriptions include *Asplenium montanum*, *Asplenium bradleyi*, *Polypodium virginianum, Polypodium appalachianum, Geocarpon* (*Mononeuria, Minuartia*) *groenlandicum,* and *Capnoides* (*Corydalis*) *sempervirens*. More widespread herbs of open areas are fairly diverse, though they occupy a limited area. *Schizachyrium scoparium*, *Danthonia spicata, Danthonia compressa*, and *Coreopsis major* have high constancy in site descriptions. Other such species with fairly high frequency include *Andropogon virginicus, Danthonia sericea,* and *Packera anonyma*. A number of species shared with forest communities are generally also present, though only a few, such as *Dryopteris marginalis, Chimaphila maculata* and *Goodyera pubescens,* have even moderate frequency. Woody species may dominate patches that have as much or more cover than the herbs. *Kalmia latifolia* is nearly constant, while *Rhododendron minus, Rhododendron maximum*, *Vaccinium pallidum, Gaylussacia baccata, Rubus* spp., and, somewhat surprisingly, *Rhododendron catawbiense* and *Hydrangea arborescens,* are at least somewhat frequent. Vines are not usually prominent, but *Smilax rotundifolia* and *Toxicodendron radicans* occur with moderate frequency. Among the trees that may occur on the edges or in crevices and deeper soil pockets, *Quercus montana* is highly constant, and *Acer rubrum, Quercus rubra, Pinus pungens,* *Pinus virginiana, Amelanchier arborea, Oxydendrum arboreum, Nyssa sylvatica, Pinus echinata,* and *Quercus alba* are at least fairly frequent.

Range and Abundance: Ranked G3? but probably safely G3. North Carolina examples are scattered throughout the Mountain region and mountainous foothills. Fewer than 50 occurrences are known. This community also occurs in Georgia, South Carolina, Tennessee, and Virginia.

Associations and Patterns: Low Elevation Rocky Summit (Acidic Subtype) is a small patch community. Most patches are one or a few acres, often less, though some occur in clusters that add up to ten acres or more. Extent is often difficult to assess because rock patches may be interspersed with forest or shrub vegetation and because important surfaces may be near vertical. Low Elevation Rocky Summits are generally surrounded by dry forest or woodland vegetation, usually a community in the Mountain Oak Forests or Mountain Dry Coniferous Woodland theme. They may also be associated with Piedmont and Mountain Glades and Barrens. The transition to the adjacent forest or woodland can sometimes be gradual and ambiguous, with woody vegetation patches becoming larger but not continuous in the peripheral areas and small open rocks continuing into the forest.

Variation: Examples vary with degree of development and with the nature of the surrounding vegetation. They may potentially vary with elevation, slope aspect, configuration of the rocks, and type of rock, but patterns of variation have not been identified.

Dynamics: Low Elevation Rocky Summits are generally among the most stable of rocky outcrop communities. They are less likely to experience undercutting and collapse than cliffs. With their deep rooting sites in crevices and deeper soil pockets, they are less likely to have vegetation mats slough off than are granitic domes. However, they are subject to stress and mortality of established vegetation caused by drought. Their high topographic position and occurrence in a landscape of dry communities exposes them to fire. Heat may stress or kill plants even where the sparse vegetation itself will not carry fire, vegetation patches on the edge may burn, and fire may jump to some isolated vegetation patches. The importance of fire in this community has received limited study or discussion, but Barden (2000) argued that it was important in at least one site (Crowders Mountain) and was responsible for maintaining a disjunct population of *Quercus ilicifolia*. While this may be one of the most fire-prone Low Elevation Rocky Summit sites, it is possible that fire is more generally important. The stressful environment may allow fire to have more dramatic effects on woody vegetation in Low Elevation Rocky Summits than in typical forest communities. The prominence of woody plants in comparison to herbaceous plants in many site descriptions may be partly a result of lack of fire.

Comments: This community is frequently described in unpublished site reports, and there was an early published description in Williams and Oosting (1944), but it otherwise has little published material. Only a couple of CVS plots appear to represent it. The comprehensive study of Wiser (1993) for higher elevation rock outcrops did not include it.

The concept of Low Elevation Rocky Summit has been narrowed from that in the 3rd Approximation by the creation of the Low Elevation Acidic Glade and other glade communities.

Low Elevation Rocky Summit (Acidic Subtype) appears to be more abundant than Low Elevation Acidic Glade, but the number of apparent occurrences has been reduced.

Rare species:
Vascular plants – *Asplenium bradleyi, Chenopodiastrum simplex, Geocarpon* (*Minuartia*) *groenlandicum, Heuchera hispida, Heuchera pubescens, Juniperus communis* var. *depressa*, *Liatris aspera, Packera millefolium, Quercus ilicifolia, Solidago simulans, Spiraea corymbosa, Steironema* (*Lysimachia*) *tonsum*, and *Woodsia appalachiana*.

Nonvascular plants – *Coscinodon cribrosus* and *Orthodontium pellucens.*

Vertebrate animals – *Crotalus horridus, Falco peregrinus anatum, Neotoma magister,* and *Plethodon yonahlossee* pop. 1.

Invertebrate animals – *Hypochilus coylei.*

LOW ELEVATION ROCKY SUMMIT (BASIC SUBTYPE)

Concept: Low Elevation Rocky Summits are flat-to-vertical outcrops of fractured rock on ridge tops, upper-to-mid slopes, or other topographically exposed settings at low to mid elevations, general below 4000 feet. Vegetation of Low Elevation Rocky Summit communities is sparse or patchy in density and is generally characterized by a mix of growth forms, including forbs, graminoids, shrubs, and trees. The Basic Subtype is a rare community that shows evidence of more base-rich, higher pH conditions, generally occurring on mafic rock or calcareous sedimentary rocks, occasionally on acidic rocks influenced by base-rich seepage.

Distinguishing Features: Low Elevation Rocky Summits are distinguished from High Elevation Rocky Summits, which have similar site configuration and vegetation structure, by an elevation generally below 4000 feet. See the Acidic Subtype description for species that indicate high elevation and low elevation.

The Basic Subtype is distinguished from the Acidic Subtype by the presence of plants preferring higher pH conditions, such as *Myriopteris (Cheilanthes) lanosa, Myriopteris tomentosa, Hylotelephium (Sedum) telephioides, Aquilegia canadensis*, *Pycnanthemum incanum*, *Philadelphus inodorus*, *Philadelphus hirsutus, Celtis tenuifolia*, and *Ptelea trifoliata*. Species that indicate base-rich conditions in forest communities, such as *Fraxinus biltmoreana* or *Ulmus rubra*, may also be present. Most species of the Acidic Subtype, such as *Micranthes* (*Hydatica*) *petiolaris, Danthonia spicata, Heuchera villosa*, and *Campanula divaricata* are also present in the Basic Subtype. Rocky summits are extremely heterogeneous environments, with moisture and nutrient levels varying greatly among small microsites. All vascular plants, including the indicator species of basic conditions, may be sparse.

Crosswalks: *Saxifraga michauxii - Cheilanthes lanosa - Hylotelephium telephioides* Rocky Summit (CEGL004989).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: Low Elevation Rocky Summits occur on ridge tops or on upper-to-mid slopes exposed to sun and wind. The rock tends to be somewhat fractured, offering at least a few deeper crevices and soil pockets. The rock may be relatively flat-lying or may include cliffs that are vertical or even overhanging. The rock structure may be very heterogeneous, with a flat top, jagged crags, vertical faces, ledges, chutes, overhanging faces, and grottos potentially present. The rock in the Basic Subtype is usually amphibolite or hornblende gneiss, but it may be calc-silicate or, less often, felsic rock that apparently is influenced by adjacent mafic rock.

Soils: Soil is limited to local small depressions and to occasional deeper accumulations in crevices. It presumably consists mainly of marginally weathered rock and accumulated organic matter but may locally include soil washed in from above. Vegetation suggests that the chemistry of this limited soil is strongly influenced by the mafic rock; presumably it has high base saturation and circumneutral pH.

Hydrology: Low Elevation Rocky Summits tend to be xeric overall. With little soil, rainfall runs off immediately, leaving the rock dry most of the time. Seeps are rare in Rocky Summits, but small ones may occur. Local microsites may concentrate or trap rainwater and runoff, creating moist conditions.

Vegetation: The vegetation on Low Elevation Rocky Summits is sparse but with a patchy structure that may include small denser areas. Large areas are bare rock with only crustose lichens. Larger lichens such as *Umbilicaria* spp., *Lasallia papulosa*, or *Cladonia* spp. may be present in places, as may a variety of mosses. Some herbs of bare rock or minimal soil, such as *Myriopteris* (*Cheilanthes*) *tomentosa, Myriopteris lanosa, Heuchera villosa, Heuchera americana, Heuchera caroliniana, Polypodium virginianum, Hylotelephium* (*Sedum*) *telephioides*, *Micranthes careyana, Micranthes caroliniana,* and *Micranthes* (*Hydatica*) *petiolaris*, are generally present, but only the *Myriopteris* have even moderate frequency in site descriptions. A diverse collection of herbs shared with the Acidic Subtype and species indicative of richer conditions is present. *Aquilegia canadensis, Helianthus divaricatus, Packera anonyma*, and *Coreopsis major* are moderately frequent in site reports. Other species include *Penstemon canescens, Penstemon smallii, Schizachyrium scoparium, Rudbeckia hirta, Liatris aspera, Andropogon gerardii, Tradescantia* spp., *Pycnanthemum incanum, Scleria oligantha, Solidago* spp., *Eupatorium godfreyanum, Danthonia spicata, Actaea racemosa*, *Chasmanthium latifolium, Asclepias verticillata*, and a great many others. Shrubs that may dominate small patches include both species indicative of the rich conditions, such as *Celtis tenuifolia, Lonicera flava, Ptelea trifoliata, Philadelphus hirsutus,* and *Physocarpus opulifolius*, and species shared with the Acidic Subtype, such as *Kalmia latifolia, Vaccinium pallidum*, and *Vaccinium stamineum*. Among trees, *Quercus montana* and *Pinus virginiana* are the most frequent species, but *Crataegus* spp., *Juniperus virginiana*, *Chionanthus virginicus*, *Ulmus rubra*, *Fraxinus biltmoreana*, and less frequently, *Carya cordiformis, Ostrya virginiana,* and *Cercis canadensis* indicate the high base status. Shrubs and trees may be diverse in individual examples, often representing more species than the herbs reported.

Range and Abundance: Ranked G1 but probably G2. In North Carolina, about a dozen occurrences are known. The majority are in the foothills or Blue Ridge escarpment, with only a few examples in the interior Blue Ridge. The synonymized association is attributed definitively only to North Carolina but may occur South Carolina or Georgia.

Associations and Patterns: Low Elevation Rocky Summit (Basic Subtype) is a small patch community. Most patches are one or a few acres, sometimes smaller, though some occur in clusters that add up to ten acres or more. Extent is often difficult to assess because rock patches may be interspersed with forest shrub vegetation and because important surfaces may be near vertical. Low Elevation Rocky Summits are generally surrounded by dry forest or woodland vegetation. Often the surrounding forest is a basic community such as Montane Oak–Hickory Forest (Basic Subtype), but it can be a more common acidic community. Occasionally the Basic Subtype is associated with a glade or woodland community such as Low Elevation Basic Glade or Montane Red Cedar–Hardwood Woodland.

Variation: Occurrences of the Basic Subtype are extremely variable, but patterns of variation have not been recognized. Examples can be expected to vary with elevation, configuration of the rocks, slope aspect, and intensity of basic influence.

Dynamics: Low Elevation Rocky Summits are generally the most stable of rocky outcrop communities. They are less likely to experience undercutting and collapse than cliffs. With their deep rooting sites in crevices and deeper soil pockets, they are less likely to have vegetation mats slough off than are granitic domes. However, they are subject to stress and mortality of established vegetation caused by drought. Their high topographic position and occurrence in a landscape of dry communities exposes them to fire. Heat may stress or kill plants even though the sparse vegetation itself will not carry fire, and vegetation patches on the edge may burn.

Comments: This community is very little studied. No CVS plots appear to have been sampled in it and no published literature has been identified.

The concept of Low Elevation Rocky Summit has been narrowed from the 3rd Approximation by the creation of the Low Elevation Basic Glade and other glade communities. Low Elevation Basic Glade occurrences seem to be substantially more abundant than Low Elevation Rocky Summit (Basic Subtype) occurrences.

Rare species:
Vascular plants – *Berberis canadensis, Crataegus pallens, Geocarpon* (*Mononeuria*) *groenlandicum, Liatris aspera, Liatris microcephala, Liatris turgida, Micranthes caroliniana, Packera millefolium, Primula meadia, Spiranthes ochroleuca, Tradescantia virginiana,* and *Woodsia appalachiana*.

Nonvascular plants – *Bryum limbatum.*

Vertebrate animals – *Crotalus horridus*.

Invertebrate animals – *Heraclides* (*Papilio) cresphontes*.

LOW ELEVATION ROCKY SUMMIT (QUARTZITE LEDGE SUBTYPE)

Concept: The Quartzite Ledge Subtype is a distinctive community of the flat-lying quartzite outcrops around Linville Gorge. It is intermediate between Low Elevation Rocky Summit and High Elevation Rocky Summit, occurring near the elevational boundary and sharing characteristics with both; it also shares characteristics with High Elevation Granitic Dome and Low Elevation Acidic Glade. It has additional unique characteristics related to extreme acidity, bedding plane exposure with limited fracturing, and exposure to fire. It is characterized by the narrow endemic species *Hudsonia montana* and by abundant *Kalmia* (*Leiophyllum*) *buxifolia* and *Rhododendron carolinianum*, along with herbaceous mats dominated by *Bryodesma (Selaginella) tortipilum*.

Distinguishing Features: The Quartzite Ledge Subtype occurs around 4000 feet, the transition elevation between Low Elevation Rocky Summit and High Elevation Rocky Summit. It can be distinguished from all other subtypes of both by the combination of flat-lying quartzite with limited fracturing, along with sparse patchy vegetation dominated by *Bryodesma tortipilum*, *Kalmia buxifolia*, *Rhododendron carolinianum*, and *Hudsonia montana*. Not all quartzite outcrops support this subtype. It is presently known only on the southeast rim of Linville Gorge in Burke County where *Hudsonia montana* occurs, but it may be recognized outside of the range of *Hudsonia* if flat-lying quartzite ledges are found to support an otherwise-similar community.

While the Quartzite Ledge Subtype resembles High Elevation Granitic Dome in having *Bryodesma tortipilum* as a near-constant patch dominant, and in sharing a number of species, including *Carex umbellata, Danthonia sericea*, and several shrubs, there are substantial floristic as well as environmental differences. In roughly 15 plots in the Carolina Vegetation Survey database for the Quartzite Ledge Subtype and 40 for Granitic Domes, plant species frequent in the Quartzite Ledge Subtype and seldom or never in Granitic Domes include *Hypericum densiflorum, Xerophyllum asphodeloides, Coreopsis major*, and *Tsuga caroliniana*. Species of High Elevation Granitic Domes and scarce or absent in this subtype include *Hypericum gentianoides, Houstonia longifolia, Hypericum buckleyi, Krigia montana*, and *Diervilla sessilifolia*.

Crosswalks: *Leiophyllum buxifolium - (Hudsonia montana) / Selaginella tortipila - Carex umbellata* Rocky Summit (CEGL007010).
G670 Southern Appalachian Rocky Outcrop Group.
Southern Appalachian Rocky Summit Ecological System (CES202.327).

Sites: The Quartzite Ledge Subtype occurs on level exposed beds of quartzite with limited fracturing. Examples are at around 4000 feet elevation.

Soils: Soil is largely limited to shallow mats on the rock surface. Given the limited weathering residue left by quartzite, they may consist largely of windblown material and organic matter accumulated by plants.

Hydrology: The Quartzite Ledge Subtype, as with other rock outcrop communities, is xeric overall because of the limited soil. However, rainfall may run off more slowly from the horizontal surface than it does in most rock outcrops.

Vegetation: The Quartzite Ledge Subtype vegetation is patchy, with areas of herbs and shrubs interspersed with areas of bare or lichen-covered rock. *Bryodesma tortipilum* dominates the herbaceous areas, and *Carex umbellata* and *Xerophyllum asphodeloides* are frequent species in Newell (1997) and Newell and Peet (1998) plot data. Other herbs typical of Low Elevation Rocky Summits or shared with adjacent forests are present at low frequency in plot data but may be more frequent in sites as a whole, including *Danthonia sericea, Coreopsis major, Paronychia argyrocoma*, *Chasmanthium laxum, Iris verna, Lysimachia quadrifolia, Liatris virgata*, and *Pteridium latiusculum*. Several rare herbaceous species also occur, including *Liatris helleri* and *Geocarpon* (*Mononeuria*) *groenlandicum*. Shrubs that frequently dominate woody patches include *Rhododendron carolinianum, Kalmia buxifolia, Rhododendron catawbiense, Kalmia latifolia, Eubotrys recurvus, Gaylussacia baccata*, and *Fothergilla major*, while *Hudsonia montana, Lyonia ligustrina, Clethra acuminata, Ilex montana*, and other species may also occur. The NVC description also noted *Hypericum densiflorum*. *Smilax rotundifolia* and *Smilax glauca* are fairly frequent. Frequent trees include *Pinus pungens, Pinus rigida, Acer rubrum*, *Tsuga caroliniana, Pinus strobus, Pinus virginiana, Nyssa sylvatica*, and *Quercus montana.*

Range and Abundance: Ranked G1. This is a narrow endemic community, known only from the eastern rim of Linville Gorge in Burke County and unlikely to be found in other states.

Associations and Patterns: The Quartzite Ledge Subtype is a small patch community, with occurrences of up to a few acres in aggregate. It may be surrounded by a variety of dry forest communities such as Chestnut Oak Forest or Pine–Oak/Heath.

Variation: This is a narrowly defined community. Variation is primarily in the transition to other communities.

Dynamics: Much attention has been paid to the dynamics of the Quartzite Ledge Subtype, because of concern for the federally listed *Hudsonia montana*. Unpublished work by Cecil Frost and observations by botanists working with this species have described the importance of fire. This community is highly dependent on burning to maintain its open character. In the absence of fire, woody cover increases at the expense of herbaceous vegetation and perhaps open rock as well. The small-statured *Hudsonia montana* is eventually eliminated from soil mats by taller *Rhododendron, Kalmia*, and other shrubs, or becomes confined to shallower soils that are marginal for its survival. The NVC description describes the presumed natural structure as essentially extinct, though noting that it is being restored in places by prescribed burning. The dilemma is illustrated by the absence of *Hudsonia montana* from most of the plot data.

Other than fire, dynamics of this subtype are probably intermediate between those of other subtypes and those of granitic domes. The soil mats are shallow, but the flat surface makes it less likely that they will fall off. However, it is likely that drought may cause mortality of shrubs and trees, and that mats are easily destroyed to restart primary succession.

Comments: This community has been difficult to place in classifications, as it shares characteristics with multiple different rock outcrop types. It was treated as a variant of High Elevation Rocky Summit in the 3rd Approximation. Its elevational range is near the 4000 foot elevation that is the general division between High Elevation and Low Elevation Rocky Summit.

However, most examples fall below 4000 feet, and the xeric nature of the vegetation, importance of fire, and absence of most of the characteristic high elevation plant species tie it more closely to other Low Elevation Rocky Summits. Newell (1997) initially synonymized her equivalent vegetation type with the association that represents High Elevation Granitic Dome, because of the dominance of *Bryodesma tortipilum* and the presence of *Carex umbellata*. The transition from low elevation to high elevation types of granitic domes is lower than for rocky summits, and its 4000 foot elevation is within the range of High Elevation Granitic Dome. The smooth, unfractured bedding planes support similar shallow, minimally anchored soil mats. However, ad hoc analysis of plot data by NatureServe in 1997 for the two community types illustrated the differences. The importance of fire and the tendency of woody vegetation to increase in cover in its absence gives the Quartzite Ledge Subtype affinity with various glade communities. Finally, the patchiness of the vegetation makes it difficult to characterize the vegetation structure. This is the case with several rock outcrop communities, but it is made more difficult because of the presumed change in vegetation structure with lack of fire.

Rare species:
Vascular plants – *Dicentra eximia, Geocarpon* (*Minuartia*) *groenlandicum, Hudsonia montana, Liatris aspera, Liatris helleri,* and *Trichophorum cespitosum*.

LOW ELEVATION GRANITIC DOME

Concept: Low Elevation Granitic Domes are communities of large, smooth, exfoliation surfaces of granitic rock, occurring at lower elevations than High Elevation Granitic Domes, generally below 3000 feet. The exfoliated surfaces have few cracks or crevices that allow deep rooting of plants. Vegetation consists primarily of lichens on bare rock or of shallow mats generally dominated by *Bryodesma (Selaginella) rupestre*.

Distinguishing Features: Low Elevation Granitic Domes are distinguished from High Elevation Granitic Domes by elevation and vegetation. The elevational boundary is around 3000 feet, but the types may overlap somewhat. Species that occur in High Elevation Granitic Domes but seldom in Low Elevation Granitic Domes include *Carex misera, Carex biltmoreana, Trichophorum cespitosum, Danthonia compressa, Hypericum buckleyi, Packera millefolium,* and *Robinia hartwigii*. Species that occur in Low Elevation Granitic Domes but seldom or less often in High Elevation include *Bryodesma rupestre, Danthonia spicata, Hypericum gentianoides, Hexasepalum (Diodia) teres, Phemeranthus teretifolius, Phlox nivalis ssp. hentzii, Rhododendron minus, Chionanthus virginicus, Juniperus virginiana*, *Pinus virginiana*, and *Carya* spp.

Granitic Domes are distinguished from most other rock outcrop communities (except Granitic Flatrocks) by a near absence of crevices and deep soil pockets, so that what vascular vegetation there is tends to be strongly dominated by shallow mats. In contrast, glades have undulating rock with more extensive areas of better-developed shallow soil where graminoids and low shrubs may predominate. Rocky summits may have local areas of shallow soil mats, but also support substantial plant cover rooted in crevices or deeper pockets. Cliffs are located in more topographically sheltered situations, generally on lower slopes or gorge walls, and generally also are more fractured. Smooth, exfoliated rock faces which extend onto lower slopes or gorge walls should be treated as Low Elevation Granitic Domes if the rock is largely free of fractures and the vegetation is similar to that described above.

Another community that may occur on the same rock outcrops as Low Elevation Granitic Domes is Low Elevation Seep (Bedrock Subtype). It is a wetland community that occurs where seepage areas are extensive and have well-developed bryophyte mats or distinctive wetland flora. It should be recognized only for large, well-developed patches, while small seeps should be treated as part of the Low Elevation Granitic Dome community.

Low Elevation Granitic Domes sometimes have zones along their edges with vegetation that resembles Pine–Oak/Heath. These areas should be considered part of the Granitic Dome community unless they cover a substantial area or extend far from the rock outcrop.

Low Elevation Granitic Domes grade conceptually into Low Elevation Basic Glades. The Brushy Mountains Subtype especially resembles it. Glades are distinguished by more continuous soils and vegetation, though their soils are still shallow and their vegetation of low stature; much flora is shared. Often glades are on rocks that appear to be exfoliation surfaces but that are more irregular, with undulating surfaces and more weathering pits. Both communities can contain patches that resemble the other, and in such cases, classification may need to be decided by the preponderance of cover. Only if there are substantial contiguous areas of both should both types be recognized on a single outcrop.

Low Elevation Granitic Domes share many characteristics with Granitic Flatrocks but are distinguished by geographic location and associated floristic differences. The most characteristic Granitic Flatrock species are largely or completely absent in Low Elevation Granitic Domes.

Crosswalks: *Selaginella rupestris - Schizachyrium scoparium - Hypericum gentianoides - Bulbostylis capillaris* Granitic Dome (CEGL007690).
G671 Piedmont-Blue Ridge Dome & Flatrock Group.
Southern Appalachian Granitic Dome Ecological System (CES202.297).

Sites: Low Elevation Granitic Domes occur on outcrops of exfoliated massive rock, usually granite or related rocks or granitic gneiss. Slopes may be gentle or steep, but large examples often curve gradually from nearly flat to nearly vertical. Domes are usually in upper slope positions and most often face south. Examples are known from 1700 feet to 3300 feet in elevation.

Soils: Soils are generally absent, except for patchy mats of shallow organic or mineral matter, usually of a sandy texture. Shallow continuous soils occur at the periphery.

Hydrology: Low Elevation Granitic Domes tend to be xeric overall. With little soil, rainfall runs off immediately, leaving the rock dry most of the time. It is notable that some examples occur in areas with twice the rainfall of other examples, with no noticeable difference in vegetation.

Small seeps are common on the edges of domes, where moisture percolating through forest soil meets the bare rock. Occasionally a more persistent small stream may flow down the rock. Where domes have flatter tops, they may have small weathering pits that can trap water for a while after rains.

Vegetation: Low Elevation Granitic Domes include large areas of rock that is bare or covered with crustose lichens. Areas of *Umbilicaria* sp. or *Lasallia papulosa* may be present. Nonvascular plants that may colonize bare rock include *Grimmia laevigata, Bucklandiella* (*Racomitrium*) *heterosticha, Polytrichum juniperinum, Polytrichum commune*, and in wet areas, *Sphagnum* spp., *Andreaea rupestris*, and *Hedwigia ciliata*. Clumps of *Cladonia* spp. are common. Vegetation mats of *Bryodesma rupestre* dominate the portions with vascular vegetation. Deeper mats are usually dominated by *Schizachyrium scoparium* or *Danthonia spicata*, both of which are highly constant in occurrences. Other frequent herbs which may dominate patches include *Danthonia sericea, Andropogon virginicus, Hypericum gentianoides, Capnoides* (*Corydalis*) *sempervirens, Coreopsis major*, *Phemeranthus teretifolius*, and *Micranthes* (*Hydatica*) *petiolaris*. Other species at least fairly frequent in occurrences or in the few CVS plots include *Campanula divaricata, Hexasepalum (Diodia) teres, Polygala curtisii, Hylotelephium telephioides, Heuchera villosa, Heuchera americana, Heuchera parviflora, Bulbostylis capillaris, Carex biltmoreana, Houstonia longifolia* var. *glabra, Houstonia purpurea, Dryopteris marginalis, Geocarpon groenlandicum, Packera anonyma, Packera millefolium, Pycnanthemum incanum*, and *Scleria triglomerata* (perhaps *oligantha*). A great variety of herbs occurs in one or two examples, including species shared with other rock outcrops, species shared with glades, and species typical of burned woodlands. Where soil accumulations are deep enough to support shrubs, *Kalmia latifolia* is highly constant and *Rhododendron minus, Vaccinium pallidum, Vaccinium stamineum*, and *Rhododendron maximum* are frequent. *Pinus rigida, Quercus montana*, and *Juniperus virginiana* are the most frequent trees. Also fairly frequent are *Amelanchier arborea/laevis, Chionanthus virginicus, Pinus pungens,* and *Quercus coccinea*. A few occurrences have *Pinus echinata* or *Quercus stellata*. A few occurrences have small rich portions that may contain species such as *Ptelea trifoliata*, *Physocarpus opulifolius*, or *Philadelphus hirsutus*.

Range and Abundance: Ranked G2 but perhaps G3. In North Carolina, this community is scattered through the Blue Ridge, including the escarpment area, and locally in the foothills. There is a concentration in the southern mountains of Henderson, Transylvania, and Macon counties. This community also ranges southward to Georgia and Alabama.

Associations and Patterns: Low Elevation Granitic Domes are best considered small patch communities. Many examples are a few acres in size, but larger ones may be tens of acres and a few complexes exceed 100 acres. Low Elevation Granitic Domes are usually bordered by Pine–Oak/Heath or various oak forests. Lower edges may grade to Acidic Cove Forest. Patches of the rare Low Elevation Seep (Bedrock Subtype) or Low Elevation Acidic Glade (Biltmore Sedge Subtype) may be associated with them.

Two other communities may occur on the same rock outcrops as Low Elevation Granitic Domes. Low Elevation Seep (Bedrock Subtype) is a wetland community that occurs where seepage areas are extensive and have well-developed bryophyte mats or distinctive wetland flora. Low Elevation Acidic Glade (Biltmore Sedge Subtype) is a dense graminoid-dominated community, generally of *Carex biltmoreana*. Both of these communities should be recognized only for large, well-developed patches, while small seeps and patches of *Carex biltmoreana* should be treated as part of the Low Elevation Granitic Dome community.

Variation: Examples vary with configuration of the rock. Relative amounts of bare rock and vegetation mats may vary with steepness but also with amount of visitation, and they may change over time.

Dynamics: Granitic Dome communities are primary successional communities like other rock outcrops, but they display a distinctive kind of successional dynamics as described by Oosting and Anderson (1937) for High Elevation Granitic Domes. Bare rock is colonized by mosses, particularly *Grimmia laevigata*, and by *Bryodesma tortipilum*. These pioneer mats trap sand grains and wind-blown dust, and accumulate organic matter, forming shallow soil that eventually can be colonized by other plants. As mats expand at their edges and become thicker, larger herbs and eventually shrubs and trees can root in them. Because the mats are not well anchored to the smooth rock beneath, most mats slough off under their own weight before they become very old. This tendency is greater on the steeper slopes and is exacerbated both by the death of the shallowly rooted trees and shrubs and by saturation of the mats during heavy rains. This cyclic succession maintains a predominance of bare rock and early successional mats despite the occurrence of many examples in areas with very high rainfall. Spalling of the rock surface also occasionally renews the unweathered rock surface. The overall complex of vegetation zones appears relatively stable over time. However, flatter upper edges of domes are less susceptible to sloughing, and a more continuous zone of shallow soil shrubland can develop there. Most of the sparse vegetation of the community would not carry fire and probably is little affected by fire in surrounding communities. However, it is possible that the upper edge may shift in response to fire dynamics or dry and wet weather cycles.

Comments: The 4th Approximation treatment of Low Elevation Granitic Dome has been narrowed from earlier classifications. The 3rd Approximation included a Basic Variant of Low Elevation Granitic Dome, which was treated as a subtype in early drafts of the 4th Approximation. It has been removed to be treated as the Brushy Mountains subtype of Low Elevation Basic Glade, because examples appear to be more heavily vegetated than typical Low Elevation Granitic Dome. Nevertheless, that subtype more resembles Low Elevation Granitic Dome than the Typic Subtype of Low Elevation Basic Glade does. A few outcrops in the Brushy Mountains are intermediate, with sparser vegetation that leads them to be classified as Low Elevation Granitic Dome but with some of the distinctive species of Low Elevation Basic Glade (Brushy Mountain Subtype).

Low Elevation Granitic Domes share many characteristics with Granitic Flatrocks, including the distinctive cyclic succession of unanchored soil mats, but their steepness causes differences. Vegetation mats are slower to start and are sooner destroyed by sloughing off. Few mats reach the stage of dominance by woody vegetation. Also, the distinctive pools of flatrocks are absent on the steep slopes of domes.

Granitic domes are easier environments to study than cliffs, but quantitative study has been limited. Only a few CVS plots have been sampled. Numerous examples are described in site reports and some published floristic studies have described them (e.g., Cooper and Hardin 1970, Dumond 1970, Taggart 1973).

Rare species:
Vascular plants – *Allium keeverae, Asplenium pinnatifidum, Danthonia epilis, Dicentra eximia, Fleischmannia incarnata, Geocarpon groenlandicum, Hackelia virginiana, Hexalectris spicata, Huperzia porophila, Packera millefolium, Panicum flexile, Rhynchospora alba, Solidago simulans, Spiraea corymbosa, Thermopsis mollis, Trichophorum cespitosum,* and *Trichostema setaceum*.

Nonvascular plants – *Macrocoma sullivantii, Orthotrichum keeverae*, and *Physcia pseudospeciosa*.

Invertebrate animals – *Hypochilus* coylei and *Trimerotropis saxatilis*.

MONTANE CLIFF (ACIDIC SUBTYPE)

Concept: Montane Cliffs are steep-to-vertical, sparsely vegetated rock outcrops on river bluffs, lower slopes, and other topographically sheltered locations. This range of sites is narrower than the features that are commonly called cliffs; vertical outcrops on ridge tops and upper slopes are classified as Rocky Summit communities. Some of the communities called cliffs in the 3rd Approximation have been removed to the new glade types. The Acidic Herb Subtype covers the more common examples where species of mafic or calcareous rock are absent.

Distinguishing Features: Montane Cliffs are generally distinguished from forest and shrubland communities by having contiguous rock outcroppings large enough to form a canopy break. In general, the minimum size is about 10 meters in height. Cliffs may have much more vertical surface area than area in map projection, and less vertical cliffs can, paradoxically, more readily produce a canopy opening. Smaller rock outcrops that are completely shaded by the adjacent forest and that have few or no herbs typical of rock outcrops should not be treated as occurrences. Montane Cliffs are distinguished from Rocky Summit communities by occurring in more topographically sheltered locations, generally below mid slope or in narrow gorges or ravines. The plant species that are incidentally present are more likely to include mesophytic species such as *Tsuga canadensis, Quercus rubra, Betula* spp., or *Rhododendron maximum*, and to lack plants of more exposed sites. However, cliffs are heterogeneous environments, and xerophytic, mesophytic, and even hydrophytic species are often present in different microsites in close proximity. In addition, cliffs can vary with slope aspect and degree of topographic sheltering.

Montane Cliffs are distinguished from Low Elevation Acidic Glades and Low Elevation Basic Glades by having vertical rock more prominent and by having only limited area of soil mats with herbaceous vegetation. The herbaceous and woody vegetation that is present on Montane Cliffs is primarily rooted on bare rock or in crevices or deep pockets rather than in soil mats.

Distinguishing Montane Cliffs from Spray Cliffs and from some Low Elevation Seep (Bedrock Subtype) examples may be difficult. Spray Cliffs are permanently or usually wet, with aerial spray an important source of water, while Low Elevation Seeps are extensively wet due to seepage alone. However, seepage is often also important in Spray Cliffs. Montane Cliffs may have limited areas kept wet by seepage, but these do not dominate the outcrop. Montane Cliffs in particularly humid settings may have heavy bryophyte cover that makes it difficult to tell if seepage is important.

The Acidic Subtype is distinguished from the Mafic and Calcareous Subtypes by the absence of plant species indicative of higher pH conditions. Indicator plants are sometimes present only in small numbers even in well-developed examples of these communities, as all plants are usually sparse on cliffs.

Crosswalks: *Asplenium montanum - Heuchera villosa* Felsic Cliff Vegetation (CEGL004980).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Appalachian Montane Cliff and Talus Ecological System (CES202.330).

Sites: Montane Cliff communities occur on steep, often vertical or even overhanging rock outcrops in lower topographic positions. They may be adjacent to streams, on the edges of flat bottoms, on lower side slopes, or occasionally on higher slopes that face north or are in narrow gorges. Besides vertical rock faces, they may also include ledges, grottos, a flatter area at the top, and open areas of fallen rock at the base, as well as crevices, chutes, and soil pockets. They generally don't include significant expanses of smooth exfoliated rock. The rock in the Acidic Subtype may be felsic gneiss, schist, granitic rocks, quartzite, or other acidic rock types. Cliffs may occur over a broad range of elevations, encompassing the zones of both Low Elevation and High Elevation Rocky Summit. Examples are known from 1000-5200 feet and rarely higher, but most are in the lower part of this range.

Soils: Soil is limited to small patches and occasional deeper accumulations on ledges or in crevices or chutes. Soil may be either marginally weathered rock and accumulated organic matter or deposits of soil washed in from above. Soils are acidic and low in nutrients.

Hydrology: Cliffs are extremely heterogeneous in moisture levels and behavior of water. Most portions are dry to xeric because rainfall runs off rapidly from the bare rock. However, they may have areas where runoff accumulates or even scours the surface locally. Cliffs usually include some seepage areas, where water emerges from fractures in the rock or flows across the rock face from above. The conditions on dry parts are somewhat less extreme than on Rocky Summits or Granitic Domes because of their more sheltered position. Though cliffs often occur along rivers or streams, areas strongly affected by flooding by the flowing water are not included.

Vegetation: Montane Cliff vegetation is sparse overall, but patches of dense vegetation may be present on flat cliff tops, on ledges, amid broken rock at the base, and in larger soil-filled crevices or pockets. Rock faces have sparse cover of specialist herbs, while shallow soil areas have some additional species shared with other rock outcrop communities. In the Acidic Subtype, the highly constant species in site descriptions include *Heuchera villosa, Micranthes petiolaris* (*Hydatica, Saxifraga michauxii*), *Asplenium montanum, Dryopteris marginalis*, *Krigia montana, Campanula divaricata*, and *Heuchera parviflora*. Other outcrop species that occur less frequently include *Polypodium virginianum, Polypodium appalachianum, Danthonia spicata, Danthonia compressa, Coreopsis major, Carex pensylvanica, Carex biltmoreana*, other *Carex* species, *Capnoides* (*Corydalis*) *sempervirens, Micranthes careyana,* and *Schizachyrium scoparium*, while species such as *Bryodesma rupestre, Asplenium trichomanes, Asplenium platyneuron*, *Houstonia longifolia* var. *glabra*, *Eurybia surculosa*, *Solidago* spp., and many others may occur occasionally. Very moist sheltered cliffs in gorges may have *Hymenophyllum tayloriae, Crepidomanes (Trichomanes) intricatum, Vittaria appalachiana*, *Huperzia porophila*, and a number of additional common and rare bryophytes. Mesophytic species shared with nearby forests often occur in small numbers; *Eurybia divaricata, Mitchella repens*, *Galax urceolata*, and *Polystichum acrostichoides* are fairly frequent. Small seepage areas may support additional species, such as *Chelone glabra, Chelone lyonii, Parnassia asarifolia,* and *Thalictrum clavatum*, as well as *Sphagnum* spp. and other bryophytes. Nonvascular plants and lichens are sometimes abundant on the bare rock. *Umbilicaria mammulata* and other species are frequent. Not enough reports name species to tell what are common, but others noted include *Bartramia pomiformis, Atrichum* spp. *Andreaea* sp., *Bryoxiphium norvegicum, Radula sullivantii, Umbilicaria* (*Lasallia*) *papulosa, Ephebe solida*, and *Gymnoderma lineare*. Woody species are present on the edges and rooted in deeper crevices and soil pockets, and often have more cover than herbs. *Kalmia latifolia* and *Rhododendron maximum* are highly constant, and *Rhododendron minus* is frequent. The only other shrubs with a moderate frequency are *Clethra acuminata* and *Rubus alleghaniensis*, but a variety of other species occur occasionally. A few vine species, *Smilax rotundifolia, Smilax glauca, Toxicodendron radicans* and *Isotrema macrophyllum* occur in multiple examples. Trees are extremely variable, including both mesophytic species such as *Tsuga canadensis* and *Quercus rubra* and drier site species such as *Quercus montana, Tsuga caroliniana, Pinus virginiana, Juniperus virginiana*, and *Robinia pseudo-acacia*.

Range and Abundance: Ranked G3G4 but probably G4. Examples are present throughout the Mountain region and scattered in the foothills. More than 100 examples are known in North Carolina. Nevertheless, overall extent is limited, with less than 1000 acres likely to have ever existed. The equivalent association ranges southward to Georgia and may occur in Virginia.

Associations and Patterns: Montane Cliffs are small patch communities. Many examples are one acre or less, though some complexes are believed to be several acres. Size is difficult to measure because of the large amount of vertical surface. They are sometimes bordered by a river or creek below, but otherwise are surrounded by forests that are most often Mountain Cove Forests or Mountain Oak Forests. Floodplain forests may border them at the base.

Variation: This subtype is fairly diverse. Variants may be able to be distinguished with more study, possibly including examples on quartzite, examples on felsic gneisses and schists, and very moist, moss-covered examples transitional to Spray Cliff.

Dynamics: Montane Cliff communities generally are stable, though they are undergoing slow primary succession. There may be occasional local natural disturbances by rocks breaking or by trees falling from the top. Because they are topographically sheltered and because most of the larger plants are rooted in crevices or deep soil pockets, cliffs are better buffered from both windthrow and drought than are the shallow soil mats of granitic domes and most glades. Plants on bare rock or in shallower soil may be stressed or killed during drought. Because cliffs usually have forest above and below, most examples are at least partly shaded by adjacent trees. Light levels may occasionally change as a result of canopy gaps in the adjacent forest, which sometimes results in an influx of weedy species. Examples surrounded by oak forests presumably were exposed to fire, but since fire would not carry through the sparse vegetation, its effects might be limited to the edges and to scorching by radiant heat. Many examples are surrounded by mesic forest or are next to streams, where they probably had limited exposure to fire.

Comments: The acidic, mafic, and calcareous cliff communities, treated as full types in the 3rd Approximation, have been reduced to subtypes here. In general, the variation in these communities due to chemical influences, while real, appears to be more limited than previously believed.

Cliffs are very difficult to study quantitatively because steep terrain limits access. Plots are generally almost impossible to sample on them. When plots are done, they often present a biased or unrepresentative picture, because only the flatter, most accessible portions are sampled. Newell (1997) had a few rock outcrop samples at Linville Gorge, some of which were Montane Cliff edges or ledges, others of which were Low Elevation Rocky Summit. Montane Cliffs are described in many unpublished site descriptions, with varying thoroughness. Few published studies specifically address them, though some, such as Cooper and Hardin (1970) mention them.

Much descriptive literature differentiates cliffs by slope aspect. These differences can be striking when extreme, but variable occurrence of seepage and extremely variable microsites usually make the distinction nearly meaningless. The most sheltered cliffs can potentially be very dry, and even south-facing cliffs can have moist crevices or wet seeps. Slope aspect is potentially increasingly important in the more exposed vertical portions of some Rocky Summit communities.

Earlier drafts of the 4th Approximation included a Montane Cliff (Acidic Lichen Subtype), synonymous with *Lasallia papulosa - Lasallia pensylvanica* Nonvascular Vegetation (CEGL004385) in the NVC. It was defined based on exceptionally large, lichen-covered quartzite cliffs in the Sauratown Mountains. While those examples are unusual, smaller umbilicate lichen zones are present on other cliffs in a range of size. Discussion with the concept author of the NVC association led to the conclusion that the distinction was not worth maintaining, though the association remains in the NVC at present.

Rare species:
Vascular plants – *Asplenium bradleyi, Asplenium pinnatifidum, Buckleya distichophylla, Chelone obliqua, Chenopodiastrum simplex, Cystopteris tenuis, Dicentra eximia, Didymoglossum petersii, Diervilla rivularis, Geocarpon* (*Minuartia*) *groenlandicum, Hackelia virginiana, Heuchera pubescens?, Huperzia porophila, Hymenophyllum tayloriae, Liatris turgida, Silphium perfoliatum*, and *Veronica anagallis-aquatica*.

Nonvascular plants – *Acrobolbus ciliatus, Brachythecium rotaeanum, Bryoxiphium norvegicum, Bryum limbatum*, *Gymnoderma lineare, Homaliadelphus sharpii, Lejeunea blomquistii, Leptohymenium sharpii, Nardia scalaris* ssp. *botryoidea, Neckera complanata, Orthodontium pellucens, Palamocladium leskeoides, Plagiochila austinii, Plagiochila sullivantii, Porella wataugensis, Rinodina chrysomelaena, Rockefellera crossophylla, Scopelophila ligulata, Sphagnum contortum, Sphagnum squarrosum, Sphagnum warnstorfii, Syntrichia* (*Tortula*) *ammonsiana,* and *Tetrodontium brownianum.*

Vertebrate animals – *Aneides aeneus, Aneides caryaensis, Crotalus horridus, Eurycea longicauda longicauda, Neotoma magister*, *Plethodon wehrlei,* and *Plethodon yonahlossee* pop. 1.

MONTANE CLIFF (MAFIC SUBTYPE)

Concept: Montane Cliffs are steep to vertical, sparsely vegetated rock outcrops on river bluffs, lower slopes, and other topographically sheltered locations. This range of sites is narrower than the features that are commonly called cliffs; vertical outcrops on ridge tops and upper slopes are classified as Rocky Summit communities. Some of the communities called cliffs in the 3rd Approximation have been removed to the new glade types. The Mafic Subtype covers examples occurring on mafic rock substrates or mixed substrates containing plant species characteristic of higher base status conditions.

Distinguishing Features: Montane Cliffs are distinguished from forest and shrubland communities by having contiguous rock outcroppings large enough to form a canopy break. They are distinguished from Low Elevation Acidic Glades and Low Elevation Basic Glades by having vertical rock more prominent and by having only limited area of soil mats with herbaceous vegetation. The herbaceous and woody vegetation that is present on Montane Cliffs is primarily rooted on bare rock or in crevices or deep pockets rather than in thin soil mats. See the Montane Cliff (Acidic Herb Subtype) for more details on distinguishing Montane Cliffs from other rock outcrop communities.

The Mafic Subtype is distinguished by the presence of plants that indicate basic soil conditions but without those indicative of stronger calcareous conditions. *Cystopteris protrusa, Micranthes (Saxifraga) careyana, Micranthes (Saxifraga) caroliniana, Asplenium trichomanes, Asplenium rhizophyllum, Aquilegia canadensis, Hydrangea arborescens, Philadelphus inodorus, Ulmus rubra*, or species of Rich Cove Forests indicate high base status. Indicator plants are often low in abundance, with more widespread species of rock outcrops or of surrounding forests more common. *Toxicodendron radicans* is sometimes abundant. Species typical of the Calcareous Subtype but not to the Mafic Subtype include *Pellaea atropurpurea, Asplenium ruta-muraria, Asplenium resiliens, Cystopteris bulbifera*, and a variety of mosses. The Mafic Subtype generally occurs on mafic rock such as amphibolite or hornblende gneiss but may occur on felsic or other acidic rocks that are influenced by base-rich seepage.

Crosswalks: (*Hydrangea arborescens, Toxicodendron radicans) / Heuchera americana - (Dichanthelium depauperatum, Woodsia obtusa)* Cliff Shrubland (CEGL004395).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Appalachian Montane Cliff and Talus Ecological System (CES202.330).

Sites: Montane Cliff communities occur on steep, often vertical or even overhanging rock outcrops in lower topographic positions. They may be adjacent to streams, on the edges of flat bottoms, on lower slopes, or occasionally on higher slopes that face north or are in narrow gorges. Besides vertical rock faces, they may also include ledges, grottos, a flatter area at the top, and open areas of fallen rock at the base, was well as crevices, chutes, and soil pockets. The rock in the Mafic Subtype is generally amphibolite or hornblende gneiss, or chemically related rocks such as metabasalt or greenstone. This community may occasionally occur on felsic or acidic rocks that underlie mafic rocks and are influenced by seepage from them. It may possibly occur on ultramafic rocks where their extreme chemistry is mitigated by alteration or mixture with other kinds of rock. Examples are known from 1400-4700 feet elevation.

Soils: Soil is limited to small patches and occasional deeper accumulations on ledges or in crevices or chutes. Soil may be either marginally weathered rock and accumulated organic matter or deposits of soil washed in from above. Soils may be acidic or circumneutral but are generally higher in pH and base saturation than those in the Acidic Herb Subtype.

Hydrology: Cliffs are extremely heterogeneous in moisture levels and behavior of water. Most portions are dry to xeric because rainfall runs off rapidly from the bare rock. However, they may have areas where runoff accumulates or even scours the surface locally. Cliffs usually include some seepage areas, where water emerges from fractures in the rock or flows across the rock face from above. The conditions on dry parts are less extreme than on Rocky Summits or Granitic Domes because of their more sheltered position.

Vegetation: Vegetation in the Mafic Subtype is sparse overall, but patches of dense vegetation may be present on flat cliff tops, on ledges, amid broken rock at the base, and in larger soil-filled crevices or pockets. Rock faces have sparse cover of specialist herbs, while shallow soil areas have some additional species shared with other rock outcrop communities, along with specialized species of high pH outcrops, more generalist species of open areas, and weedy species. No species have high constancy in site descriptions, but the most frequent herbaceous species are *Heuchera villosa, Heuchera americana, Tradescantia subaspera*, and *Dryopteris marginalis*, followed by *Micranthes careyana, Carex biltmoreana, Coreopsis major,* and *Micranthes* (*Hydatica*) *petiolaris.* Numerous herb species are less frequent but occur in several sites, including *Cystopteris protrusa, Woodsia obtusa, Krigia montana, Asplenium montanum, Asplenium trichomanes* var. *trichomanes, Myriopteris* (*Cheilanthes*) *lanosa, Heuchera parviflora, Micranthes caroliniana, Primula (Dodecatheon) meadia, Houstonia tenuifolia, Campanula divaricata, Andropogon gerardii, Eupatorium sessilifolium* var. *sessilifolium*, *Schizachyrium scoparium, Sorghastrum nutans, Panicum gattingeri, Solidago simulans, Helianthus divaricatus, Lespedeza hirta, Ambrosia artemisiifolia,* and *Pseudognaphalium obtusifolium*. Additional species seem to occur with lower frequency but serve to indicate base-rich conditions when they are present, including *Asplenium rhizophyllum* and *Aquilegia canadensis*. Most cliffs also have some species shared with mesic or rich forests. *Polygonatum biflorum* and *Eurybia divaricata* occur with frequency as high as most of the outcrop species, while *Polystichum acrostichoides, Sedum ternatum, Laportea canadensis, Pycnanthemum beadlei, Adiantum pedatum,* and *Silene virginica* are fairly frequent. A large number of additional species, such as *Prosartes lanuginosa, Hydrophyllum virginianum, Osmorhiza claytoniana, Phacelia bipinnatifida*, and *Geranium maculatum* indicate base-rich conditions. Small seepage areas may have a variety of wetland species, such as *Osmundastrum cinnamomeum, Calamagrostis coarctata*, and *Thalictrum clavatum*. Nonvascular plants are thought to be an important component in the Mafic Subtype, probably with more abundance and diversity than in the Acidic Subtype, but information on species is limited. Woody species are confined to microsites with deeper soil, which may be very limited or fairly abundant in different occurrences. A great variety of shrubs may occur, none with high frequency. They include ones indicating base-rich conditions, such as *Hydrangea arborea, Rosa carolina, Amelanchier sanguinea, Philadelphus hirsutus, Philadelphus inodorus, Ptelea trifoliata*, and *Symphoricarpos orbiculatus*, along with ones shared with acidic cliffs, such as *Kalmia latifolia, Rhododendron maximum, Clethra acuminata*, and *Amorpha glabra*. The latter occur with much lower frequency than in the Acidic Subtype. Vines are often present, with *Toxicodendron radicans* and

Parthenocissus quinquefolia particularly frequent. The trees that are present are similarly quite variable. The only species with high frequency are *Quercus montana* and *Fraxinus americana/biltmoreana*, though *Crataegus* spp. and *Juniperus virginiana* occur in several examples. The range of other tree species includes ones suggestive of basic conditions, such as *Ulmus rubra, Juniperus virginiana*, and *Juglans nigra*, as well as widespread species such as *Pinus strobus, Quercus rubra*, and *Pinus* spp.

Range and Abundance: Ranked G3? but would be better as G3 or G2G3. It clearly is not as common as G4. In North Carolina, there are fewer than 40 examples known. Examples are scattered over most of the Blue Ridge, with a higher density in the Amphibolite Mountains area of Ashe County and in the Craggy Mountains. Virtually no examples are known in the foothills area but a few may be found. The equivalent NVC association is attributed to Alabama and potentially to Georgia and Tennessee.

Associations and Patterns: The Mafic Subtype, like other subtypes, is a small patch community. Many examples are one acre or less, though some complexes are believed to be several acres. As with other cliffs, defining extent is complex because they may have more vertical surface than area of map projection. They may be bordered by a river or creek below, but otherwise are surrounded by forests that are most often Mountain Cove Forests or Mountain Oak Forests. Surrounding forests are usually base-rich communities such as Rich Cove Forest, Montane Oak–Hickory Forest (Basic Subtype), or High Elevation Red Oak Forest (Rich Subtype).

Variation: The Mafic Subtype is very heterogeneous, and variants may be recognized in the future. Examples may vary with degree of development (openness versus shading and degree of weathering of the rock), amount of seepage, amount of sheltering by topography, and elevation, as well as showing biogeographic differences.

Dynamics: Montane Cliff communities generally are stable, though they are undergoing slow primary succession. There may be occasional local natural disturbances by rocks breaking or by trees falling from the top. Because they are topographically sheltered and because most of the larger plants are rooted in crevices or deep soil pockets, cliffs are better buffered from both windthrow and drought than are the shallow soil mats of granitic domes and most glades. Plants on bare rock or in shallower soil may be stressed or killed during drought. Because cliffs usually have forest above and below, most examples are at least partly shaded by adjacent trees. Light levels may occasionally change as a result of canopy gaps in the adjacent forest, which sometimes results in an influx of weedy species. Examples surrounded by oak forests presumably were exposed to fire, but since fire would not carry through the sparse vegetation, its effects might be limited to the edges and to scorching by radiant heat. Many examples are surrounded by mesic forest or are next to streams, where they probably had limited exposure to fire.

Comments: The acidic, mafic, and calcareous cliff communities, treated as full types in the 3rd Approximation, have been reduced to subtypes here. In general, the variation in these communities due to chemical influences, while real, appears to be more limited than previously believed. The distinction between the Mafic Subtype and Calcareous Subtype needs further clarification. Cliffs are very difficult to study because steep terrain limits access. Plots are generally almost impossible to sample on them, and no CVS plot data exist. They are described in many unpublished site descriptions, with varying thoroughness.

Rare species:
Vascular plants – *Adlumia fungosa, Arabis adpressipilis*, *Arabis patens, Berberis canadensis, Celastrus scandens, Coreopsis grandiflora* var. *grandiflora, Crataegus pallens, Cystopteris tenuis, Dicentra eximia, Draba ramosissima, Heuchera pubescens, Meehania cordata, Micranthes caroliniana, Muhlenbergia sobolifera, Packera millefolium, Sedum glaucophyllum, Sisyrinchium dichotomum, Smilax hugeri, Solidago simulans, Trichophorum cespitosum,* and *Woodsia appalachiana*.

Nonvascular plants – *Gymnoderma lineare, Lejeunea cavifolia, Syntrichia* (*Tortula*) *ammonsiana,* and *Syntrichia* (*Tortula*) *fragilis.*

Vertebrate animals – *Aneides aeneus, Aneides caryaensis, Crotalus horridus, Eurycea longicauda longicauda, Falco peregrinus, Neotoma magister,* and *Plethodon yonahlossee* pop. 1.

Invertebrate animals – *Hypochilus coylei*.

MONTANE CLIFF (CALCAREOUS SUBTYPE)

Concept: Montane Cliffs are steep-to-vertical, sparsely vegetated rock outcrops on river bluffs, lower slopes, and other topographically sheltered locations. The Calcareous Subtype covers examples on dry to moist calcareous rock, characterized by a strongly calciphilic flora, with species such as *Pellaea atropurpurea, Asplenium ruta-muraria, Asplenium resiliens, Aquilegia canadensis, Cystopteris bulbifera*, and a variety of mosses.

Distinguishing Features: Montane Cliffs are distinguished from forest and shrubland communities by having contiguous rock outcroppings large enough to form a canopy break. They are distinguished from Low Elevation Acidic Glades and Low Elevation Basic Glades by having vertical rock more prominent and by having only limited areas of soil mats with herbaceous vegetation. The herbaceous and woody vegetation that is present on Montane Cliffs is primarily rooted on bare rock or in crevices or deep pockets rather than in thin soil mats. See the Montane Cliff (Acidic Herb Subtype) for more details on distinguishing Montane Cliffs from other rock outcrop communities.

The Calcareous Subtype is distinguished from other subtypes by the presence of strongly calciphilic plants such as *Pellaea atropurpurea, Cystopteris bulbifera, Asplenium ruta-muraria* var. *cryptolepis,* and *Asplenium resiliens*. It also has an overall flora that contains more base-loving species such as *Aquilegia canadensis* and *Asplenium rhizophyllum* than the Mafic Subtype.

Crosswalks: *Asplenium ruta-muraria - Pellaea atropurpurea* Cliff Sparse Vegetation (CEGL004476).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Appalachian Montane Cliff and Talus Ecological System (CES202.330).

Sites: Montane Cliff communities occur on steep, often vertical or even overhanging rock outcrops in lower topographic positions. They may be adjacent to streams, on the edges of flat bottoms, on lower side slopes, or occasionally on higher slopes that face north or are in narrow gorges. Besides vertical rock faces, they may also include ledges, grottos, vertical or horizontal solution cavities, a flatter area at the top, and open areas of fallen rock at the base, was well as crevices, chutes, and soil pockets. The rock in the Calcareous Subtype may be limestone, dolomite, marble, or occasionally calc-silicate rock, or potentially a mix that includes some of these calcium-rich rocks.

Soils: Soil is limited to small patches and occasional deeper accumulations on ledges or in crevices or chutes. Soil may be either marginally weathered rock and accumulated organic matter or deposits of soil washed in from above. Soils probably are circumneutral or slightly basic and are high in base saturation and calcium content.

Hydrology: Cliffs are extremely heterogeneous in moisture levels and behavior of water. Most portions are dry to xeric because rainfall runs off rapidly from the bare rock. However, they may have areas where runoff accumulates or even scours the surface locally. Cliffs usually include some seepage areas, where water emerges from fractures in the rock or flows across the rock face from above. Because of the solubility of calcareous rock, solution cavities may conduct water or provide microsites for water to pool. Conversely, solution cavities may provide greater potential for internal drainage of water out of the reach of plants. In extreme cases, larger caves may be present. The conditions on dry parts are less extreme than on Rocky Summits or Granitic Domes because of their more sheltered position.

Vegetation: Vegetation in the Calcareous Subtype is sparse overall, but patches of dense vegetation may be present on flat cliff tops, on ledges, amid broken rock at the base, and in larger soil-filled crevices or pockets. Rock faces have sparse cover of specialist herbs, while shallow soil areas have some additional species shared with other rock outcrop communities, along with specialized species of high pH outcrops, more generalist species of open areas, and weedy species. Though examples are very variable in composition, the overall vegetation is more strongly of base-loving plants than in the Mafic Subtype, with a much lower abundance of the widespread acid-tolerant species. Species with the highest frequency in site descriptions are *Dryopteris marginalis, Asplenium trichomanes* var. *trichomanes*, *Asplenium resiliens, Asplenium rhizophyllum, Pellaea atropurpurea, Polystichum acrostichoides, Aquilegia canadensis,* and *Sedum ternatum*. Oosting (1941) also found *Adiantum pedatum* and *Sedum ternatum* frequent. Other species that are fairly frequent include *Asarum canadense, Heuchera* spp., *Campanula divaricata, Coreopsis major, Impatiens capensis*, *Asplenium platyneuron, Arisaema triphyllum, Pleopeltis michauxiana (Polypodium polypodioides*), *Botrypus virginianus*, *Lycopodioides (Selaginella) apodum*, and *Mitella diphylla*. A number of other species occur with low frequency but indicate the calcium-rich conditions, including *Cystopteris protrusa, Cystopteris bulbifera, Cystopteris fragilis, Myriopteris tomentosa, Myriopteris alabamensis, Solidago flexicaulis, Asplenium ruta-muraria* var. *cryptolepis, Cubelium concolor, Arabidopsis lyrata, Carex manhartii, Borodinia burkii (Arabis laevigata* var. *burkii*), *Urtica dioica*, *Anticlea (Zigadenus) glauca*, *Carex plantaginea,* and *Polygala senega*. Nonvascular plants are thought to be an important component in the Calcareous Subtype, where they may be more abundant and diverse than in the Acidic Herb Subtype and may include specialist species, but they are seldom listed in site descriptions.

Among woody plants that inhabit the microsites with deeper soil, the only highly constant species is *Hydrangea arborescens*, though *Philadelphus hirsutus* is also fairly frequent. Vines, particularly *Toxicodendron radicans* and *Parthenocissus quinquefolia*, are usually present. Other shrubs indicative of rich conditions are present at lower frequency, including *Lindera benzoin, Ptelea trifoliata, Euonymus atropurpureus*, and *Dirca palustris*. No tree species have high constancy, but a number of species indicative of calcareous conditions may occur, including *Fraxinus americana, Fraxinus biltmoreana, Celtis occidentalis, Ulmus rubra, Acer saccharum, Acer nigrum, Quercus muhlenbergii,* and *Cercis canadensis*, along with *Juniperus virginiana, Ostrya virginiana, Chionanthus virginicus*, and more widespread species.

Range and Abundance: Ranked G3G4. This subtype is extremely rare in North Carolina, since it depends on the coincidence of rare calcareous rock types with topographic processes that form cliffs. Most examples are confined to geologic areas known to have calcareous rocks, such as the Hot Springs window, Grandfather Mountain window, and Murphy syncline, but a couple of apparent examples occur elsewhere. The equivalent NVC association is more abundant in states that have extensive limestone such as Tennessee and Virginia. It is defined very broadly, extending to Pennsylvania and Alabama as well as Kentucky, and may warrant subdivision.

Associations and Patterns: The Calcareous Subtype is a small patch community, with even the largest complexes no more than a few acres. As with other cliffs, defining extent may be complex because they may have more vertical surface than area of map projection. The community may potentially be bordered by a river or creek, but otherwise is generally surrounded by rich mesophytic communities such as Rich Cove Forest (Foothills Rich or Montane Rich Subtype).

Variation: The Calcareous Subtype is very heterogeneous even among its few examples. Variants may be recognized in the future. Examples may vary with type of rock (limestone, dolomite, or calc-silicate), degree of development (openness versus shading and degree of weathering of the rock), amount of seepage, amount of sheltering by topography, and elevation. Because examples are confined to a handful of widely separated geologic areas, biogeography may prove an important basis for division.

Dynamics: Montane Cliff communities generally are stable, though they are undergoing slow primary succession. The solubility of calcareous rocks may speed the physical breakdown of cliffs, but the often-limited amount of residual material might slow soil accumulation. There may be occasional local natural disturbances by rocks breaking or by trees falling from the top. Because most of the larger plants are rooted in crevices or deep soil pockets, they are better buffered from both windthrow and drought than are the shallow soil mats of granitic domes and most glades. Plants on bare rock or in shallower soil may be stressed or killed during drought. Because cliffs usually have forest above and below, most examples are at least partly shaded by adjacent trees. Light levels may occasionally change as a result of canopy gaps in the adjacent forest, which sometimes results in an influx of weedy species. Examples surrounded by oak forests presumably were exposed to fire, but since fire would not carry through the sparse vegetation, its effects might be limited to the edges and to scorching by radiant heat. Many examples are surrounded by mesic forest or are next to streams, where they probably had limited exposure to fire.

Comments: The acidic, mafic, and calcareous cliff communities, treated as full types in the 3rd Approximation, have been reduced to subtypes here. In general, the variation in these communities due to chemical influences, while real, appears to be more limited than previously believed. The distinction between the Mafic Subtype and Calcareous Subtype needs further investigation.

Cliffs are very difficult to study because steep terrain limits access. No CVS plot data exist for this subtype. However, Oosting (1941) represents an early thorough study of their flora. Examples are described in many unpublished site descriptions, with varying thoroughness.

Cystopteris bulbifera - (Asplenium rhizophyllum) Sparse Vegetation (CEGL004394) is another calcareous cliff association of sinkhole walls, occurring in adjacent states. North Carolina has no known sinkholes in the Mountains, but it is possible that some of our Calcareous Subtype vegetation would fit this association better.

Rare species:
Vascular plants – *Adlumia fungosa, Anticlea glauca, Arabis patens, Asplenium ruta-muraria* var. *cryptolepis, Buckleya distichophylla, Carex eburnea, Clematis catesbyana, Croton monanthogynus, Dicentra eximia, Draba ramosissima, Matelea obliqua, Myriopteris*

alabamensis, Oligoneuron rigidum, Packera paupercula var. *appalachiana, Phlox subulata, Polygala senega, Sedum glaucophyllum,* and *Symphyotrichum oblongifolium.*

Nonvascular plants – *Cyrto-hypnum pygmaeum, Dichodontium pellucidum, Didymodon fallax, Didymodon tophaceus, Encalypta procera, Entodon compressus, Entodon concinnus, Entodon sullivantii, Eucladium verticillatum, Homaliadelphus sharpii, Leptodontium flexifolium, Mannia californica, Neckera complanata, Orthodontium pellucens, Orthotrichum strangulatum, Palamocladium leskeoides, Plagiochasma intermedium, Plagiochasma wrightii, Plagiochila austinii, Plagiomnium carolinianum, Plagiomnium rostratum, Platydictya* (*Serpoleskea*) *confervoides, Scopelophila ligulata,* and *Tortula plinthobia*.

Vertebrate animals – *Aneides aeneus, Aneides caryaensis, Eurycea longicauda longicauda,* and *Plethodon yonahlossee* pop. 1.

TALUS VINELAND

Concept: Talus Vineland is a non-forest community of open boulderfields or expanses of loose large rocks. Vegetation is either sparse or, if denser, is dominated by woody vines which may cover the rocks from a limited number of rooting sites.

Distinguishing Features: Talus Vinelands are distinguished from all forest communities, including those of boulderfields, by lack of a well-developed tree canopy. They are distinguished from rock outcrop communities by consisting largely of loose boulders with little bedrock. Talus Vineland is defined conceptually as any community on open talus. It may have an extensive cover of vines but vegetation is often sparse.

Crosswalks: *Parthenocissus quinquefolia / (Dicentra eximia)* Sparse Vegetation (CEGL004454).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Appalachian Montane Cliff and Talus Ecological System (CES202.330).

Sites: Talus Vineland occurs on steep slopes at the bases of cliffs or on the walls of gorges. The ground is covered with loose rocks, usually of boulder size, and there is extensive void space beneath the rock. The rock may potentially be of any type that occurs in massive beds but is most often of highly resistant types such as quartzite or quartz-rich metasedimentary rocks.

Soils: No developed soil is present. Small accumulations of organic matter, dust, and rock fragments occur in patches between the boulders.

Hydrology: The boulderfields or talus slopes are generally xeric due to the lack of soil. Rainfall runs off the surface to deeper levels very quickly.

Vegetation: The Talus Vineland community is not well known. Its vegetation generally is sparse, but it may have more extensive cover of vines, especially *Parthenocissus quinquefolia, Toxicodendron radicans*, or *Muscadinia rotundifolia*, or potentially of herbs. Bryophytes or lichens may be abundant if the talus is moist. Herbs noted as occurring in examples include *Polymnia canadensis, Dryopteris marginalis, Dioscorea villosa, Dicentra eximia*, and *Adlumia fungosa*. Trees and shrubs may be absent, but some individuals, potentially large ones, may be present on the edges or in less extreme microsites.

Range and Abundance: Ranked G2G3Q, but likely rarer and without need for an indication of taxonomic question. The communities are very poorly known in North Carolina. The only examples currently recorded are in Mitchell and Madison counties, but they should be sought in extremely rocky places such as the Nantahala Gorge and Grandfather Mountain. The NVC association is attributed only to North Carolina and Tennessee. Related associations are present in Virginia.

Associations and Patterns: Talus Vinelands are small patch communities. The size of the few examples is not well known. They may potentially be a few acres in size.

Variation: Nothing is known of variation, but examples can be expected to vary with degree of topographic exposure and amount of seepage.

Dynamics: Little is known of the dynamics of Talus Vinelands. Addition of falling rock from above may constitute a chronic natural disturbance, though the frequency is not known. The openness is due to inhospitable site conditions rather than chronic disturbance. Shallowly rooted vegetation may be particularly prone to stress or mortality during drought, but vines or trees that become large and have extensive root systems that reach below the boulders or into adjacent soil may be well buffered from drought. The lack of a forest canopy, as is present in the various boulderfield forest communities, presumably is due to more recent origin or more chronic disturbance.

Comments: This community was not known at the time of the 3rd Approximation. It remains poorly known and very little documented.

Rare species:
Vascular plants – *Adlumia fungosa* and *Dicentra eximia*.

PIEDMONT CLIFF (ACIDIC SUBTYPE)

Concept: Piedmont Cliffs are steep to vertical, sparsely vegetated rock outcrops on river bluffs, lower slopes, and other topographically sheltered locations. The vegetation often includes some woody plants rooted in deeper soil pockets or crevices, but the overall woody cover is low. The Acidic Subtype encompasses the more common examples occurring on felsic igneous and metamorphic rocks and other acidic rocks and lacking flora indicative of base-rich conditions.

Distinguishing Features: Piedmont Cliffs are distinguished from forest and shrubland communities by having contiguous rock outcroppings large enough to form a canopy break. In general, the minimum size is about 10 meters in height. Smaller rock outcrops that are completely shaded by the adjacent forest and that have few or no herbs typical of rock outcrops should not be treated as occurrences.

Piedmont Cliffs are distinguished from various Piedmont and Mountain Glades and Barrens communities by having lower vegetation cover, with much bare rock present, herbaceous cover persistently less than 25 percent, and woody plants restricted to more favorable microsites. Cliffs generally have substantial vertical or very steep surfaces. Flat ledges on cliff faces and related vegetation on flatter tops of outcrops are included in the cliff occurrence. Piedmont Cliffs are distinguished from Granitic Flatrocks, which also have substantial bare rock, by steepness and by having more fractured rock rather than a smooth exfoliated surface. Larger plants on cliffs are rooted in deeper soil microsites rather than primarily in shallow soil mats. Characteristic herbs such as *Diamorpha smallii* and *Geocarpon (Mononeuria, Minuartia) uniflorum* are present in Granitic Flatrocks and not on Piedmont Cliffs. Cliffs are generally very steep and Granitic Flatrocks horizontal or gently sloping, but portions may overlap in steepness.

Lower parts of cliffs may extend near rivers or streams. They are distinguished from Rocky Bar and Shore communities, which may be bedrock outcrops, by the lack of flooding, with its associated transport of seeds and scouring of soil.

Piedmont Cliffs are distinguished from Montane Cliffs by having flora indicative of warmer lowland conditions. They largely lack characteristic mountain species such as *Micranthes petiolaris (Saxifraga michauxii)*, *Asplenium montanum*, and *Heuchera villosa*, but some examples support notable disjunct populations of them. As with other communities of the Mountain Region, Montane Cliffs with characteristic montane flora occur in the foothills of the upper Piedmont. Piedmont Cliffs are distinguished from Coastal Plain Cliffs by their location and by occurring on hard rock substrates rather than unconsolidated or marginally consolidated Coastal Plain sediments.

The Acidic Subtype is distinguished from the Basic Subtype by the absence of species that indicate base-rich conditions, such as *Aquilegia canadensis, Myriopteris (Cheilanthes) lanosa, Asplenium trichomanes, Asplenium rhizophyllum, Adiantum pedatum*, and *Asarum canadense*.

A few species that indicate base-rich conditions in forests, such as *Rhus aromatica*, are sometimes present in the Acidic Subtype. Rocks intermediate between felsic and mafic, such as andesite, and some metasedimentary rocks such as metamudstone and argillite, may support either the Acidic

Subtype or Basic Subtype, or may represent intermediate examples. They will need to be assigned based on the flora.

Crosswalks: Piedmont Acidic Cliff Vegetation (CEGL003979).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Piedmont Cliff Ecological System (CES202.386).

Sites: Piedmont Cliff communities occur on steep, often vertical or even overhanging rock outcrops in lower topographic positions. They may be adjacent to streams, on the edges of flat bottoms, on lower side slopes, or occasionally on higher slopes that face north or are in narrow gorges. Besides vertical rock faces, they may also include ledges, grottos, a flatter area at the top, and open areas of fallen rock at the base, was well as crevices, chutes, and soil pockets. They generally don't include significant expanses of smooth exfoliated rock. Rocks may be any felsic igneous or metamorphic rock or acidic metasedimentary rock, and sometimes may be intermediate rock such as diorite.

Soils: Soil is limited to small patches and occasional deeper accumulations on ledges or in crevices or chutes. Soil may be either marginally weathered rock and accumulated organic matter or deposits of soil washed in from above. Soils are acidic and low in nutrients.

Hydrology: Cliffs are extremely heterogeneous in moisture levels and behavior of water. Most portions are dry to xeric because rainfall runs off rapidly from the bare rock. However, there may be areas where runoff accumulates or even scours the surface locally. Cliffs often include some seepage areas, where water emerges from fractures in the rock or flows across the rock face from above.

Vegetation: Piedmont Cliff vegetation is sparse or patchy. Rock faces have only sparse vascular plants, but edges, soil pockets, and ledges may have dense herbaceous or woody plants or may have large individual trees or shrubs. Bryophytes and lichens may be extensive on moist or north-facing cliffs. Fewer vascular plants grow on the rock faces than in Montane Cliff, with more of the flora confined to the top or to ledges. In the Acidic Subtype, *Danthonia spicata* is the only herb with high constancy in site descriptions. Fairly frequent herbs include *Polypodium virginianum, Asplenium platyneuron, Dryopteris marginalis, Bryodesma rupestre, Hieracium venosum,* and *Antennaria plantaginifolia*. Less frequent species shared with other rock outcrop communities or open areas include *Schizachyrium scoparium, Hypericum gentianoides, Phemeranthus teretifolius, Potentilla* spp., *Sedum ternatum, Tephrosia virginiana, Micranthes virginiensis, Solidago caesia*, *Pleopeltis michauxiana (Polypodium polypodioides)*, and *Dichanthelium* spp. Though a well-developed montane flora is not present, occasional species from farther west can occur as disjunct populations, including *Galax urceolata* and even rare species such as *Asplenium bradleyi*. The most frequent shrubs are *Kalmia latifolia* and *Vaccinium arboreum*, while *Vaccinium stamineum* and other species of *Vaccinium* are fairly frequent. Several vines may be present, most frequently *Toxicodendron radicans* and *Gelsemium sempervirens*. The most frequent trees are *Juniperus virginiana* and *Quercus stellata*, but *Quercus alba, Pinus echinata, Pinus virginiana*, and *Chionanthus virginicus* are moderately frequent. Species typical of more base-rich sites, such as *Rhus aromatica, Hydrangea arborescens*, *Myriopteris lanosa,* or *Myriopteris tomentosa,* may be present in small numbers.

Range and Abundance: Ranked G2? but probably less rare. There are about two dozen occurrences in North Carolina, though the total area is well under 100 acres. The association is attributed to South Carolina and Georgia, and questionably to Alabama and Virginia.

Associations and Patterns: Piedmont Cliffs are small patch communities, with most patches a handful of acres at most and many less than one acre. As with other cliffs, assessing extent is complex because they may have more vertical area than area in map projections. Cliffs are usually bordered by oak forest above and may be bordered by oak forest, Mesic Mixed Hardwood Forest, or various floodplain communities below.

Variation: Examples vary in rock structure and its effect on vegetation structure, as well as varying geographically.

Dynamics: Piedmont Cliff communities generally are stable, though they are undergoing slow primary succession. There may be occasional local natural disturbances by rocks breaking or by trees falling from the top. Because most of the larger plants are rooted in crevices or deep soil pockets, they are better buffered from both windthrow and drought than are the shallow soil mats of Granitic Flatrocks and various glades. Plants on bare rock or in shallower soil may be stressed or killed during drought. Because cliffs usually have forest above and below, most examples are at least partly shaded by adjacent trees. Light levels may occasionally change as a result of canopy gaps in the adjacent forest, which sometimes results in an influx of weedy species. Examples surrounded by oak forests presumably were exposed to fire, but since fire would not carry through the sparse vegetation, its effects might be limited to the edges and to scorching by radiant heat. Many examples are surrounded by mesic forest or are next to streams, where they probably had limited exposure to fire.

Comments: The structure of Piedmont Acidic Cliff classification in the 3rd Approximation has been changed for the 4th Approximation. It has been narrowed by the creation of the Piedmont Acidic Glade community type, which encompasses sites with more cover of soil and vegetation, which generally are less steep. At the same time, it is now treated as a subtype rather than a type. Though the floristic differences that distinguish the two subtypes are real, they are not as pronounced as initially believed. Montane Cliffs are divided into three subtypes while Piedmont Cliffs are divided only into two. No well-developed calcareous cliffs are known in the Piedmont, though some examples of the Basic Subtype are on apparently calcium-rich metasedimentary rocks. As with other Mountain communities, Montane Cliffs replace Piedmont cliffs in the foothills zone of the upper Piedmont and in a few outlying monadnock areas such as the Sauratown Mountains.

Rare species:
Vascular plants – *Asplenium bradleyi, Clinopodium georgianum, Cirsium carolinianum, Dichanthelium bicknellii, Euphorbia mercurialina, Eurybia mirabilis, Fothergilla major,* and *Liatris squarrulosa.*

Nonvascular plants – *Pohlia lescuriana.*

PIEDMONT CLIFF (BASIC SUBTYPE)

Concept: Piedmont Cliffs are steep-to-vertical, sparsely vegetated rock outcrops on river bluffs, lower slopes, and other topographically sheltered locations. The vegetation often includes some woody plants rooted in deeper soil pockets or crevices, but the overall woody cover is low. The Basic Subtype encompasses examples with flora indicative of base-rich conditions, occurring on mafic or somewhat calcareous rocks.

Distinguishing Features: Piedmont Cliffs are distinguished from forest and shrubland communities by having contiguous rock outcroppings large enough to form a canopy break. In general, the minimum size is about 10 meters in height. Smaller rock outcrops that are completely shaded by the adjacent forest and that have few or no herbs typical of rock outcrops should not be treated as occurrences. Piedmont Cliffs are distinguished from various Piedmont and Mountain Glades and Barrens communities by having lower vegetation cover, with much bare rock present, herbaceous cover persistently less than 25 percent, and woody plants restricted to more favorable microsites. The Basic Subtype often has more plant cover than the Acidic Subtype and thus appears transitional to Piedmont Basic Glade. Cliffs generally have substantial vertical or very steep surfaces but some examples of the Basic Subtype are less steep. Flat ledges on cliff faces and related vegetation on flatter tops of outcrops are included in the cliff occurrence.

Piedmont Cliffs are distinguished from Montane Cliffs by having flora indicative of warmer lowland conditions. They largely lack characteristic mountain species such as *Micranthes petiolaris (Saxifraga michauxii)*, *Asplenium montanum*, and *Heuchera villosa*, but some examples support notable disjunct populations of them. As with other communities of the Mountain Region, Montane Cliffs with characteristic montane flora occur in the foothills of the upper Piedmont.

The Basic Subtype is distinguished from the Acidic Subtype by the presence of base-loving flora in more than token numbers. This includes *Aquilegia canadensis, Myriopteris (Cheilanthes) lanosa, Asplenium trichomanes, Asplenium rhizophyllum, Adiantum pedatum, Asarum canadense*, and a variety of species shared with Basic Mesic Forest, Dry-Mesic Basic Oak–Hickory Forest, and Dry Basic Oak–Hickory Forest, or with floodplain communities. Acid-tolerant plants typical of the Acidic Subtype are usually present as well. In the absence of full floristic information, substrate chemistry may provisionally be used to distinguish this subtype; however, some mafic rock outcrops have vegetation indistinguishable from felsic rock outcrops. Cliffs of metamudstone and andesitic igneous and metamorphic rocks, which have intermediate chemistry, should be classified as the Basic Subtype only if base-loving flora is present.

Crosswalks: Piedmont Mafic Cliff Sparse Vegetation (CEGL003982).
G691 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Piedmont Cliff Ecological System (CES202.386).

Sites: Piedmont Cliff communities generally occur on steep, often vertical or even overhanging rock outcrops in lower topographic positions, but some of the Basic Subtype are less steep. Cliffs may be adjacent to streams, on the edges of flat bottoms, on lower side slopes, or occasionally on higher slopes that face north or are in narrow gorges. Besides vertical rock faces, they may also include ledges, grottos, a flatter area at the top, and open areas of fallen rock at the base, was well as crevices, chutes, and soil pockets. Some examples are on fine-bedded rock that forms sloping areas covered with flat rock fragments. There generally is not a sizeable expanse of exfoliated rock surface. Rocks generally are either mafic rocks such as diabase or gabbro, or are base-rich metamudstone or argillite, which may be massive or finely foliated and like slate. Intermediate rocks such as diorite or andesite sometimes support Basic Subtype vegetation.

Soils: Soil is limited to small patches and occasional deeper accumulations on ledges or in crevices or chutes. Soil may be either marginally weathered rock and accumulated organic matter or deposits of soil washed in from above. Soils may be low in nutrients but are higher in pH and base saturation than those of the Acidic Subtype. They likely are finer-textured and richer in clay than the Acidic Subtype.

Hydrology: Cliffs are extremely heterogeneous in moisture levels and behavior of water. Most portions are dry to xeric because rainfall runs off rapidly from the bare rock. However, there may be areas where runoff accumulates or even scours the surface locally. Cliffs often include some seepage areas, where water emerges from fractures in the rock or flows across the rock face from above.

Vegetation: Piedmont Cliff vegetation is sparse or patchy. Rock faces have only sparse vascular plants, but edges, soil pockets, and ledges may have dense herbaceous or woody plants or may have large individual trees or shrubs. Bryophytes and lichens may be extensive on moist or north-facing cliffs. In the Basic Subtype, the most constant herbs are *Myriopteris lanosa*, *Piptochaetium avenaceum*, *Aquilegia canadensis*, and *Carex nigromarginata*. Also frequent are *Danthonia spicata, Schizachyrium scoparium, Antennaria plantaginifolia, Cunila origanoides, Pleopeltis michauxiana (Polypodium polypodioides), Solidago arguta, Commelina erecta, Danthonia sericea, Myriopteris tomentosa, Campanula divaricata, Micranthes virginiensis, Sedum glaucophyllum, Melica mutica, Hieracium venosum, Borodinia (Arabis) missouriensis, Dichanthelium depauperatum*, and *Eurybia divaricata*. Less frequent species that indicate the base-rich conditions include *Asplenium rhizophyllum, Asplenium trichomanes, Cystopteris protrusa, Elymus virginicus, Elymus hystrix, Brachyelytrum erectum, Deparia acrostichoides, Adiantum pedatum*, and *Asarum canadense*. A variety of herbs of open dry sites, such as *Yucca filamentosa* and *Opuntia* spp., are also present at low frequency. Shrubs include species of richer sites, such as *Hydrangea arborescens, Celtis pumila (tenuifolia, georgiana),* and *Rhus aromatica*, as well as more widespread species such as *Vaccinium arboreum* and *Vaccinium stamineum*, none with more than moderate frequency. Several vines are frequently present, including *Bignonia capreolata, Toxicodendron radicans*, *Lonicera sempervirens*, and the exotic *Lonicera japonica*. Among tree species, *Juniperus virginiana* is almost universally present, and *Ostrya virginiana, Ulmus alata*, *Carya glabra*, and *Pinus virginiana* occur with high frequency. Other fairly frequent species include *Cercis canadensis, Quercus montana, Acer leucoderme*, *Fraxinus americana/biltmoreana*, and *Quercus stellata*, while less frequent species such as *Tilia americana* var. *caroliniana* and *Juglans nigra* indicate base-rich conditions.

Range and Abundance: Ranked G2? but probably reliably G2. There are well under 20 occurrences in North Carolina, with a cluster of the Slate Variant in Stanley, Anson, and Union counties and other examples scattered across the Piedmont. The association is attributed to South Carolina and Georgia, and questionably to Alabama and Virginia.

Associations and Patterns: Piedmont Cliffs are small patch communities, with most patches a handful of acres at most and many less than one acre. As with other cliffs, assessing extent is complex because they may have more vertical area than area in map projection. Cliffs are usually bordered by oak forest above and may be bordered by oak forest, Mesic Mixed Hardwood Forest, or various floodplain communities below.

Variation: While the Basic Subtype examples are as variable as any rock outcrop communities, a distinctive cluster is recognized as a variant.

1. Typic Variant fits most examples, on a variety of rock types.

2. Slate Variant occurs on a narrow-ranging cluster of bluffs of, apparently, calcium-rich slate in Stanley and Union counties. The fine-bedded rock forms some hard outcrops and some areas of loose flat fragments making the physical site intermediate to those of Acidic Shale Slope Woodland and Piedmont Basic Glade (Falls Dam Slope Subtype). Its flora and vegetation structure are similar to other cliffs of the Basic Subtype, but several species, including *Acer leucoderme* and *Borodinia missouriensis*, occur primarily or exclusively in it. After further study, the Slate Variant may warrant recognition as a subtype.

Dynamics: Piedmont Cliff communities generally are stable, though they are undergoing slow primary succession. Because mafic and many metasedimentary rocks are less resistant to weathering than many felsic rocks, primary succession probably is faster in the Basic Subtype. If succession is not reset, they may develop to Piedmont Basic Glades. This may be why Piedmont Basic Glades are more numerous than well-developed cliffs. There may be occasional local natural disturbances by rocks breaking or by trees falling from the top. Because most of the larger plants are rooted in crevices or deep soil pockets, they are better buffered from both windthrow and drought than are the shallow soil mats of Granitic Flatrocks and various glades. Plants on bare rock or in shallower soil may be stressed or killed during drought. Examples occurring on slate and similar rocks have some natural disturbance from shifting of unstable fragments, though less so than other shale communities.

Light levels may occasionally change as a result of canopy gaps in the adjacent forest, which sometimes results in an influx of weedy species. Examples surrounded by oak forests presumably were exposed to fire, but since fire would not carry through the sparse vegetation, its effects might be limited to the edges and to scorching by radiant heat. Many examples are surrounded by mesic forest or are next to streams, where they probably had limited exposure to fire.

The Basic Subtype is susceptible to invasion by exotic plants to a much greater degree than most rock outcrop communities. *Lonicera japonica* is fairly frequent in it, and several other exotic species occur in examples.

Comments: The structure of Piedmont cliff classification has been changed from the 3rd Approximation. It has been narrowed by the creation of the Piedmont Basic Glade community type, which encompasses sites with more cover of soil and vegetation, which generally are less steep. At the same time, the formerly separate mafic and calcareous communities have been combined. While somewhat calcareous rocks are present in parts of the Piedmont, they are less distinctive than those that support different communities in the Mountains. Because of the ambiguous classification of some substrates, the more general term “basic” has been used for their name. The cliff communities have been changed from types into subtypes, suggesting what appears to be a closer relationship among their biota.

Rare species:
Vascular plants – *Anemone berlandieri, Borodinia missouriensis, Euphorbia mercurialina, Eurybia mirabilis, Pellaea wrightiana,* and *Sedum glaucophyllum.*

COASTAL PLAIN CLIFF

Concept: Coastal Plain Cliffs are sparsely vegetated, largely dry communities of steep-to-vertical exposures of bare sedimentary substrates.

Distinguishing Features: Coastal Plain Cliffs are distinguished from most communities of the Coastal Plain by sparse vegetation on steep-to-vertical exposures. Piedmont/Coastal Plain Heath Bluff and Cape Fear Valley Mixed Bluff Forest occur on steep bluffs but have dense vegetation. Coastal Plain Cliffs are distinguished from Coastal Plain Seepage Bank communities by having only local saturated seepage zones and having a flora consisting primarily of upland plants. They are distinguished from Piedmont Cliffs by occurring on unconsolidated Coastal Plain sediments rather than crystalline rock, and by the more dynamic environment this creates. There are substantial floristic differences between Piedmont and Coastal Plain cliff communities. Many of the most characteristic species, such as *Morella cerifera* and *Pinus taeda,* are scarce and infrequent on Piedmont cliffs. Characteristic Piedmont cliff species that don't typically occur on Coastal Plain Cliffs include *Pinus virginiana*, *Chionanthus virginicus, Rhododendron* spp., *Vaccinium pallidum, Danthonia spicata, Myriopteris (Cheilanthes) lanosa, Solidago caesia*, *Pleopeltis polypodioides,* and *Hieracium venosum*. Distinctive species of Coastal Plain Cliffs are less well known, but *Morella cerifera, Vaccinium arboreum*, and *Pinus taeda* are often common. *Mikania scandens*, *Andropogon tenuispatheus*, and a variety of weedy herbaceous species are often present.

Crosswalks: Coastal Plain Acidic Cliff Vegetation (CEGL004388).
G842 Southeast Coastal Plain Cliff & Rock Vegetation Group.
No definitive placement in an ecological system has been determined.
Piedmont/Coastal Plain Acidic Cliff (3rd approximation).

Sites: Coastal Plain Cliffs occur on bluffs of large rivers, or rarely in ravines of tributary creeks. Most are very steep to nearly vertical, but ledges and sloping areas may occur. An accumulation of fallen material at the base may be less steep. The substrate is unconsolidated or semi-consolidated clayey and sandy sediment, generally of Cretaceous age formations.

Soils: Coastal Plain Cliffs have soft or firm clay, loamy, or sandy material, but surfaces are young and soil development is limited. The rooting medium may be relatively fertile or infertile.

Hydrology: Coastal Plain Cliffs may be very heterogeneous in moisture levels. Large parts are dry, but significant zones may be moist and local areas may be saturated by seepage. A common pattern is for the outcrop of an impervious clay layer within the strata to force ground water to the surface, creating a horizontal seep whose water then flows down the face of the clay layer.

Vegetation: Coastal Plain Cliff vegetation is sparse overall, often completely absent over the central part of the cliff face. The top, the base, and ledges or areas with seepage may have locally dense vegetation. Vegetation is extremely variable among the few examples. The only frequent species is *Morella cerifera*, which is universally present on the edges. Trees on the edges may be either species of Mesic Mixed Hardwood Forest, such as *Fagus grandifolia* or *Acer floridanum*, species of floodplains such as *Platanus occidentalis*, or widely dispersed species such as *Pinus taeda, Acer rubrum*, *Liquidambar styraciflua*, or *Quercus nigra*. Shrubs noted in different examples include *Hydrangea arborescens, Vaccinium arboreum, Ilex decidua*, *Clethra alnifolia, Cyrilla racemiflora, Symplocos tinctoria, Alnus serrulata, Vaccinium elliottii*, and many others. Herbs may include disjunct or regionally uncommon species such as *Galax urceolata* or *Epigaea repens*, or weedy species such as *Eupatorium capillifolium*. The greatest diversity of herbs comes in the seepage zones. They may have widespread wetland species such as *Osmundastrum cinnamomeum, Osmunda spectabilis*, *Lorinseria areolata*, *Impatiens capensis, Hydrocotyle verticillata/umbellata, Ptilimnium capillaceum, Persicaria* spp., or *Viola lanceolata*. They may also have unexpected wetland species such as *Kellochloa (Panicum) verrucosa* or *Equisetum hyemale*. A couple of examples have zones influenced by calcareous seepage and contain *Parnassia grandifolia*.

Range and Abundance: Ranked G2? In North Carolina examples are widely scattered, with the six known examples occurring along four different rivers. The overall range is very poorly known. The NVC association is attributed definitively only to North Carolina but conceptually similar vegetation could occur in any Coastal Plain state.

Associations and Patterns: Coastal Plain Cliffs are small patch communities. As with other cliff communities, they may have more area in vertical orientation than in map projection. Cliffs are generally bordered by a river or by floodplain communities below. Otherwise, they may be bordered by Mesic Mixed Hardwood Forest, Piedmont/Coastal Plain Heath Bluff, or Dry-Mesic Oak–Hickory Forest. They could be bordered by longleaf pine communities above.

Variation: Coastal Plain Cliffs are extremely variable. The six occurrences could represent five different variants.

Dynamics: Coastal Plain Cliffs are less stable than other cliff communities. Undercutting by erosion or sapping lead to slumping which removes vegetation and developing soil and creates new bare surfaces fairly frequently. Without slumping, the steep slopes would quickly break down in the soft sediment and succession to denser vegetation would be rapid. Although the frequency of slumping is not well known, most examples appear to have recognizable scars. The sparse vegetation and location on steep slopes along rivers make fire unlikely to be an influence anywhere other than at the top of the cliff. Seepage zones may be affected by drought or alteration of ground water recharge areas.

Rare species:
Vascular plants – *Carex socialis* and *Parnassia grandifolia*.

COASTAL PLAIN MARL OUTCROPS THEME

Concept: Coastal Plain Marl Outcrops are communities occurring on outcrops of limestone in the Coastal Plain. Outcrops are very small and may be shaded by trees in the adjacent forest, but vegetation on the rocks themselves is typical of other rock outcrop communities in being a heterogeneous mix of sparse vegetation, herb cover, and patchy woody stems. The flora strongly reflects the high calcium levels yielded by the limestone.

Distinguishing Features: Coastal Plain Marl Outcrops are distinguished by having substantial cover of bare limestone over an area many meters in extent. Small outcrops and lone boulders with almost no plants, occasionally present in Basic Mesic Forest (Coastal Plain Subtype) or exposed on riverbanks, are not treated as this community. Bases of outcrops flooded enough of the time to lack terrestrial plants are excluded.

The two subtypes are distinguished by physical setting, along streams or on a lake shore.

Sites: The limestone outcrops that support Coastal Plain Marl Outcrops generally occur on bluffs or banks of creeks or rivers or, in one unique situation, on the shore of Lake Waccamaw. Undercutting by stream flow or waves likely is important in keeping the outcrops open. Outcrops are rarer on lower or mid slopes away from the creek bank, embedded in forest. Though the rock is locally called “marl” and that traditional name is retained as the community name, most or all is coquina limestone, a porous mass of cemented shells and shell fragments. A few may be calcareous-cemented sandstone. The rocks include the Castle Hayne and Waccamaw Formations, and possibly some of the Cretaceous formations. True marl, a crumbly earth-like calcareous material, does not outcrop in North Carolina.

Soils: Soil on the outcrops themselves consists of small pockets of accumulated organic matter, deposited clay and sand, and the limited insoluble material released from the limestone. All are smaller than the minimum map unit for soil mapping.

Hydrology: Communities are probably generally mesic but are heterogeneous. Limited size of soil pockets makes them prone to drying quickly, while the open rock is very dry, but their position at the base of slopes and usually next to water may provide an ongoing or periodic source of water input by flooding, runoff, or seepage.

Vegetation: Vascular plants on the rock outcrops tends to be sparse, with larger plants limited to solution pockets and crevices. Outcrops are small enough that they often are shaded by trees rooted in adjacent communities, but their occurrence along streams or, in one case, a lake, leads to sunny conditions in some examples. Plants include a mix of species of various high-calcium sites, such as *Aquilegia canadensis,* rare specialist species such as *Asplenium heteroresiliens, Cystopteris tennesseensis,* and *Adiantum capillus-veneris*, and more widespread species such as *Asplenium platyneuron* and *Polystichum acrostichoides*. Vines are often prominent, especially *Toxicodendron radicans, Hydrangea* (*Decumaria*) *barbara*, and the exotic *Lonicera japonica*. Bryophytes often have higher cover. *Conocephalum salebrosum* is abundant in the Lake Shore Subtype, while *Anomodon attenuatus, Claopodium* (*Anomodon*) *rostratum*, and *Dumortiera hirsuta* are abundant in the Bluff Subtype.

Dynamics: Coastal Plain Marl Outcrops are stable over periods of years, but given the porous limestone's extreme susceptibility to weathering, they presumably are maintained in the long run only by periodic erosion and slumping. Occasional stream or lake flooding may affect the lower portions of outcrops, but they are unlikely to be exposed to fire. The occurrence of highly local populations of plants that are not in the surrounding landscape suggests that the outcrops have persisted for long periods.

Comments: This is the most narrowly defined theme in the 4th Approximation, containing only a single type with two subtypes. This reflects the unique distinctness of these communities, as the only terrestrial rock outcrop communities in the Coastal Plain. Presumably the closest affinity of this theme would be with Low Elevation Cliffs and Rock Outcrops. An alternative treatment, only marginally rejected, would be to create a slightly broader Coastal Plain cliffs and rock outcrops theme, which would include Coastal Plain Cliff community.

The author has not heard an explanation of the distinctive usage of the term "marl" for the very different limestones in North Carolina. True marl was widely used as an agricultural amendment in parts of England, where it is abundant. By the time of colonization it may simply be that settlers used the local limestone for the same purpose.

KEY TO COASTAL PLAIN MARL OUTCROPS

1. Community occurring on the shore of a natural lake. Sparse vegetation dominated by *Adiantum capillus*-veneris and liverworts. Known only at Lake Waccamaw. .... **Coastal Plain Marl Outcrop (Lake Shore Subtype)**
1. Community not occurring on the shore of a lake. Occurring on banks or bluffs along a stream or river, or on upland slopes. Vegetation various, but *Adiantum capillus-veneris* absent. .... **Coastal Plain Marl Outcrop (Bluff Subtype)**

COASTAL PLAIN MARL OUTCROP (BLUFF SUBTYPE)

Concept: Coastal Plain Marl Outcrops are terrestrial communities occurring on outcrops of limestone in the Coastal Plain. The Bluff Subtype covers all examples other than the very distinctive Lake Shore Subtype. The handful of examples occur on high river bluffs or low but seldom flooded upper stream banks in the Coastal Plain. These outcrops are small and generally are substantially shaded by trees rooted in adjacent forests but have very distinctive flora on the rocks. The setting is usually a mix of dry and wet microhabitats.

Distinguishing Features: Coastal Plain Marl Outcrops are distinguished by the presence of bare or vegetated limestone that is not regularly flooded. Calciphilic vascular plants such as *Asplenium heteroresiliens, Cystopteris tennesseensis*, and *Aquilegia canadensis* are usually present. Distinctive calciphilic bryophytes are believed to be present but are not well studied. The Bluff Subtype is distinguished by its environment, occurring on bluffs or stream banks, with substantial forest shading.

Crosswalks: *Aquilegia canadensis - Asplenium heteroresiliens* Rock Outcrop (CEGL004269).
G584 Southeastern Coastal Plain Barrens & Glade.
Southern Atlantic Coastal Plain Mesic Hardwood Forest Ecological System (CES203.242).

Sites: The limestone outcrops that support the Bluff Subtype occur on bluffs or banks of creeks or rivers in the outer Coastal Plain. They are generally of coquina limestone but may include calcareous-cemented sandstone.

Soils: Soil on the outcrops themselves consists of small pockets of accumulated organic matter, deposited clay and sand, and the limited insoluble material released from the limestone. All are smaller than the minimum map unit for soil mapping.

Hydrology: Communities are probably generally mesic but are heterogeneous. Limited size of soil pockets makes them prone to drying quickly, while the open rock is very dry, but their common position at the base of slopes and usually next to water leads to high humidity and may provide an ongoing or periodic source of water input by flooding, runoff, or seepage.

Vegetation: Vegetation on the rock outcrop itself is sparse or patchy. *Aquilegia canadensis* is the most constant species, but some of the rare plants, especially *Asplenium heteroresiliens*, are also among the most frequent in site descriptions. Other herbs that have moderate frequency include *Cystopteris tennesseensis, Asplenium platyneuron,* and *Polystichum acrostichoides*. Other herbs noted occasionally include *Melica mutica, Sanicula odorata, Carex digitalis*, and *Solidago caesia*. Vines, especially *Hydrangea* (*Decumaria*) *barbara, Lonicera japonica*, and *Toxicodendron radicans,* may be abundant. The rocks often have abundant bryophyte cover. These are not well documented, but likely usually include *Claopodium* (*Anomodon*) *rostratum* and *Anomodon attenuatus* and may include *Dumortiera hirsuta* and the rare *Lejeunea bermudiana*. The outcrops generally don't have trees rooted on them, but they are shaded by trees from the adjacent forest.

Range and Abundance: Ranked G1? The uncertainty in global rank presumably is related to uncertainty in the range of the NVC association, which is definitively attributed to North and South

Carolina but questionably attributed to Georgia and Florida. This in turn probably reflects uncertainty in classification or interpretation, as to whether the more extensive limestone outcrops in Florida represent this association or a different one. Given the large range and biogeographic differences, this community is probably best regarded as being endemic to the Carolinas and being a true G1 element. In North Carolina, the Bluff Subtype is widely scattered through the southern half of the outer Coastal Plain, from Craven and Jones to Brunswick County. Overall, fewer than ten occurrences are known.

Associations and Patterns: The Bluff Subtype occurs embedded in Basic Mesic Forest (Coastal Plain Subtype).

Variation: No variants are defined. Differences between examples on large river bluffs and along smaller creek banks need investigation and may be significant.

Dynamics: Dynamics are those discussed in the theme description. Many examples clearly have been present for a long time, since they support rare flora not found nearby. This subtype is particularly threatened by invasion by exotic plants, primarily *Lonicera japonica* but also including *Youngia japonica*, *Stellaria media*, and *Microstegium vimineum*.

Comments: Study of this community has been limited to a single floristic thesis (Sears 1966) and a study of the rare ferns (Jones-Roe 1982). Outcrops are difficult to represent in plots, because of their small size and irregular shape.

Although no rare animal species are known to be associated with this community, the potential exists for notable snails and other invertebrates.

Rare species:
Vascular plants – *Arenaria lanuginosa* var. *lanuginosa, Asplenium heteroresiliens, Cystopteris tennesseensis,* and *Oplismenus setarius*.

Nonvascular plants – *Lejeunea bermudiana*.

COASTAL PLAIN MARL OUTCROP (LAKE SHORE SUBTYPE)

Concept: Coastal Plain Marl Outcrops are terrestrial communities occurring on outcrops of limestone in the Coastal Plain. The Lake Shore Subtype covers the unique limestone bluff on the north shore of Lake Waccamaw, exposed to spray and to storm waves and not shaded by trees.

Distinguishing Features: The Lake Shore Subtype is distinguished by the presence of bare or vegetated limestone that is not regularly flooded, on an open lake shore bluff. It is unlikely to be found anywhere other than Lake Waccamaw.

Crosswalks: *Adiantum capillus-veneris / Conocephalum salebrosum* Rock Outcrop (CEGL004515).
G584 Southeastern Coastal Plain Barrens & Glade Group
No definitive placement in an ecological system has been determined.

Sites: The Lake Shore Subtype occurs on an outcrop of coquina limestone on a bluff on the north shore of Lake Waccamaw.

Soils: The substrate is bare limestone with only small accumulations of organic and mineral material in pockets and crevices.

Hydrology: The community has highly variable moisture levels. Because Lake Waccamaw is subject to frequent south winds and develops substantial waves on the north shore on most summer days, the outcrop is often wetted by spray from waves. When not receiving spray, the lack of soil presumably makes for dry conditions. Seepage from the soils above may create more permanent moisture in minor portions.

Vegetation: The Lake Shore Subtype has sparse vascular vegetation, with *Adiantum capillus-veneris* the dominant species. Other species include *Aquilegia canadensis* and trailing vines of *Toxicodendron radicans* and *Hydrangea (Decumaria*) *barbara*. The liverwort *Conocephalum salebrosum* has high cover in wetter areas.

Range and Abundance: Ranked G1Q but the community is very distinct and no more questionable than most communities. The single example on Lake Waccamaw is the only example likely to exist, as this is the only lake with limestone occurring along it anywhere north of Florida and south of New England.

Associations and Patterns: The one example is bordered below by Natural Lake Shoreline (Lake Waccamaw Pondlily Subtype). The natural community bordering on the upland side is not known, as no natural vegetation remains there.

Variation: Only a single example exists.

Dynamics: Dynamics are similar to those described in the theme description. The presence of a long-distance disjunct plant population indicates great antiquity in the open outcrop.

Rare species:
Vascular plants – *Adiantum capillus-veneris*.

Nonvascular plants – *Cylindrocolea rhizantha* and *Lejeunea bermudiana.*

GRANITIC FLATROCKS THEME

Concept: Granitic Flatrocks are communities occurring on nearly level outcrops of exfoliating granitic rock in the eastern and central Piedmont. The pavement-like surfaces largely lack crevices or other sites for deep rooting by plants. The individual communities represent different major stages of primary succession: barely vegetated bedrock, shallow soil with herbaceous vegetation, and continuous shallow soil capable of supporting xerophytic woodland trees.

Distinguishing Features: The Granitic Flatrock theme is distinguished by naturally sparse, denser herbaceous, or stunted woodland vegetation associated with flat-lying exfoliated granitic rock at or near the surface. They are separated from the Low Elevation Granitic Dome community in the Low Elevation Cliffs and Rock Outcrops theme by their gentle slope, which changes soil development, as well as differing climate and regional flora. The edge of the Granitic Flatrocks theme occurs where the distinctive xerophytic vegetation gives way to more typical forest communities.

Sites: Sites are unfractured pavement-like outcrops of exfoliating granite, adamellite, syenite, or related igneous or high grade metamorphic rocks, level or gently sloping, at about the same elevation as the surrounding land. Rock may be extensive at the surface or may be covered with a shallow layer of soil. Rock surfaces may have shallow weathering pits, large or small loose rock fragments, and occasionally larger loose slabs of rock but have extensive pavement-like surfaces. Flatrocks may be on upland ridges or may be exposed on gentle slopes above streams. In a few examples, they extend to the banks of streams that flow over the bedrock.

Soils: Soils consist of sandy-textured partially weathered rock and accumulated organic matter. They range from barely present to continuous shallow layers. The more continuous soil areas are often treated as Wake (Lithic Udispamment), Louisburg (Ruptic-Ultic Dystrochrept), or, farther west, Ashlar (Typic Dystrudept).

Hydrology: Moisture conditions may have extreme fluctuations. The limited soil depth creates extremely dry conditions much of the year but the limited water penetration allows soils to be saturated during wet periods. Local areas of seepage may be present on edges of open rock, and water may pool seasonally in weathering depressions.

Vegetation: Vegetation varies greatly among the three communities in this theme, but all are more open than the surrounding forest. Thorough vegetation descriptions were published early (Oosting and Anderson 1939, McVaugh 1943), and interest has continued to lead to publications ((Palmer 1970, Wyatt and Fowler 1977, Phillips 1982). The Annual Herb Subtype often has sparse vegetation or may consist of a mosaic of lichens, mosses, spikemosses (*Bryodesma (Selaginella) rupestre*), and small herbs that include habitat specialist species such as *Diamorpha smallii*, *Geocarpon* (*Mononeuria, Minuartia, Arenaria) uniflora* and *Cyperus granitophilus*, as well as more widespread rock outcrop species such as *Phemeranthus (Talinum) teretifolius* and *Hypericum gentianoides*. The Perennial Herb Subtype has more continuous vegetation of larger herbaceous plants such as *Andropogon virginicus* and *Packera tomentosa,* along with some shrubs. Granitic Flatrock Border Woodland has a tree canopy dominated by species characteristic of xeric sites, such as *Juniperus virginiana, Quercus stellata,* and *Pinus virginiana*.

Dynamics: The successional dynamics of Granitic Flatrocks were a theme of interest to early ecologists. Oosting and Anderson (1939), McVaugh (1943), Palmer (1970), and other authors interpreted the concentric zonation of soil mats as representing successional time; they fit the finely described vegetation patch types into successional sequences that remains generally accepted. They noted that lichens are the first pioneers to establish on bare rock, but that they don't seem to contribute to soil development. Mat-forming mosses and spikemoss (*Bryodesma (Selaginella*) *rupestre*) also establish on bare rock and are more capable of trapping sand and clay and depositing organic matter to begin building soil. A small number of specialized herbs, mostly annuals, take hold in the extremely shallow soil accumulations in depressions or in the moss mats. As soil mats thicken, perennial herbs and then larger herbs can establish. Shrubs and tree seedlings are able to survive as the mats thicken. Succession may ultimately lead to the somewhat deeper soil and continuous woody vegetation of the Granitic Flatrock Border Woodland community. Oosting and Anderson (1939) and McVaugh (1943) also noted different successional pathways in different microsites, including seepages and small depressions that hold water long enough to exclude many species.

Most authors also noted that flatrocks are "self-perpetuating," tending to support a cyclic succession pattern, where rock repeatedly becomes bare and primary succession begins anew. They noted wind, drought, and fire as causes of the disturbance that regenerates bare rock. The shallow soil leaves trees vulnerable to wind throw and drought. When live or dead trees fall, they can pull up soil mats and destroy the accumulated soil. This effect has been observed by the author in recent years after droughts and major storms. Fire presumably once was an additional source of natural disturbance, at least on the edges of flatrocks adjacent to surrounding forests. Given the high organic content of the shallow soil, fire during drought might destroy more than just the woody plants. However, the sparse vegetation of the open rock would not carry fire. The only study of fire in Granitic Flatrocks appears to be that of Caspary and Affolter (2012). They found that, even in a prescribed burn where isolated patches were all deliberately ignited if the fire did not spread to them, a single fire had limited effect. They noted the occurrence of a drought later in the year of the fire, which may have contributed to what mortality they saw in plants in shallow soils.

The presence of a number of weedy species in undisturbed flatrocks has been noted and discussed (Burbanck and Platt 1964, Wyatt and Fowler 1977). It appears that the open environment, with limited competition, allows them to persist.

Though similar primary and cyclic succession patterns occur in Low Elevation Granitic Dome and High Elevation Granitic Dome communities, the lack of slope in Granitic Flatrocks brings some differences. Soil mats are likely to persist longer in Granitic Flatrocks, weathering debris would be removed more slowly, water and soil are more likely to pool in weathering depressions, and erosion by flowing water is likely to be less vigorous.

It is unclear how much the cyclic succession involves the larger surrounding zone of Granitic Flatrock Border Woodland. Soil pulled up by falling trees there is more readily replaced from the surroundings. However, the susceptibility to natural disturbance because of the shallow soil is presumed to be the cause of the distinctive xerophytic flora and abundance of successional species in these woodlands. It may be that a longer-term cyclic dynamic occurs, with woodlands and open rock alternately expanding and contracting in response to climatic cycles on the scale of decades. Palmer (1970) noted that the border woodland at one site appeared to have expanded from 1949 to 1966, but also believed it might expand and contract over longer time periods.

The open Granitic Flatrocks are extremely sensitive to mechanical disturbance, including even moderate foot traffic, while the unique environment attracts such traffic. The hard level surface and open vegetation also attract vehicle traffic and dumping of trash, while the unweathered rock without overburden makes flatrocks attractive for quarrying. Traffic destroys the vegetation of both the Annual Herb and Perennial Herb Subtype, and it is possible that the relative proportions of these communities seen at present reflects this as well as the configuration of the rock.

Like the other glade, barren, and rock outcrop communities, Granitic Flatrocks are an anomaly in the Piedmont climate, which supports the development of thick saprolite, deep soils, and forest vegetation. Oosting and Anderson (1939) appear to have thought flatrocks originated recently as a result of human actions. Burbanck and Platt (1964) suggested a shifting pattern of flatrocks disappearing and appearing across the landscape, and this view was favored by Wyatt and Fowler (1977). However, no flatrocks have been reported to have appeared recently. The most characteristic plants do not seem to appear at artificially created bare rock exposures. While many of the plant species are ruderal species and some others are shared with other kinds of rock outcrop or open communities, McVaugh (1943) argued that the existence of a distinctive flora of species with no other habitat, along with the amount of time it would take for them to disperse to the small sites over distances of unsuitable habitat, suggest great antiquity. Wyatt and Fowler (1977) noted reduction in characteristic and community-endemic species as one travels away from the center of flatrock distribution in northcentral Georgia. A shifting mosaic would be expected to produce a more random pattern of richness in these species, as individual rocks would be of differing age. In the end, the existence of multiple specialized endemic species that don't occur in other rock outcrop communities suggests many millennia of evolutionary time in this habitat.

Comments: Granitic Flatrocks are clearly closely related to glade and barren communities on other rock types, sharing features of ecology, vegetation structure, and species composition. Thus, this community type could as easily be termed "Granitic Glade." The flatrock name has been retained because of its long and well-established usage. It was modified slightly from the often-used "Granite Flatrock," changing it to "Granitic Flatrock," since several kinds of rock that are not strictly granite can also support them.

The structure of the classification of the Granitic Flatrocks theme and its component communities is different from other parts of the 4th Approximation. The somewhat analogous Granitic Dome Basic Woodland is separated from the associated Low Elevation Granitic Dome and instead placed with other communities having similar vegetation structure, while the Granitic Flatrock Border Woodland is included in the Granitic Flatrocks theme despite the very different vegetation structure. While a different decision could have been made, and a more parallel treatment used, it appears that the granitic flatrock environment is more distinct from other rock outcrops than that of granitic dome, and that the border woodland is more closely tied to it ecologically.

KEY TO GRANITIC FLATROCKS

1. Vegetation with substantial tree cover, more than 50% cover when not recently disturbed. Xerophytic composition, usually with abundant *Pinus* spp. or *Juniperus virginiana,* distinguishes it from adjacent forests.. **Granitic Flatrock Border Woodland**

1. Vegetation without substantial tree cover; only sparse trees or young trees are present; vegetation generally sparse or dense herbaceous cover, with limited shrub patches.

   2. Vegetation dominated by combinations of small annual herbs, small mosses such as *Grimmia laevigata*, and lichens, often with substantial bare rock …………………………………………………………………………………………………… **Granitic Flatrock (Annual Herb Subtype)**

   2. Vegetation dominated by combinations of predominantly long-lived and larger herbs, including grasses such as *Andropogon virginicus* and *Schizachyrium scoparium*, forbs such as *Packera tomentosa*, and large mosses such as *Polytrichum* spp. and *Sphagnum* spp.; bare rock and smaller herbs are present in smaller amounts and in small patches........... ………………………………………………………………… **Granitic Flatrock (Perennial Herb Subtype)**

GRANITIC FLATROCK (ANNUAL HERB SUBTYPE)

Concept: Granitic Flatrock communities are sparsely vegetated or herbaceous communities of flatrock outcrops. The Annual Herb Subtype represents the zones in the vegetation mosaic that occur on the shallowest soil accumulations or on bare rock, where plants are primarily annual herbs, small bryophytes, or lichens. This subtype represents the earliest stages of primary succession. Characteristic flatrock endemic species such as *Diamorpha smallii, Sedum pusillum, Portulaca smallii, Geocarpon* (*Mononeuria*) *uniflora,* and *Cyperus granitophilus* occur primarily in this subtype.

Distinguishing Features: Granitic Flatrocks are distinguished from Granitic Domes by floristic differences such as the presence of *Diamorpha smallii, Sedum pusillum, Geocarpon* (*Mononeuria*) *glabra, Packera tomentosa, Croton willdenowii*, and the absence of plants more characteristic of the Blue Ridge, as well as by their location in the central and eastern Piedmont. They are generally distinguished by gentler topography and the associated presence of small weathering depressions, but the range of slopes can overlap with that of Granitic Domes. Other types of rock outcrops generally have a different physical structure, containing crevices, fractures, deeper soil pockets, and more irregular surfaces, though some microsites may be similar. Though they share many species, the different rock structure generally leads to different flora, vegetation structure, and ecological dynamics.

The Annual Herb Subtype is distinguished from other zones by the dominance of smaller mosses, lichens, or annual herbs, usually *Diamorpha, Mononeuria, Sedum,* or *Portulaca*, but also including *Hexasepalum (Diodia) teres, Cyperus granitophilus, Hypericum gentianoides*, and others. Mats of *Grimmia laevigata* are included, but beds of *Polytrichum* spp., *Sphagnum* spp. beds in seeps, and other larger mosses are included with the Perennial Herb Subtype.

Crosswalks: *Diamorpha smallii - Minuartia glabra - Minuartia uniflora - Cyperus granitophilus* Flatrock Vegetation (CEGL004344).
G671 Piedmont-Blue Ridge Dome & Flatrock Group
Southern Piedmont Granite Flatrock and Outcrop Ecological System (CES202.329).

Sites: The Annual Herb Subtype occurs on open flatrock outcrops of granitic rocks. It may include flat areas, gentle slopes, and shallow weathering depressions.

Soils: Soil is absent or consists solely of very shallow accumulations of organic matter and sandy partially weathered granite.

Hydrology: The Annual Herb Subtype generally is very dry, due to lack of soil and water-holding capacity. However, because of the impermeable bedrock, it may be seasonally wet, especially in weathering depressions.

Vegetation: The vegetation of the Annual Herb Subtype is generally a fine-scale mosaic of several zones or patch types of short-lived or small-stature plants. Most distinctive, though not always most extensive, are areas dominated by *Diamorpha smallii, Portulaca smallii, Geocarpon* (*Mononeuria, Minuartia) glabrum*, *Geocarpon uniflorum*, or *Cyperus granitophilus*, species which occur exclusively, or nearly so, in Granitic Flatrocks and in this subtype. Other herbs of extremely shallow soils, such as *Hypericum gentianoides, Hexasepalum (Diodia) teres*, *Bulbostylis capillaris*, or *Croton willdenowii* (*Crotonopsis elliptica*) may also dominate patches. Patches dominated by *Bryodesma (Selaginella) rupestre* are also included in this subtype; though perennial, they represent early stages of primary succession. Large patches of this subtype may be dominated by mats of *Grimmia laevigata* or other small mosses, other substantial areas by crustose lichens or unvegetated bedrock. Any of the larger plants characteristic of the Perennial Herb Subtype may occur with limited cover; vegetation plots often capture portions of that community and suggest greater presence of them. Though this is inherently a sparsely vegetated community, trees rooted on the edge may provide substantial cover.

Granitic Flatrock vegetation was described in early thorough studies by Oosting and Anderson (1939) and McVaugh (1943), who described multiple zones. Later authors (e.g. Palmer 1970, Wyatt and Fowler 1977) focused on specific sites or concentrated in other states. Only a few CVS plots exist for this community.

Range and Abundance: Ranked G3. The approximately 30 examples are scattered in the eastern and central Piedmont, with a denser cluster in eastern Wake and adjacent Franklin County. This community ranges from North Carolina to Alabama. One of the best developed examples globally is just a few miles into South Carolina. A closely related flatrock community, reported to be more floristically depauperate, occurs in Virginia.

Associations and Patterns: The Annual Herb Subtype usually is closely intermixed with the Perennial Herb Subtype, but the proportions of the communities vary. Some flatrocks are predominantly one or the other. Oosting and Anderson (1939) and McVaugh (1943) emphasized concentric patterns in vegetation mats, with the Annual Herb Subtype vegetation occurring on the outside of patches and the Perennial Herb Subtype in the presumably older centers. The Perennial Herb Subtype often also occurs as a broad zone on the edge of the open rock, with the Annual Herb Zone making up more of the center. Most Granitic Flatrocks probably once were surrounded by Granitic Flatrock Border Woodland, though not all examples retain them now.

Variation: This community represents several distinctive kinds of patches, which may vary in extent with undulations of the rock surface and with disturbance history.

Dynamics: General flatrock dynamics are described more fully in the theme description. The Annual Herb Subtype represents the earliest stages of the primary succession characteristic of flatrocks. Crustose lichens may be the first colonists on bare rock, but Oosting and Anderson (1939) noted that they do not contribute to soil accumulation. *Grimmia laevigata* moss beds and the annual herb patches may accumulate shallow soil by depositing organic matter and trapping dust or sand. Soil eventually builds up enough to support the vegetation of the Perennial Herb Zone. McVaugh noted that the larger mosses *Polytrichum ohioense* and *Polytrichum commune* invade soil mats and eliminate the lichens and smaller mosses, and that they greatly increase the extent and thickness of the mats. Because of the limited and discontinuous vegetation cover in the Annual Herb Subtype, fire presumably plays little or no role. However, both authors mention the role of wind, drought, and fire in destroying the later successional stages and regenerating the early stages of the Annual Herb Subtype.

Comments: It is not entirely clear if it is useful to have the two subtypes distinguished, when they are so closely intermixed and each is still heterogeneous. It is not practical to recognize even finer subtypes for all the different fine-scale vegetation zones that have been described. However, the subtypes do occur in differing proportions on different outcrops, and they may respond differently to threats such as trampling and climate change.

Rare species:
Vascular plants – *Cyperus granitophilus, Geocarpon* (*Minuartia*) *uniflorum, Isoetes piedmontana, Isolepis carinata, Portulaca smallii,* and *Sedum pusillum*.

Nonvascular plants – *Archidium* donnellii and *Campylopus oerstedianus.*

GRANITIC FLATROCK (PERENNIAL HERB SUBTYPE)

Concept: Granitic Flatrock communities are sparsely vegetated or herbaceous communities of flatrock outcrops. The Perennial Herb Subtype represents the zones that occur on thicker soil accumulations, where larger perennial herbs predominate and some shrub cover may be present.

Distinguishing Features: Granitic Flatrocks are distinguished from Granitic Domes by floristic differences such as the presence of *Diamorpha smallii, Sedum pusillum, Geocarpon* (*Mononeuria*) *glabrum, Packera tomentosa, Croton willdenowii*, and the absence of plants more characteristic of the Blue Ridge, as well as by their location in the central and eastern Piedmont. They are generally distinguished by gentler topography and the associated presence of small weathering depressions, but the range of slopes can overlap with that of Granitic Domes. Granitic Flatrocks are distinguished from all other rock outcrop communities by the characteristic physical structure produced by exfoliation, with shallow depressions but few crevices, fractures, or deeper soil pockets.

The Perennial Herb Subtype is distinguished from the Annual Herb Subtype by the dominance of larger and longer-lived species, which may include grasses such as *Andropogon virginicus* or *Schizachyrium scoparium*, forbs such as *Packera tomentosa,* or large mosses such as *Polytrichum commune* or *Sphagnum* spp. Species of the Annual Herb Subtype may also be present.

Crosswalks: *Packera tomentosa - Croton michauxii* var. *ellipticus - Schizachyrium scoparium - (Selaginella rupestris)* Flatrock Vegetation (CEGL004298).
G671 Piedmont-Blue Ridge Dome & Flatrock Group
Southern Piedmont Granite Flatrock and Outcrop Ecological System (CES202.329).

Sites: The Perennial Herb Subtype occurs on open flatrock outcrops of granitic rocks. It may include flat areas, gentle slopes, shallow weathering depressions, and local seepage areas.

Soils: Soils are shallow accumulations of organic matter and sandy partially weathered granite, a few inches to a foot in depth. Soil mapping often includes these areas with Wake (Lithic Udipsamment), Louisburg (Ruptic-Ultic Dystrochrept) or Ashlar (Typic Dystrochrept), or simply as rock outcrop.

Hydrology: The Perennial Herb Subtype generally is very dry, due to lack of soil and water-holding capacity. However, because of the impermeable bedrock, it may be seasonally wet, especially in weathering depressions. Locally areas may be saturated with seepage for extended periods.

Vegetation: The Perennial Herb Subtype often includes patches or zones with very different dominant species, though they may occur in many mixtures. *Andropogon virginicus* is the most constant species and most often the dominant grass, but *Andropogon ternarius, Schizachyrium scoparium, Danthonia sericea, Danthonia spicata, Chasmanthium laxum*, or other grasses may be abundant. *Packera tomentosa* or *Packera anonyma* are the most constant forbs. *Asplenium platyneuron, Opuntia mesacantha* ssp. *mesacantha*, and *Yucca* spp. are also frequent. A number of other species are frequent enough to be considered characteristic, including *Aristida dichotoma,* *Tridens flavus, Agave* (*Manfreda*) *virginica, Krigia virginica, Geranium carolinianum, Micranthes virginica, Commelina erecta* var. *erecta*, *Juncus dichotomus, Panicum philadelphicum* ssp. *lithophilum*, *Eupatorium hyssopifolium, Eupatorium rotundifolium, Salvia lyrata,* several *Cyperus* species, and larger mosses such as *Polytrichum commune* and *Polytrichum ohioense*. Various species shared with the Annual Herb Subtype are also present, such as *Hexasepalum (Diodia) teres, Croton willdenowii (Crotonopsis elliptica*), and *Hypericum gentianoides*. In the deeper, older soil mats, some woody species may be established. *Smilax rotundifolia, Gelsemium sempervirens*, *Rhus copallinum*, and *Vaccinium arboreum* are frequent. Small *Juniperus virginiana* and other trees may be present; they may be short-lived or may be the beginning of succession to woody dominance. In seepage areas, *Sphagnum lescurii*, *Lindernia monticola, Eupatorium perfoliatum, Greeneochloa coarctata (Calamagrostis cinnoides*), *Utricularia juncea*, the moss *Philonotus fontana*, and other wetland species may predominate, though some of the above species may also be present.

Granitic Flatrock vegetation was described in early thorough studies by Oosting and Anderson (1939) and McVaugh (1943), who described multiple zones. Later authors (e.g. Palmer 1970, Wyatt and Fowler 1977) focused on specific sites or concentrated in other states. Only a few CVS plots exist for this community.

Range and Abundance: Ranked G3. The approximately 30 examples are scattered in the eastern and central Piedmont, with a denser cluster in eastern Wake and adjacent Franklin County. This community ranges from North Carolina to Alabama.

Associations and Patterns: The Perennial Herb Subtype usually is closely intermixed with the Annual Herb Subtype, but the proportions of the communities vary. Some flatrocks are predominantly one or the other. Most authors emphasize concentric patterns in vegetation mats, with the Annual Herb Subtype vegetation occurring on the outside of patches and the Perennial Herb Subtype in the presumably older centers with thicker soil. The Perennial Herb Subtype often also occurs as a broad zone on the edge of the open rock, with the Annual Herb Zone making up more of the center. Most Granitic Flatrocks probably once were surrounded by Granitic Flatrock Border Woodland, though not all examples retain them now.

Variation: This community represents several distinctive kinds of patches, which may vary in extent with undulations of the rock surface, presence of seepage, and disturbance history. Rare flatrocks have extensive and relatively long-term seepage; these need further investigation but may require division into a separate type.

Dynamics: General flatrock dynamics are described more fully in the theme description. The Perennial Herb Subtype represents the middle stages of the primary succession characteristic of flatrocks. If undisturbed, its patches will continue to trap mineral particles and accrete organic matter until shrubs and trees are able to invade. Once trees have grown fairly large, they are susceptible to wind throw as well as drought mortality because of the shallow soils. Patches in the interior of the open flatrock probably are destroyed and returned to bare rock fairly quickly at this stage, but patches on the edge may merge into the adjacent Granitic Flatrock Border Woodland until a more severe disturbance affects them. Fire may spread into patches on the edge of the open rock but probably has no effect on isolated patches surrounded by the Annual Herb Subtype.

The conditions that allow many native weed species to persist in this community also make it susceptible to invasion by exotic plants. *Lonicera japonica* and *Lespedeza cuneata* can be particularly abundant.

Comments: It is not entirely clear if it is useful to have the two subtypes distinguished, when they are so closely intermixed and each is still heterogeneous. It is not practical to recognize even narrower subtypes for all the different fine-scale vegetation zones that have been described. However, the subtypes do occur in differing proportions on different outcrops, and they may respond differently to threats such as trampling and climate change.

Rare species:
Vascular plants – *Cyperus granitophilus, Panicum philadelphicum* ssp. *lithophilum,* and *Sedum pusillum*.

Nonvascular plants – *Cleistocarpidium palustre*.

GRANITIC FLATROCK BORDER WOODLAND

Concept: Granitic Flatrock Border Woodlands are open xerophytic forests or woodlands on shallow soils around Granitic Flatrocks, more xerophytic than the surrounding upland forests. They are generally dominated by pines, with abundant *Juniperus virginiana* and a varying mix of drought-tolerant hardwoods such as *Quercus stellata, Quercus marilandica, Ulmus alata, Carya glabra*, and *Carya tomentosa*. Some mesophytic and even a few wetland species may be present in minor amounts. *Quercus phellos* occurs in a number of examples but is not a major component.

Distinguishing Features: Granitic Flatrock Border Woodland should be recognized where substantial natural xerophytic tree canopy occurs around or between open Granitic Flatrock communities. Small islands of woody vegetation on open rocks should be treated as part of the Perennial Herb Subtype, but large patches may be viewed as Granitic Flatrock Border Woodland. It is distinguished from all other upland forests and woodlands by its location on shallow soil over exfoliated granitic rock in the eastern or central Piedmont.

Granitic Dome Basic Woodland is a conceptually similar community also associated with exfoliated rock but on mountainous terrain in the foothills or Blue Ridge. It lacks the eastern Piedmont flora and has distinct montane components. Piedmont Acidic Glade is the only other eastern Piedmont community that may be naturally dominated by *Pinus virginiana* or *Pinus taeda*, but it is more often dominated or codominated by *Quercus montana* or other oak species. Its canopy is more open and it has a well-developed grassy (occasionally shrubby) ground cover. Piedmont Basic Glade also shares an open structure created by shallow soil and bedrock. It is distinguished by a large component of flora indicative of higher pH and base saturation. However, a few of its characteristic species, such as *Rhus aromatica* and *Chionanthus virginicus,* are sometimes found in Granitic Flatrock Border Woodland.

Granitic Flatrock Border Woodlands can be particularly hard to distinguish from pine-dominated anthropogenic successional communities, especially because they may often share an abundance of invasive nonnative plants. Granitic Flatrock Border Woodlands are most easily distinguished by their site characteristics, including soils too shallow to plow, absence of evidence of cultivation, and association with flatrock outcrops. Good examples are more likely to have uneven-aged canopy trees, to have many oaks and hickories that are the same age as the pines, and to have abundant *Juniperus*. Successional forests have pines of uniform age and, if they contain oaks or hickories, to have these be notably younger.

Crosswalks: *Pinus (virginiana, taeda) / Juniperus virginiana - Chionanthus virginicus - Ulmus alata* Granitic Flatrock Border Woodland (CEGL003993).
G976 Piedmont-Cumberland Acidic Glade and Barrens Group.
Southern Piedmont Granite Flatrock and Outcrop Ecological System (CES202.329).

Sites: Granitic Flatrock Border Woodlands occur on shallow soils with exfoliated granitic rock beneath, generally adjacent to open rock outcrops. They may be uphill or downhill from surrounding forest sites.

Soils: Soils are continuous but are shallow and sandy. They may be relatively fertile. The abundance of unweathered minerals may give them higher abundance of base cations than the typical Piedmont soils formed in saprolite from felsic rocks. On detailed soil maps they are treated as Wake (Lithic Udispamment), Louisburg (Ruptic-Ultic Dystrochrept), or, farther west, Ashlar (Typic Dystrudept). These are often mapped as complexes with rock outcrop or with Typic Kanhapludults or Typic Hapludults, especially Saw, Wedowee, and Pacolet.

Hydrology: Granitic Flatrock Border Woodlands are dry for much of the year because of the shallow soil; the environment can be extremely stressful during droughts. However, because of the limited infiltration of water, they can be saturated during wet periods.

Vegetation: Granitic Flatrock Border Woodlands generally have a somewhat open canopy, though it may occasionally be as dense as a typical forest. The canopy is a mix of xerophytic tree species. *Juniperus virginiana* is the most constant species, and some species of pine, most often *Pinus taeda* or *Pinus virginiana*, is usually dominant or codominant. *Pinus echinata* sometimes is also a component and may have been more so in the past. *Quercus stellata, Carya glabra, Carya tomentosa,* and *Ulmus alata* may be codominant or dominant in some examples. Less frequent tree species include *Quercus marilandica, Carya pallida, Quercus phellos*, *Quercus nigra*, and *Quercus alba*. The understory is not well developed beneath the short canopy, but *Prunus serotina, Nyssa sylvatica, Acer rubrum, Benthamidia* (*Cornus*) *florida, Ilex opaca,* or *Chionanthus virginicus* may occur, along with most of the canopy species. The shrub layer may be sparse to fairly dense. *Rhus copallinum* is the most frequent species in the few CVS plots and among qualitative reports, but *Vaccinium arboreum* may dominate. The exotic *Ligustrum sinense* can also become dense. Occasional shrubs include *Vaccinium fuscatum, Toxicodendron pubescens, Rosa carolina, Viburnum prunifolium, Castanea pumila,* and *Ilex decidua*, as well as any of the species typical of Piedmont Oak Forests. Woody vines are often extensive in cover. *Lonicera sempervirens, Smilax rotundifolia, Toxicodendron radicans*, *Parthenocissus quinquefolia*, or *Muscadinia rotundifolia* may dominate the ground cover in large portions, but at present it often has become dominated by the exotic *Lonicera japonica*. Herbs are generally sparse, but local patches may have denser stands of *Chasmanthium laxum, Danthonia spicata,* or *Piptochaetium avenaceum*. Grasses of more open areas, including *Schizachyrium scoparium* and *Andropogon ternarius* may be present in small numbers. These grasses likely would have been more abundant when fires occurred regularly. *Asplenium platyneuron* and *Chimaphila maculata* are the most frequent herbs, but *Yucca flaccida, Yucca filamentosa,* and *Opuntia mesacantha* ssp. *mesacantha* are fairly frequent. Other herb species that occur with low frequency include *Penstemon canescens, Pycnanthemum tenuifolium, Melica mutica, Lespedeza* spp., *Cunila origanoides, Athyrium asplenioides, Dichanthelium* spp., *Endodeca serpentaria, Commelina erecta* var. *erecta*, *Aristida purpurascens*, and many others.

Range and Abundance: Ranked G3? but perhaps better ranked G2 or G2G3. This community was recognized only relatively recently and has not been well inventoried. It potentially is as abundant as the other G3-ranked Granitic Flatrock communities, but more examples appear to have been destroyed or degraded. It was often not described in qualitative reports, and many ecologists, including the author, long dismissed it as degraded oak-hickory forest. It is believed to range from North Carolina to Georgia and possibly to Alabama.

Associations and Patterns: Granitic Flatrock Border Woodland occurs with Granitic Flatrock communities, sometimes occurring as small patches within the mosaic and usually forming a broad ring around them. Though most examples are now surrounded by fields, developed areas, or successional forests, they naturally graded to typical Piedmont Oak Forests.

Variation: Examples vary in canopy composition but causes and patterns of variation are not well known.

Dynamics: General flatrock dynamics are described more fully in the theme description. The open canopy, small stature of trees, abundance of pines, and frequency of weedy species in all strata of Granitic Flatrock Border Woodland suggest a greater frequency of natural disturbance and tree mortality than in typical Piedmont forests. Greater susceptibility to drought and windthrow because of the shallow soils is presumably the reason. The continuous litter would allow them to burn at the same frequency as the surrounding forests. As in various glade and barren communities, fire may have had more effect in creating open vegetation on the extreme sites. While examples now have high cover of vines and sometimes shrubs, and often have limited herb cover, with regular fire they likely would be grassy.

Granitic Flatrock Border Woodland patches adjacent to the open rock are susceptible to being destroyed by of uprooting trees, restarting the cyclic succession process with bare rock and moss mats. However, the broader ring of woodland surrounding the open rock appears to be more stable and to regenerate as woodland after typical disturbance. Windthrow pits in its interior are more readily refilled by soil from adjacent areas, and trees quickly regenerate. However, it may be that the ring widens and narrows in response to climatic cycles.

Comments: Granitic Flatrock Border Woodland was not initially recognized as a distinctive natural community. Though many of the published papers (Oosting and Anderson 1939, McVaugh 1943, Palmer 1970, Wyatt and Fowler 1977) described the woody vegetation, at least as the end stage of succession, it was not generally very clear how much it contrasts with more typical forests. The small stature, abundance of successional tree species in the canopy, abundance of weedy species, and sometimes heavy invasion by exotic species, make them resemble more altered Piedmont forests that are not usually the target of conservation. However, they appear to be naturally distinct and to retain these characteristics even in the absence of recent alteration.

Rare species: No rare species are known to be associated with this community.

PIEDMONT AND MOUNTAIN GLADES AND BARRENS THEME

Concept: Piedmont and Mountain Glades and Barrens are more heavily vegetated than rock outcrop communities but are more open than the forests that typically develop with the climate and natural fire regimes of the Piedmont and Mountain regions. Some combination of rock, soil, and topography makes them unable to support typical forest, though they may additionally depend on fire to maintain their natural character. A variety of such factors are represented by the communities within this theme. These communities may naturally have the structure of an open woodland or savanna, or they may have a heterogeneous structure that mixes tree, shrub, and herb dominance in a fine-scale mosaic.

Distinguishing Features: Piedmont and Mountain Glades and Barrens are distinguished from forest communities by having a more open tree canopy. Tree cover is naturally less than 50% in all but a couple of the communities in this theme. It may be denser at present in communities that depend on fire for their maintenance but seldom is a fully closed canopy even in the long absence of fire. While many forests in these regions are believed to have been more open with more regular fire, the canopies of Piedmont and Mountain Glades and Barrens are more open still.

Piedmont and Mountain Glades and Barrens are distinguished from High Elevation Rock Outcrops and Low Elevation Cliffs and Rock Outcrops by having denser vegetation and more soil. Rock outcrop communities have sparse vegetation at least in the center of community patches. While individual trees in them may have significant cover, rooted plants are limited to crevices, soil mats, or similar microsites that make up a small minority of community's area. In contrast, Piedmont and Mountain Glades and Barrens have at least shallow soil cover and rooted plants over the majority of their area. Granitic Flatrocks generally can be distinguished from Piedmont and Mountain Glades and Barrens in the same way as the Rock Outcrops. The Granitic Flatrock Border Woodland could be placed in either theme, as it is similar in structure to some Piedmont and Mountain Glades and Barrens but can be distinguished by its association with granitic flatrocks – flat or gently sloping exfoliated granite surfaces in the Piedmont.

Sites: Piedmont and Mountain Piedmont and Mountain Glades and Barrens occupy a wide variety of sites that have in common that they limit tree cover without being predominantly bare rock. As the terms are used here, glades are communities where bedrock is near the surface, so that shallow soil limits tree cover. Communities named as woodlands are less extreme and have more tree cover, but still have cover limited by some aspect of the substrate. Some, the shale slope woodlands, have shallow soil but are also affected by slope instability. The shale breaks into flat fragments that, on steep slopes, shift readily and make rooting of plants difficult. Barrens are woodland or savanna communities that have soils that are deep but that have physical or chemical properties that are extreme and limit tree cover. Though the term "forest" is retained in the names of the Xeric Hardpan Forests, they are more truly barrens.

Soils: Soils vary drastically among the different communities in this theme. In glade communities they are shallow, with bedrock near the surface. These soils may consist of shallow mats or deep fill in crevices and are often extremely heterogeneous. In other communities, soils are deep, but have extreme physical or chemical properties. Hardpan soils have montmorillonite as a predominant clay mineral, and they shrink and swell in response to changes in water content. This movement limits the rooting ability of woody plants. Soils derived from ultramafic rocks have unusual chemistry, with low calcium to magnesium ratios and high content of toxic metals such nickel and chromium.

Hydrology: Hydrology varies, and moisture conditions may vary in ways that do not fit the normal moisture gradients. The shallow soils of glades dry quickly between rains and are prone to extreme drought stress. Hardpan soils can perch water on the surface, creating short-lived wet conditions, but the lack of water penetration, combined with limitations on plant rooting, subjects plants to drought stress. Ultramafic rock sites may have normal moisture levels consistent with their topographic position, but consistently support vegetation suggestive of drier conditions.

Vegetation: Vegetation in Piedmont and Mountain Glades and Barrens varies greatly among the different communities. Common to all is limited tree cover, less than in typical forests, and substantial cover by herbs or low shrubs. Most trees are species shared with drier forest communities, such as *Quercus stellata, Quercus montana, Quercus marilandica, Pinus virginiana, Pinus echinata, Pinus rigida, Carya pallida*, and *Juniperus virginiana*. Shrubs vary even more, reflecting soil chemistry. Acidic communities may have beds of *Vaccinium pallidum, Kalmia latifolia*, or *Gaylussacia baccata*, while basic communities may have *Rhus aromatica* or an abundance of vines such as *Toxicodendron radicans*. Herb layers usually are dominated by grasses. Because of the open canopy, most contain many species intolerant of shade, while the dry site conditions also favor drought-tolerant species. Herbs common to many communities include *Schizachyrium scoparium, Danthonia spicata, Dichanthelium* spp., *Coreopsis major,* and somewhat less frequently, *Sorghastrum nutans, Andropogon gerardii*, and *Piptochaetium avenaceum*. Glades, especially, may contain species shared with rock outcrop communities, including *Bryodesma rupestre*, *Hypericum gentianoides*, and *Phemeranthus teretifolius*, as well as a variety of bryophytes and lichens. Basic communities contain species shared with communities with richer soils; they may even contain typical floodplain species such as *Elymus hystrix, Elymus virginicus*, and *Chasmanthium latifolium*. Ultramafic barrens contain particularly odd mixes of species, since their composition is determined by tolerance to unusual soil chemistry. Species such as *Podophyllum peltatum* may occur beneath drought tolerant species such as *Quercus marilandica*. Ultramafic barrens also may have narrowly endemic species, such as *Symphyotrichum rhiannon* or notable disjunct species such as *Sporobolus heterolepis*.

Dynamics: The dynamics of Piedmont and Mountain Glades and Barrens varies widely, but all of these communities represent stable open communities. While they are sometimes called "early successional," this characterization is not ecologically correct. They are not created by severe disturbance and are not dominated by ruderal or pioneer species. Under natural disturbance regimes they do not change in a directional way toward forest. Even with present-day altered disturbance regimes, where woody vegetation is denser, most do not form closed forests. In the language of succession, glades and barrens would be called edaphic climax or disclimax communities. They are closely tied to distinctive environments and are generally dominated by long-lived herbaceous as well as woody species. Most of their characteristic species do not readily colonize disturbed sites, but occasionally a fire or removal of standing vegetation will reveal their unexpected presence. A rare careful soil seed bank study in one of these communities, Xeric Hardpan Forest (Northern Prairie Barren Subtype) (Walker 2009) demonstrated that there is not a substantial soil seed back for these species. The soil seed bank consisted almost entirely of ruderal species of *Digitaria, Dichanthelium, Juncus*, and *Cyperus*.

The relationship of Piedmont and Mountain Glades and Barrens to the prevailing regional natural fire regimes varies. Because they tend to occur as small patches, most natural and earlier anthropogenic ignition must generally have occurred by fire spreading from adjacent forests. While the rare lightning ignition might have been more likely to spread in the grassy vegetation of some barrens, fire frequency could not have been appreciably higher than in the surrounding landscape. In barrens, with continuous fuels, fire frequency presumably matched that of the surrounding landscape. In these communities, fire often is important in determining their natural structure. These are places where “a little fire goes a long way.” The same fire regime that prevailed in the surrounding forests can produce stronger ecological effects in barrens, leading to more open vegetation because of the more extreme environment and greater difficulty of seedling establishment for woody species. Although chronic fire would produce a more open structure than at present in the widespread forest communities, suggesting reduced contrast between them and the barrens, the stronger effects of fire in barrens might actually increase the contrast in vegetation structure. However, regular fire might also shift community boundaries, creating the openness of barrens in the edges of patches where conditions are marginal for forest.

In contrast, glade communities often have discontinuous fuels, with patches of bare rock, bryophyte or lichen areas, and only irregular distribution of litter and grass. They generally would not carry fire well and tend to burn in a patchy manner. Different patches may burn, depending on the direction of the fire’s approach, but some patches may almost never burn. Fire may still be important in determining the vegetation structure of the edges and of better-connected portions, but it may have little influence on other parts.

Piedmont and Mountain Glades and Barrens may also be affected more by other natural disturbances and environmental stresses than the surrounding forests are. Shallowly rooted trees are more susceptible to blowing down in storms. Drought is more likely to kill trees with limited rooting depth. Periodic drought-caused tree mortality may be an important cause of the open structure of these communities. The author has observed numerous cases of substantial tree mortality in glades during droughts which, while fairly severe, did not kill any trees in the adjacent forest. Though less obvious, mortality of tree seedlings in drought probably is a larger cause of openness. It may take a series of unusually moist years to allow new trees to mature in these communities. Because of these dynamics, tree stands in some glade communities may be more even-aged than typical natural forests or may have most of their trees limited to a few cohorts. While the same could be true in barrens communities, their more uniform vegetation and more regular exposure to prevailing fire regimes makes it more likely that they have continuous tree regeneration and uneven-aged structure similar to natural forests.

Comments: Much attention has been given to “Piedmont prairies” in the last several decades (Barden 1997). Though much of the interest in prairies was created by rediscovery of early historical writings describing large open areas, the existence of open sunny communities in the Piedmont is attested to by a substantial native flora that is now largely confined to roadsides, power line corridors, and other areas that are kept open by mowing but without soil disturbance. A large number of rare plants species with prairie affinities, either also occurring in Midwestern prairies or being closely related to species that occur there, are present in several areas in the Piedmont.

The popular concept of prairie as currently used in North Carolina, however, confounds several different kinds of ecologically distinct vegetation, and this has led to confusion and misdirected effort. Some of the confusion comes from looking to states farther west, which had large prairie landscapes that did not exist in North Carolina. Some is based on the true early successional vegetation in abandoned fields. The Piedmont and Mountain Glades and Barrens communities in this theme are the more natural component of the prairie concept. Though they almost certainly existed primarily as open grassy woodlands or savannas rather than treeless grasslands in presettlement and early colonial times, they are the natural habitat for almost all of the rare species of prairie affinities. These species occur in artificial openings almost exclusively in areas with concentrations of the distinctive soils and with remnants of the natural communities in this theme. Such species have not become widespread on roadsides in other, even nearby, parts of the Piedmont.

Some early accounts of open vegetation were from the Mecklenburg County area and from around Gold Hill, areas that had concentrations of barrens. However, much of the early description of open areas cited as evidence of widespread Piedmont prairies was probably not based on Piedmont and Mountain Glades and Barrens. Early travelers generally followed existing trails and lodged in native villages, rather than sampling cross-country transects. Their observations were heavily biased toward the areas most altered by human settlement, concentrated in large river valleys. A rare description of a journey that was a more objective transect, the border between Virginia and North Carolina, (Byrd 1728) mentions Indians burning the woods but does not describe extensive open areas beyond immediate settlements. Other evidence cited in support of a belief in widespread prairies, such as the presence of bison, is equivocal. It is controversial how abundant bison were in the Piedmont in prehistoric and early historic times. Given that “Buffalo” is an English surname and that the name was apparently sometimes used for feral cattle, the existence of it in place names is not definitive evidence that *Bison bison* was seen in those places at all. It is also not clear that now-vanished eastern ecotypes of bison would not have thrived in forests that burned more often.

Though detailed understanding of plant species composition in early travelers’ accounts of open areas is generally impossible, many of these areas almost certainly were primarily abandoned fields, which would have been especially numerous in the years following decimation of the native population by European diseases and which may not have been recognized as such. Bartram’s (1793) description of fields of wild strawberries certainly is suggestive of an old field, if not an actively managed one. Old field vegetation, a few years after abandonment, is dominated by *Andropogon virginicus* (Oosting 1942, Keever 1950, Schafale 1986), a species that superficially resembles the *Schizachyrium scoparium* that dominates many Piedmont and Mountain Glades and Barrens but which has a distinctly different ecology. Most old field species have ruderal adaptations and are distinct from those typical of both Piedmont and Mountain Glades and Barrens and Midwestern prairies. While some ruderal old field species have prospered on roadsides, the rare species and many other species associated with them on roadsides are not typical of old fields. At the same time, the large component of ruderal species found in artificial openings at present would almost certainly not have been present in naturally stable glades and barrens.

Though early writers sometimes enthusiastically described riding for miles through open sunny areas (e.g., Bartram 1793), it should be noted that such writings do not indicate that that is what dominated their journeys. Their descriptions are not those of the endless prairies of the Midwest, and they do not seem like the words of people who have ridden for days through such terrain. Indeed, beyond their romantic idea of an idyllic landscape, much of their enthusiasm seems to come from the contrast with the prevailing forest that hemmed in the rest of their journeys.

KEY TO PIEDMONT AND MOUNTAIN GLADES AND BARRENS

1. Community in the Mountains or mountain-like foothills, associated with other mountain communities. In ambiguous cases, flora more typical of the Mountains present, though species of the Piedmont may also be present.

2. Substrate of unstable fragments of shale or other thin-bedded rock; openness of vegetation driven more by instability than by limited soil depth; rare communities known primarily in the vicinity of Hot Springs and the lower French Broad River gorge.

3. Substrate of calcareous shale or siltstone; flora showing evidence of higher pH and base status; *Juniperus virginiana* abundant; multiple calciphilic species present. .... **Calcareous Shale Slope Woodland**

3. Substrate of acidic shale or siltstone; *Pinus virginiana* dominant; *Juniperus virginiana* absent or rare; flora lacking calciphilic species. .... **Acidic Shale Slope Woodland**

2. Substrate primarily of bedrock or stable soil; openness of vegetation driven by shallow soil, soil chemistry, or other factors but not primarily by slope instability; throughout the Mountain and foothills region.

4. Substrate of ultramafic rock such dunite, peridotite, or serpentinite, either deep or shallow soil; vegetation more open and appearing more xerophytic than expected for the soil depth and topography; vegetation containing unusual combinations of xerophytic and mesophytic species not typical of shallow soils; open vegetation structure apparently driven by unusual soil chemistry (though also dependent on fire); species known to be ultramafic endemics, such as *Symphyotrichum rhiannon*, and prairie species confined to ultramafic substrates in North Carolina, such as *Sporobolus heterolepis*, usually present; extremely rare communities known in only a few sites.

5. Vegetation a woodland or open forest dominated by *Pinus rigida*; known from Buck Creek Barrens .... **Ultramafic Outcrop Barren (Pitch Pine Subtype)**

5. Vegetation not dominated by *Pinus rigida*

6. Vegetation a woodland or open forest dominated by *Quercus alba*; known from Buck Creek Barrens.................................. **Ultramafic Outcrop Barren (White Oak Subtype)**

6. Vegetation dominated by *Pinus virginiana*; known from Webster and possibly other lower elevation ultramafic sites. ... **Ultramafic Outcrop Barren (Virginia Pine Subtype)**

4. Substrate not ultramafic rock, or if rarely so, not showing the distinctive vegetation characteristics of Ultramafic Outcrop Barrens; open vegetation structure apparently caused primarily by shallow soil and bedrock; species composition reflecting dry conditions caused by shallow soil (though local wet areas may be present); ultramafic endemic species absent; widespread in the region.

7. Flora containing species indicative of higher pH, higher base saturation conditions, such as *Fraxinus* spp., *Carya* spp., *Juniperus virginiana, Aquilegia canadensis, Hylotelephium (Sedum) telephioides, Primula* (*Dodecatheon*) *meadia, Sedum glaucophyllum, Myriopteris (Cheilanthes) lanosa, Borodinia (Boechera) laevigata*, and *Penstemon canescens*, though more widespread species such as *Quercus montana, Pinus* spp,. *Danthonia* spp., and *Schizachyrium scoparium* may be more abundant; substrate often clearly amphibolite, calc-silicate, or other rock that produces basic conditions, but sometimes granite or other felsic rocks that nevertheless support flora of basic conditions.

8. Vegetation a woodland or open forest; soils only marginally shallow enough to produce open vegetation; usually associated with exfoliated granitic rock outcrops and communities such as Low Elevation Granitic Dome or Low Elevation Basic Glade.

9. Vegetation nearly a closed forest, dominated by *Carya* spp. or *Fraxinus* spp., sometimes in combination with oaks. .... **Granitic Dome Basic Woodland**

9. Vegetation an open woodland or savanna dominated or codominated by *Juniperus virginiana*. ....**Montane Red Cedar–Hardwood Woodland**

8. Vegetation a glade, either a fine-scale patchy mosaic of bare rock, herbaceous vegetation, and woody vegetation or continuous herbaceous vegetation with sparse to moderate tree cover.

10. Glade occurring at high elevation (above 4000 feet) on amphibolite substrate; very rare community known only at Bluff Mountain, Mount Jefferson, and one Virginia site. ....**High Elevation Mafic Glade**

10. Glade generally occurring below 4000 feet, or if rarely higher, with a dry slope aspect and containing species typical of lower elevations.

11. Glade in the Brushy Mountains region of the foothills, containing a distinctive suite of species that includes *Croton willdenowii (= Crotonopsis elliptica), Hypericum radfordiorum, Allium keeverae, Pseudognaphalium obtusifolium, Coreopsis tripteris, Senna marilandica*, and *Hexasepalum (Diodia) teres*. ....**Low Elevation Basic Glade (Brushy Mountains Subtype)**

11. Glade not in the Brushy Mountains, elsewhere in the Mountains or foothills; vegetation various but lacking most of the characteristic species of the Brushy Mountains Subtype .... **Low Elevation Basic Glade (Montane Subtype)**

7. Flora not containing species indicative of higher pH or higher base saturation as above; all flora tolerant of strongly acidic conditions; substrate felsic rock or other rock that produces acidic soils.

12. Vegetation predominantly herbaceous, dominated by *Carex biltmoreana*; periodically saturated by seepage; often associated with exfoliated granitic outcrops and communities such as Low Elevation Granitic Dome ....**Low Elevation Acidic Glade (Biltmore Sedge Subtype**)

12. Vegetation various, either predominantly herbaceous and dominated by *Danthonia, Schizachyrium*, or species other than *Carex biltmoreana*, or a mosaic of rock, herbaceous, and woody vegetation in small patches. ...**Low Elevation Acidic Glade (Grass Subtype)**

1. Community in the Piedmont away from the mountainous foothills, associated with Piedmont communities; flora more typical of the Mountains absent.

13. Openness of vegetation driven primarily by shallow soil over bedrock, rarely in combination with slope instability; vegetation structure a glade, with either a fine-scale patchy mosaic of bare rock, herbaceous vegetation, and woody vegetation or continuous herbaceous vegetation with sparse to moderate tree cover.

14. Community containing species of soils with higher pH and higher base saturation, such as *Fraxinus* spp., *Cercis canadensis, Rhus aromatica, Myriopteris (Cheilanthes) tomentosa*, and *Myriopteris lanosa*, with species such as *Chionanthus virginicus* and *Carya* spp. typically more abundant, though widespread acid-tolerant species may also be abundant; occurring on substrates of mafic rock such as diabase or gabbro or occasionally on calcareous meta-sedimentary rock.

15. Community resembling a flatrock, consisting of diabase outcropping in a level bedrock pavement with open rock areas interspersed with shallow soil mats; flora combines species similar to Granitic Flatrocks, such as *Portulaca smallii*, *Cyperus granitophilus*, and *Isoetes*

piedmontana, with species needing high base status, such as *Ruellia humilis, Berberis canadensis, Symphoricarpos orbiculatus, Matelea decipiens, Lithospermum canescens* and *Clematis ochroleuca*; very rare community known in North Carolina only around Butner. ....**Diabase Glade**

15. Community without the characteristic suite of species of Diabase Glade, though many other species are shared; generally without most species shared with Granitic Flatrock; site flat to steeply sloping but not a pavement of diabase or gabbro.

16. Substrate somewhat unstable, consisting of loose, flat fragments of thin-bedded meta-sedimentary rock; open vegetation with abundant *Pinus virginiana* and limited dense grass patches; very rare community currently known only near Falls Dam in and near Uwharrie National Forest................................. **Piedmont Basic Glade (Falls Dam Slope Subtype)**

16. Substrate largely stable, consisting of a mosaic of shallow soil and limited bedrock outcrops, rock often highly fractured; vegetation various, occasionally with abundant *Pinus virginiana* but more often with *Carya* spp., *Quercus stellata*, *Ulmus alata, Pinus echinata*, or other species; grassy patches often extensive. .... **Piedmont Basic Glade (Typic Subtype)**

14. Community lacking species of higher pH or higher base status; vegetation dominated by more widespread acid-tolerant species .... **Piedmont Acidic Glade**

13. Openness of vegetation not driven primarily by shallow soil or unstable substrate; soil rocky or not but open conditions more caused by a hardpan, shrink-swell soil (generally mapped as Iredell or related vertic or montmorillonitic series), or by a steep slope with a southerly or westerly aspect, in combination with fire; community an open woodland with substantial tree cover, generally dominated by *Quercus stellata, Quercus marilandica*, or *Pinus echinata*, or an open prairie savanna with a dense herbaceous layer and sparser trees of these species.

17. Substrate of ultramafic rock such as dunite, peridotite, or serpentinite, with either deep or shallow soil; vegetation more open and appearing more xerophytic than expected for the soil depth and topography; vegetation containing unusual combinations of xerophytic and mesophytic species not typical of shallow soils; open vegetation structure apparently driven by unusual soil chemistry.............................. **Ultramafic Outcrop Barren (Piedmont Subtype)**

17. Substrate not of ultramafic rock, or if rarely so, not showing the distinctive vegetation characteristics of Ultramafic Outcrop Barrens; open conditions caused by a hardpan, shrink-swell soil, or by a steep slope with a southerly or westerly aspect.

18. Open conditions driven primarily by a steep slope with a southerly or westerly aspect and fire, though rocky soil may contribute; vegetation consisting of species tolerant of extremely acidic conditions. ....**Xeric Piedmont Slope Woodland**

18. Open conditions caused by a dense clay hardpan or shrink-swell soil (generally mapped as Iredell or related vertic or montmorillonitic series); community on unusually flat uplands or on ridgetops or upper slopes; vegetation may consist of acid-tolerant species or species requiring less acidic conditions.

19. Vegetation a woodland or open forest consisting solely of acid-tolerant species; species of higher pH sites absent; *Vaccinium* spp. generally abundant; substrate clayey sedimentary or meta-sedimentary rock. .... **Xeric Hardpan Forest (Acidic Subtype)**

19. Vegetation a woodland or open forest containing species associated with higher pH and base saturation, or an open prairie savanna with a dense grassy herb layer; *Vaccinium* spp. generally scarce or absent; substrate diabase, gabbro, or other mafic rock.

20. Vegetation containing a substantial number of rare and uncommon species associated with open prairie conditions, such as *Silphium terebinthinaceum, Cirsium carolinianum, Elymus canadensis, Eryngium yuccifolium, Liatris squarrosa, Parthenium auriculatum, Parthenium integrifolium, Tragia urticifolia*, and *Sorghastrum nutans*; believed to have occurred naturally as an open prairie savanna though now known only from degraded remnants. These communities appear to have occurred only where hardpan or vertic soil conditions on flat ground are extensive, primarily around northeast Durham and Butner and around Charlotte.

21. Community around northeast Durham or Butner; containing characteristic species such as *Echinacea laevigata, Oligoneuron album*, *Lithospermum canescens*, and *Baptisia aberrans*..........**Xeric Hardpan Forest (Northern Prairie Barren Subtype)**

21. Community around Charlotte; containing characteristic species such as *Symphyotrichum georgianum var. georgianum* and *Helianthus schweinitzii* ....**Xeric Hardpan Forest (Southern Prairie Barren Subtype)**

20. Vegetation not as above; vegetation open forest or woodland that was likely more open and had more grass cover in the past, but which lacks most of the characteristic species of the Northern and Southern Prairie Barren Subtypes. These communities occur where areas of hardpan or vertic soil conditions are less extensive, perhaps affecting fire dynamics and species pools in the past.

22. Community on a ridge top or upper slope in hilly terrain on gabbro or other mafic rocks, primarily in the Uwharrie Mountains area; sites with boulders and sometimes small rock outcrops; canopy usually with *Carya carolinae-septentrionalis* dominant or codominant with *Quercus stellata*. .... **Xeric Hardpan Forest (Basic Rocky Subtype)**

22. Community on unusually flat upland terrain, on gabbro, diabase, or basalt; woodland dominated by *Quercus stellata*, with limited *Carya carolinae-septentrionalis* .... **Xeric Hardpan Forest (Basic Hardpan Subtype)**

HIGH ELEVATION MAFIC GLADE

Concept: High Elevation Mafic Glades are very rare glade communities of high elevation, relatively unfractured amphibolite or hornblende gneiss outcrops. They have patchy shallow soils that support a mosaic of grass and shrub vegetation alternating with bare rock and lichen cover.

Distinguishing Features: High Elevation Mafic Glades are extremely rare communities distinguished by smooth bedrock with irregular shallow soil cover. They may be steep or nearly flat. They have a characteristic species composition that includes *Schizachyrium scoparium, Helianthemum bicknellii, Ionactis linariifolia, Coreopsis major, Danthonia spicata, Cladonia* spp., and *Cladina* spp. The Little Bluestem Basic Subtype of High Elevation Rocky Summit similarly has abundant *Schizachyrium scoparium* and *Coreopsis major* but lacks the other species. It has more fractured rock but has more bare rock with less plant cover.

Crosswalks: *(Kalmia latifolia, Physocarpus opulifolius) / Schizachyrium scoparium - Thalictrum revolutum - Sibbaldiopsis tridentata* Shrub Grassland Vegetation (CEGL004238).
G180 Appalachian Mafic Barrens Group.
Southern and Central Appalachian Mafic Glade and Barrens Ecological System (CES202.348).

Sites: High Elevation Mafic Glades occur on relatively unfractured outcrops of mafic bedrock that have substantial shallow soil cover. They occur at elevations above 4,000 feet.

Soils: Soils consist of shallow mats of organic matter and accumulated mineral material lying on bedrock.

Hydrology: High Elevation Mafic Glades are generally dry because of shallow soil. However, local seepage may be present on the edges, and water may be trapped above the impermeable bedrock, making the glade wet after heavy rains.

Vegetation: The vegetation of High Elevation Mafic Glades is patchy and irregular in structure. Areas of lichen-covered bedrock, grassy herbaceous vegetation, shrub thickets, and stunted trees form a fine-scale mosaic. Lichens, *Cladonia* or *Cladina* spp., may dominate the more open areas. If recognized as a distinct species, *Cladonia psoromica* is a lichen endemic to the Bluff Mountain occurrence of this community. Plants typical of rock outcrops, such as *Hypericum gentianoides, Micranthes petiolaris* (*Saxifraga michauxii*)*, Campanula divaricata*, *Crocanthemum propinquum*, or *Hylotelephium* (*Sedum*) *telephioides*, occur sparsely in the shallowest soil accumulations. Somewhat deeper soil mats are dominated by *Schizachyrium scoparium*, which is generally the herb with the highest cover. Other herbs that are fairly abundant include *Coreopsis major, Danthonia compressa, Danthonia spicata, Ionactis linariifolia, Thalictrum amphibolum* (*revolutum*)*, Avenella flexuosa,* and *Sibbaldiopsis tridentata*. Additional herbs may include *Pycnanthemum tenuifolium, Carex* spp., *Solidago nemoralis, Dichanthelium meridionale, Aletris farinosa*, *Pyrola americana*, and *Gaultheria procumbens*. Woody patches are dominated by thickets of *Rhododendron catawbiense, Kalmia latifolia*, or *Physocarpus opulifolius*. Other shrubs include *Vaccinium corymbosum, Vaccinium stamineum*, and *Vaccinium pallidum*. Stunted trees are often present along with the shrubs, particularly *Quercus alba, Quercus rubra, Quercus montana,* and *Amelanchier laevis*.

Range and Abundance: Ranked G1. Only three examples are known, two in North Carolina, in Ashe County, one in southern Virginia.

Associations and Patterns: High Elevation Mafic Glades are small patch communities that, in the few known examples, are surrounded by oak forests.

Variation: Each of the few examples is different enough to recognize as a variant. Though the most abundant species are the same, there are substantial differences in the other plants present:

1. Bluff Mountain Variant is nearly flat and has extensive cover of *Cladonia/Cladina* lichens.

2. Mount Jefferson Variant is steeply sloping and has little lichen cover.

Dynamics: Next to nothing is known about the dynamics of High Elevation Mafic Glades. Their open structure appears to be maintained by shallow soil and perhaps by periodic drought, but occasional fire may affect them. Though not well documented, there is some suggestion that at least the Bluff Mountain example has increased in woody cover in recent decades.

Comments: This community was originally defined as unique to Bluff Mountain. The type has been merged with two other high elevation amphibolite glades, at Mountain Jefferson and at Buffalo Mountain in Virginia, though the three are different enough to be recognized as distinct variants. There is a published description of the Mount Jefferson glade in Poindexter and Murrell (2008).

High Elevation Mafic Glade as currently defined is a very distinctive, narrowly defined community, more so than implied by the name. No other examples are believed to occur. A few other basic glade communities are known above 4000 feet, but these are similar enough to other Low Elevation Basic Glades to be included there. If other glade-like communities on mafic rock at higher elevations are found, it may be best to treat them as a new subtype rather than to broaden the concept of this rare community.

Rare species:
Vascular plants – *Crocanthemum bicknellii, Crocanthemum propinquum, Gentianopsis crinita, Lilium philadelphicum, Phlox subulata,* and *Spiranthes ochroleuca*.

Nonvascular plants – *Cladonia psoromica, Lophoziopsis excisa,* and *Mesoptychia heterocolpos.*

LOW ELEVATION ACIDIC GLADE (GRASS SUBTYPE)

Concept: Low Elevation Acidic Glades are Mountain communities of shallow soils, with limited tree cover but with extensive ground cover, occurring on acidic rocks and lacking plants indicative of base-rich conditions. Most occur on rock surfaces that are undulating or irregular but lack the characteristics of Granitic Dome sites. Vegetation generally includes dense grass with patches of shrubs and sometimes trees, but it may occasionally include moderate tree cover and more extensive low shrub cover throughout the community. The Grass Subtype encompasses all examples not dominated by *Carex biltmoreana*.

Distinguishing Features: Low Elevation Acidic Glades are distinguished from Low Elevation Granitic Domes by the predominance of extensive soil mats, capable of supporting grasses or sedges. Lichen-covered bare rock and thin mats dominated by species such as *Bryodesma* are usually present but occupy only a small part of the area, while grassy mats and low shrub patches predominate. Trees may be largely confined to the edge or to rare microsites, as in Granitic Domes, but may also be dispersed through much of the community. Low Elevation Acidic Glade should be recognized only where grassy or shrubby vegetation rather than rock predominates over an entire rocky patch or where it covers a large enough contiguous area to be regarded as a separate community.

Low Elevation Acidic Glades are distinguished from Low Elevation Basic Glades by the absence of plant species characteristic of higher pH conditions, such as *Hylotelephium* (*Sedum*) *telephioides*, *Primula* (*Dodecatheon*) *meadia, Sedum glaucophyllum, Myriopteris* (*Cheilanthes*) *lanosa, Borodinia* (*Arabis*) *laevigata*, and *Penstemon canescens.* Low Elevation Acidic Glades are distinguished from Low Elevation Rocky Summits by having few crevices and having more continuous vegetation and less open rock. They have abundant grassy or low shrub mats in shallow soil but relatively few forbs or woody plants rooted in crevices.

Low Elevation Acidic Glades are distinguished from Montane Red Cedar—Hardwood Woodland, Granitic Dome Basic Woodland, and from other forests and woodlands by having limited tree cover –generally well less than 50% even when undisturbed.

The Grass Subtype is distinguished from the Biltmore Sedge Subtype by having grassy mats predominantly consisting of *Schizachyrium scoparium, Danthonia spicata*, or other dry-site grasses or herbs rather than *Carex biltmoreana* or other *Carex* spp. The few examples with extensive cover of *Vaccinium pallidum* are also included in the Grass Subtype.

Crosswalks: *(Quercus montana) / Vaccinium pallidum / Schizachyrium scoparium - Danthonia spicata / Cladonia* spp. Scrub Grassland (CEGL004990).
G976 Piedmont-Cumberland Acidic Glade and Barrens Group.
Southern Appalachian Granitic Dome Ecological System (CES202.297).

Sites: Low Elevation Acidic Glades occur on rock surfaces with extensive cover of shallow soil and only limited bare rock. Examples range from 1000-4000 feet in elevation. Most are on gentle to moderate slopes. The rock generally has few of the deep fractures that commonly occur in Rocky Summits. The surface is undulating, pitted, or somewhat irregular, unlike the smoother rock of

Granitic Domes. Many are on granitic rocks that are prone to exfoliation, some on dip slopes of bedded rock.

Soils: Soils are shallow mats of accumulated organic matter and small rock fragments. They generally are not distinguished in soil surveys or are mapped as rock.

Hydrology: The Grass Subtype is generally dry because of shallow soils. During drought periods moisture stress may quickly become extreme. Small portions may be saturated by seepage for part of the year or in wet periods.

Vegetation: The vegetation is patchy but generally includes extensive cover of grass. *Schizachyrium scoparium, Danthonia sericea*, or *Danthonia spicata* usually dominate. Other frequent herbs in either CVS plots or site descriptions include *Coreopsis major, Helianthus divaricatus, Solidago odora, Tephrosia virginiana, Sorghastrum nutans, Andropogon gerardii, Dichanthelium acuminatum,* and *Asplenium platyneuron*. Rock outcrop species such as *Micranthes petiolaris* (*Saxifraga michauxii*)*, Hypericum gentianoides, Bryodesma rupestre*, *Campanula divaricata*, and *Phemeranthus teretifolius* are often present in small numbers. Additional herbs that may be fairly abundant include *Packera anonyma, Symphyotrichum patens, Aristida purpurascens, Panicum virgatum*, and *Dennstaedtia punctilobula*. Additional herbs that may be present include *Dichanthelium dichotomum* var. *dichotomum*, *Houstonia purpurea, Juncus dichotomus, Krigia virginica, Lechea racemulosa*, *Linum striatum, Solidago pinetorum, Pityopsis graminifolia, Baptisia tinctoria, Ionactis linariifolia, Cunila origanoides, Antennaria plantaginea, Agrostis perennans*, and *Avenella (Deschampsia) flexuosa*. Trees are usually present with low cover. *Quercus montana* usually dominates. *Carya glabra, Pinus pungens, Pinus rigida*, *Pinus virginiana, Amelanchier arborea, Juniperus virginiana, Ulmus alata*, or other species may be present. *Vaccinium pallidum* is usually present, sometimes with substantial cover. *Vaccinium stamineum, Kalmia latifolia, Gaylussacia baccata, Hypericum prolificum*, or *Amorpha glabra* are often present, as are *Smilax rotundifolia*, *Smilax glauca*, and *Parthenocissus quinquefolia*.

Range and Abundance: Ranked G2. North Carolina examples range throughout the Mountains, with a few in the foothills area. The synonymized association is definitively known only in North Carolina but may occur in South Carolina and could possibly be found in Georgia.

Associations and Patterns: Low Elevation Acidic Glades occur as small patches, generally surrounded by dry forest communities such as Chestnut Oak Forest or Montane Oak—Hickory Forest. They may sometimes be associated with more open rock outcrop communities, especially Low Elevation Granitic Dome. Because of a difference in elevational cutoff, they may conceivably be associated with High Elevation Granitic Domes.

Variation: No variants are defined. Examples vary in the density of vegetation and amount of bare rock, as well as in the dominant plants.

Dynamics: Low Elevation Acidic Glades are maintained in a non-forested state primarily by physical conditions. Limited moisture holding capacity and shallow rooting depth limit tree growth and stature. Drought periodically causes mortality and probably is an important mechanism maintaining the open vegetation structure. As with other glades, vegetation may be continuous enough to carry fire in some parts of the community but not in others, so that fire effects are patchy. As small patches, ignition in these communities comes from the surrounding forests, and fires in flammable parts presumably are similar in frequency. Fire may be important for maintaining grass dominance and limiting abundance of shrubs and trees, though glades stay open at least for long periods in the absence of fire.

It is possible that these glades represent a later stage in the weathering of exfoliation surfaces, developing if spalling does not create a fresh surface periodically. The irregular rock surface that is present in most examples appears to be a result of greater weathering, though the substrate remains hard bedrock. It is also possible that the irregular surface results from differences in the rock, perhaps less uniform composition or texture. The irregular surface presumably contributes to the more extensive soil development in Low Elevation Acidic Glades compared to Granitic Domes by making sloughing of soil mats less likely. Nevertheless, it is possible that, like Granitic Domes and Granitic Flatrocks, Low Elevation Acidic Glades are maintained in a cyclic succession by the occasional destruction of soil mats by falling trees.

Comments: There is no analogous high elevation acidic glade community defined. Such a community could exist but none are known in the state.

The definition of Low Elevation Acidic Glades conceptually is based on predominant vegetation in a fine-scale mosaic, and thus depends on scale. Vegetation similar to these glades can occur in patches as a minority of the mosaic in Low Elevation Granitic Domes or Low Elevation Rocky Summits. Conversely, bare rock and vegetation similar to Low Elevation Granitic Dome or Low Elevation Rocky Summit can occur in small amounts in Low Elevation Acidic Glades.

Rare species:
Vascular plants – *Packera millefolium* and *Solidago simulans.*

Vertebrate animals – *Crotalus horridus.*

LOW ELEVATION ACIDIC GLADE (BILTMORE SEDGE SUBTYPE)

Concept: Low Elevation Acidic Glades are communities of shallow soils, with limited tree cover but with extensive ground cover, occurring on acidic rocks and lacking plants indicative of base-rich conditions. The Biltmore Sedge occurs on smooth exfoliated granitic rock where some seepage is present and where *Carex biltmoreana* is dominant or abundant.

Distinguishing Features: Low Elevation Acidic Glades are distinguished from Low Elevation Granitic Domes by the predominance of extensive soil mats, capable of supporting dense grasses or sedges. The Biltmore Sedge Subtype is distinguished from the Grass Subtype by having abundant *Carex biltmoreana*. It is similarly distinguished from Low Elevation Granitic Dome and High Elevation Granitic Dome, which may also contain small patches of *Carex biltmoreana*, by greater cover of graminoids and herbs. Bare and lichen-covered rock and shallow mats dominated by *Bryodesma* are only a minor component of this community. While patches of *Smilax biltmoreana* may occur on Granitic Domes, only ones that are extensive enough to be a free-standing community should be treated as this subtype.

Crosswalks: *Carex biltmoreana* - *Pycnanthemum* spp. - *Krigia montana* Acidic Glade (CEGL004523).
G976 Piedmont-Cumberland Acidic Glade and Barrens Group.
Southern Appalachian Granitic Dome Ecological System (CES202.297).

Sites: Low Elevation Acidic Glades occur on rock surfaces with extensive cover of shallow soil and only limited bare rock. In the Biltmore Sedge Subtype the rock is usually smooth exfoliated granitic bedrock but it may be the undulating, irregular, or pitted bedrock typical of the Grass Subtype. Patches may be gently sloping or steep. At least one example appears to be an old landslide scar but most are on the edges of larger granitic dome complexes. Examples are known from 2500 to 4800 feet elevation.

Soils: Soils are shallow mats of accumulated organic matter and small rock fragments. They generally are not distinguished in soil surveys or are mapped as rock.

Hydrology: The Biltmore Sedge Subtype is generally seasonally saturated but may be nearly permanently saturated.

Vegetation: The vegetation of the Biltmore Sedge subtype may be patchy or may be a relatively continuous stand. *Carex biltmoreana* is dominant or abundant. Other species that are fairly frequent and at least sometimes fairly abundant include *Krigia montana, Micranthes (Hydatica) petiolaris, Coreopsis pubescens, Dichanthelium dichotomum* var. *dichotomum, Oenothera fruticosa, Thalictrum revolutum, Thalictrum clavatum,* and *Oxypolis rigidior*. Species less frequent but sometimes abundant include *Pycnanthemum montanum, Heuchera villosa, Heuchera americana, Solidago patula, Houstonia serpyllifolia, Viola cucullata, Viola primulifolia, Andropogon gerardii, Physostegia virginiensis, Eryngium yuccifolium, Eurybia divaricata,* and *Trautvetteria carolinensis*. Woody species may be absent but shrub patches and small trees may be rooted in the community. *Diervilla sessilifolia, Hydrangea arborescens, Kalmia latifolia,* *Rhododendron maximum*, or *Hamamelis virginiana* are among the shrubs that may be present. Trees may include *Quercus montana, Pinus* spp., *Quercus rubra,* or other species.

Range and Abundance: The synonymized association is ranked G2G3 but is probably rarer. The Biltmore Sedge Subtype is known from a handful of sites in the Mountains, Blue Ridge escarpment, and foothills, primarily south of Asheville. It also is reported to occur in South Carolina and Georgia.

Associations and Patterns: The Biltmore Sedge Subtype usually occurs adjacent to Low Elevation Granitic Dome or High Elevation Granitic Dome communities. Less often it may be associated with Low Elevation Basic Glade or with the Grass Subtype of Low Elevation Acidic Glade. It generally is bordered on one side by Chestnut Oak Forest, Montane Oak–Hickory Forest, or other upland forest communities and may be surrounded by them.

Variation: This is a narrowly defined community with limited variation.

Dynamics: The dynamics of the Biltmore Sedge Subtype are poorly known. Like the Grass Subtype, it may be relatively stable. Or, like the smaller herb mats in Low and High Elevation Granitic Domes, it may periodically slough off or be pulled up by falling trees, resetting primary succession. Because the Biltmore Sedge Subtype is wet much of the time, fire is unlikely to carry through it. However, burning is possible during dry periods. The effect of fire on this community is not known.

Comments: The relationship between the Biltmore Sedge Subtype and the Grass Subtype is less close than between most subtypes in the Fourth Approximation. Given the role of seepage, the Biltmore Sedge Subtype could almost as easily be regarded as a subtype of Low Elevation Seep akin to its Bedrock Subtype. It appears to be transitional to that community. In addition, the typical patch size is small enough that it might almost be regarded as merely a part of the mosaic of granitic dome communities. However, its absence in most granitic dome communities is a reason for tracking it as a separate entity. *Carex biltmoreana* as a species is rare enough to be on the Natural Heritage Program's watch list and was once tracked as a rare species.

Rare species:

Vascular plants – *Packera millefolium*.

LOW ELEVATION BASIC GLADE (MONTANE SUBTYPE)

Concept: Low Elevation Basic Glades are communities of shallow soils, with limited tree cover but with extensive ground cover, occurring on many kinds of rock and containing plants indicative of base-rich conditions. Most occur on rock surfaces that are relatively unfractured, but which are undulating or irregular and lack the characteristics of Granitic Dome sites. Vegetation generally includes dense grass or other herbs with patches of shrubs and sometimes trees, but it may occasionally include moderate tree cover and more extensive low shrub cover throughout the community.

The Montane Subtype presently is broadly defined, encompassing most examples in the Mountains and most examples in the foothills, with the exception of the distinctive examples in the Brushy Mountains Subtype.

Distinguishing Features: Low Elevation Basic Glades are distinguished from both Low Elevation Granitic Domes and Low Elevation Acidic Glades by the presence of plants characteristic of higher pH soils, such as *Hylotelephium (Sedum) telephioides, Primula* (*Dodecatheon*) *meadia, Sedum glaucophyllum, Myriopteris (Cheilanthes) lanosa, Borodinia (Boechera) laevigata*, and *Penstemon canescens.* In the woody strata, *Fraxinus biltmoreana, Juniperus virginiana*, *Chionanthus virginiana*, and *Carya glabra* are generally abundant while *Pinus* spp. are scarce.

Low Elevation Basic Glades are distinguished from High Elevation Mafic Glades by the absence of characteristic high elevation species such as *Sibbaldiopsis tridentata* and the distinctive composition of that community. Most occur below 4000 feet elevation, but a few are high enough to overlap in elevation. Low Elevation Basic Glades are distinguished from Low Elevation Rocky Summits by having few crevices or fractures in the rock; by having fewer deep-rooted forbs, shrubs, and trees that depend on deeper soil; and by having more extensive plant cover and limited bare rock.

The Montane Subtype is distinguished from the Brushy Mountains Subtype by largely lacking a suite of distinctive plant species, including *Croton willdenowii (Crotonopsis elliptica), Hypericum radfordiorum, Allium keeverae, Pseudognaphalium obtusifolium, Coreopsis tripteris, Senna marilandica*, and *Hexasepalum (Diodia) teres*.

Crosswalks: *Selaginella rupestris - Schizachyrium scoparium - Hylotelephium telephioides - Allium cernuum* Mafic Glade (CEGL004991).
G180 Appalachian Mafic Barrens Group.
Southern and Central Appalachian Mafic Glade and Barrens Ecological System (CES202.348).

Sites: Low Elevation Basic Glades occur on rock surfaces with extensive cover of shallow soil and only limited bare rock. Most are on gentle-to-moderate slopes. The rock generally has few of the deep fractures that commonly occur in Rocky Summits. The surface is undulating, pitted, or somewhat irregular, unlike the smoother rock of Granitic Domes. Some examples occur on amphibolite or other mafic rocks but some occur on felsic rocks without an obvious reason to support the flora of base-rich sites. Some are on granitic rocks that are prone to exfoliation, some on dip slopes of rock beds or metamorphic foliation, some on other kinds of rock surfaces. Examples are known from 1500-4600 feet in elevation but could occur somewhat lower or higher.

Soils: Soils are shallow mats of accumulated organic matter and small rock fragments. They generally are not distinguished in soil surveys or are mapped as rock. Based on the flora, they are presumed to be relatively high in base saturation and to have higher pH than the Acidic Subtype.

Hydrology: Low Elevation Basic Glades generally are dry because of shallow soils. During drought periods moisture stress may quickly become extreme. Small portions may be saturated by seepage for part of the year or in wet periods.

Vegetation: The vegetation is patchy but generally includes extensive cover of grass. Dominant grasses in patches may include *Schizachyrium scoparium, Andropogon gerardii, Danthonia spicata, Danthonia sericea, Piptochaetium avenaceum*, and rarely, *Chasmanthium latifolium, Elymus virginicus*, or other species. The herbaceous flora usually is moderately to very diverse, with much variation among examples. Some of the most frequent species in CVS plots or site descriptions include *Coreopsis major, Hylotelephium telephioides, Hypericum punctatum, Hypericum gentianoides, Packera anonyma, Antennaria plantaginifolia, Campanula divaricata, Penstemon canescens, Helianthus divaricatus, Micranthes (Hydatica) petiolaris, Tradescantia subaspera, Euphorbia pubentissima, Parthenium integrifolium, Coreopsis pubescens, Lespedeza virginica, Packera anonyma, Polygonatum biflorum*, and *Ambrosia artemisiifolia*. Members of a large pool of less frequent herbs may be present, including *Aquilegia canadensis, Amsonia tabernaemontana, Primula* (*Dodecatheon*) *meadia, Rudbeckia triloba* var. *pinnatiloba*, *Elymus hystrix, Liatris* spp., *Solidago* spp. (*sphacelata, speciosa, nemoralis, pinetorum*, and others), *Symphyotrichum* spp. (*patens, lateriflorum, undulatum*, and others), *Agalinis tenuifolia, Apocynum cannabinum, Allium allegheniense, Krigia montana, Pycnanthemum montanum, Micranthes virginiensis, Micranthes careyana, Muhlenbergia capillaris, Muhlenbergia tenuiflora, Scleria ciliata*, *Tephrosia virginiana, Sericocarpus linifolius,* and many others. In addition, plants of more open rock outcrops, such as *Heuchera villosa, Heuchera americana, Bryodesma (Selaginella) rupestris, Bryodesma tortipilum, Bulbostylis capillaris, Myriopteris (Cheilanthes) tomentosa, Myriopteris lanosa*, and *Capnoides* (*Corydalis*) *sempervirens* are often present in limited portions.

Woody vegetation tends to be patchy, though occasionally trees are dispersed throughout the community in an open canopy. *Quercus montana* is the most frequent species, but *Juniperus virginiana* is in most examples. *Carya* spp. (*pallida, tomentosa, glabra*, or *ovata*) is often prominent. Other frequent tree species include *Fraxinus biltmoreana, Fraxinus americana, Chionanthus virginicus, Crataegus* spp., *Diospyros virginiana*, and *Amelanchier sanguinea. Pinus virginiana* and other pines, as well as other *Quercus* species, may be present but with lower frequency. Shrubs are patchy. *Rosa carolina* is the most frequent species. Both characteristic shrubs of basic sites, such as *Philadelphus hirsutus, Philadelphus inodorus*, and *Physocarpus opulifolius*, and widespread acid-tolerant species, such as *Vaccinium pallidum, Vaccinium stamineum*, and *Kalmia latifolia,* are fairly frequent and can dominate patches. Other shrub species may include *Hypericum densiflorum, Hypericum prolificum, Amorpha glabra, Rubus flagellaris*, *Rhus aromatica*, *Celtis tenuifolia*, *Ptelea trifoliata*, *Ceanothus americana*, and *Lonicera sempervirens*.

Range and Abundance: Ranked G2. Examples are scattered throughout the mountains and foothills. This community occurs in adjacent Virginia, likely in South Carolina, and possibly in the Blue Ridge portion of Tennessee.

Associations and Patterns: Low Elevation Basic Glades occur as small patches. They may occupy an entire open area or may be associated with Montane Red Cedar–Hardwood Woodland, Low Elevation Rocky Summit, Low Elevation Granitic Dome, High Elevation Granitic Dome, or Montane Cliff. The majority are surrounded by dry basic forest communities such as Montane Oak–Hickory Forest (Basic Subtype), but a significant number are associated with more common acidic forest communities.

Variation: The Montane Subtype is one of the most variable communities in the 4th Approximation. It likely should be divided into several subtypes when further study clarifies the patterns of variation. Four variants are tentatively defined based on the most likely axes of variation. They need further investigation.

1. Montane Rich Variant occurs within the Blue Ridge at all but the lowest elevations and has flora that suggests strongly basic conditions. Species such as *Philadelphus hirsutus, Philadelphus inodorus*, *Physocarpus opulifolius, Ptelea trifoliata, Primula meadia*, and *Aquilegia canadensis* are widespread in the community.

2. Montane Intermediate Variant occurs within the Blue Ridge at all but the lowest elevations and has flora suggestive of less strongly basic conditions, with a lower diversity and abundance of plants exclusive to basic sites. Species of wide tolerance make up much of the community, but enough basic site species are present to distinguish the community from Low Elevation Acidic Glade.

3. Foothills Rich Variant occurs in the foothills, Blue Ridge escarpment, and a few lower elevation or drier sites within the interior of the Blue Ridge. It has flora that suggests strongly basic conditions.

4. Foothills Intermediate Variant occurs in the foothills, Blue Ridge escarpment, and a few lower elevation or drier sites within the interior of the Blue Ridge. It has flora suggestive of marginally basic conditions, with species of wide tolerance making up much of the community.

As with many small patch communities, composition varies widely from one occurrence of Low Elevation Basic Glade to another. A few occurrences, such as the cluster at Box Creek Wilderness, seem particularly distinctive and may warrant a variant separate from the Foothills Rich Variant.

Dynamics: Dynamics of Low Elevation Basic Glades are similar to those described for Low Elevation Acidic Glade (Grass Subtype). They remain more open than typical forests in the absence of disturbance, but periodic mortality caused by drought may be important for keeping them open. Fire may also be influential under natural conditions but may vary among examples. Some glades have relatively contiguous herbaceous vegetation which could spread fire to most of the community, while others have enough interspersed open rock to inhibit fire spread.

The cause of basic conditions is often obvious, with the community occurring on amphibolite, hornblende gneiss, or similar rocks. However, some examples, especially of the Montane Intermediate and Foothills Intermediate variants, occur on granitic rocks. In some cases, they are associated with seepage, which may bring in additional nutrients, but in others it is not clear why they support flora of basic sites.

Comments: The type is called Basic rather than Mafic because many examples occur on felsic rocks which show floristic evidence of higher pH soils. The name Montane Subtype is generic, meant only to distinguish this subtype from the Brushy Mountains Subtype. It is less than ideal because some examples occur in the foothills region of the Piedmont at low elevations. All occur in association with other Mountain communities rather than with Piedmont communities.

Study of Low Elevation Basic Glades is limited, though many are described in site reports. Feil (1988) described the glades of Hickorynut Gorge, naming clusters as *Fraxinus americana*/mixed herbs, *Fraxinus americana/Carex biltmoreana*, and *Juniperus virginiana*/mixed herbs. Only a handful of CVS plots have been sampled.

Rare species:
Vascular plants – *Allium allegheniense, Anemone berlandieri, Arabis adpressipilis*, *Arabis patens, Berberis canadensis, Borodinia missouriensis, Buchnera americana, Calamagrostis porteri, Clematis catesbyana, Coreopsis grandiflora* var. *grandiflora, Crataegus pallens, Crataegus succulenta, Dicentra eximia*, *Draba ramosissima, Euphorbia commutata, Geocarpon* (*Mononeuria*) *groenlandicum, Huperzia porophila, Liatris aspera, Liatris microcephala?, Liatris turgida, Matelea obliqua, Orbexilum macrophyllum, Packera millefolium, Parthenium auriculatum, Phlox subulata, Primula meadia, Prunus alleghaniensis, Pycnanthemum curvipes, Quercus prinoides, Rudbeckia triloba* var. *beadlei, Sedum glaucophyllum, Silene ovata, Solidago simulans, Symphyotrichum laeve, Symphyotrichum pratense, Tradescantia virginiana, Trichophorum cespitosum, Trichostema brachiatum,* and *Woodsia appalachiana*.

Nonvascular plants – *Macrocoma sullivantii, Mannia californica, Physcia pseudospeciosa, Scopelophila ligulata, Syntrichia* (*Tortula*) *fragilis, Usnea angulata, Weissia sharpii,* and *Xanthoparmelia monticola.*

Vertebrate animals – *Crotalus horridus.*

Invertebrate animals – *Euchloe olympia, Hypochilus coylei,* and *Megathymus cofaqui.*

LOW ELEVATION BASIC GLADE (BRUSHY MOUNTAINS SUBTYPE)

Concept: Low Elevation Basic Glades are communities of shallow soils, with limited tree cover but with extensive ground cover, occurring on many kinds of rock and containing plants indicative of base-rich conditions. The Brushy Mountains Subtype covers the floristically distinctive examples currently known only from the Brushy Mountains.

Distinguishing Features: Low Elevation Basic Glades are distinguished from both Low Elevation Granitic Domes and Low Elevation Acidic Glades by the presence of plants characteristic of higher pH, base-rich soils. The Brushy Mountains Subtype is distinguished by a suite of distinctive plant species, including *Croton willdenowii (Crotonopsis elliptica), Hypericum radfordiorum, Allium keeverae, Pseudognaphalium obtusifolium, Coreopsis tripteris, Senna marilandica*, and *Hexasepalum (Diodia) teres*.

Crosswalks: *Selaginella rupestris - Croton michauxii* var. *ellipticus - Cheilanthes tomentosa - (Allium cuthbertii)* Granitic Glade Vegetation (CEGL004992).
G180 Appalachian Mafic Barrens Group.
Southern and Central Appalachian Mafic Glade and Barrens Ecological System (CES202.348).

Sites: The Brushy Mountains Subtype of Low Elevation Basic Glade occurs on smooth to gently undulating or pitted outcrops of granitic rock on upper to middle slopes. All examples appear to be on exfoliation surfaces. Examples range from 1200-2300 feet in elevation.

Soils: Soils are shallow mats of accumulated organic matter and small rock fragments. They generally are not distinguished in soil surveys or are mapped as rock. Based on the flora, they are presumed to be relatively high in base saturation and pH.

Hydrology: Low Elevation Basic Glades generally are dry because of shallow soils. During drought periods moisture stress may quickly become extreme. Small portions may be saturated by seepage for part of the year or in wet periods.

Vegetation: The glade vegetation is patchy. It may include substantial areas of rock covered by crustose lichens, *Cladonia* spp., the moss *Grimmia laevigata*, or *Brysodesma (Selaginella) rupestre*. Shallow soil mats dominated by herbs are generally extensive. Species with high constancy in CVS plots or in site reports include *Opuntia mesacantha* ssp. *mesacantha*, *Phemeranthus teretifolius, Hypericum gentianoides, Croton willdenowii (Crotonopsis elliptica), Allium keeverae, Hypericum radfordiorum, Commelina erecta* var. *erecta, Linaria canadensis, Myriopteris (Cheilanthes) lanosa, Myriopteris tomentosa, Pycnanthemum incanum, Dichanthelium acuminatum* var. *fasciculatum*, *Juncus dichotomus, Krigia virginica, Andropogon virginicus*, and *Yucca filamentosa*. Also fairly frequent in plots or reports are *Diamorpha smallii, Phlox nivalis, Schizachyrium scoparium, Danthonia sericea, Agrostis hyemalis, Micranthes (Hydatica) petiolaris, Asplenium platyneuron, Dichanthelium depauperatum, Houstonia caerulea, Coreopsis tripteris, Micranthes virginiensis*, and *Fleischmannia (Eupatorium) incarnata*. Other herbs that are less frequent but that are notable in showing the character of the community include *Hylotelephium telephioides, Aquilegia canadensis, Penstemon australis, Borodinia (Boechera) canadensis, Senna marilandica, Asplenium trichomanes, Woodsia obtusa, Phacelia dubia,* *Micranthes virginiensis*, and *Tradescantia ohiensis*. Woody plants are patchy, with trees and shrubs present in the deeper soil patches and on the edges. The most frequent dominant tree is *Juniperus virginiana*, though *Fraxinus americana* or *Fraxinus biltmoreana*, *Carya glabra*, and *Pinus virginiana* are also frequent. Other fairly frequent trees include *Ulmus alata* and *Chionanthus virginicus*. Shrubs noted, generally at low frequency, include *Rhus glabra, Rosa carolina, Symphoricarpos orbiculatus*, and *Ptelea trifoliata*.

Range and Abundance: Ranked G1. The Brushy Mountains Subtype is endemic to North Carolina and occurs only in the Brushy Mountains area in the foothills of Alexander and Wilkes counties. The entire global extent appears to be on the order of approximately 100 acres.

Associations and Patterns: Low Elevation Basic Glades are small patch communities. The Brushy Mountains Subtype generally is not associated with any rock outcrop communities, but it sometimes occurs with Montane Red Cedar–Hardwood Woodland or Granitic Dome Basic Woodland. Otherwise, it is surrounded by typical upland forest communities which may be either basic or acidic.

Variation: The Brushy Mountains Subtype is a narrowly defined community. Variants have not been defined.

Dynamics: Dynamics of the Brushy Mountains Subtype are presumed to be generally comparable to those of other glade communities. They remain more open than typical forest in the absence of disturbance, but periodic mortality caused by drought may be important for keeping them open. Fire, though likely patchy within the community, may also be influential. The Brushy Mountains Subtype is more similar to Low Elevation Granitic Dome than are other glade communities and may be more subject to the cyclic succession dynamics of vegetation mats in that community. The sequence of primary succession on Rocky Face Mountain, one example of this subtype, is described in detail in Keever, et al. (1951), and they mentioned the destruction of soil mats by uprooting trees.

As in some examples of the Montane Subtype, it is not obvious why the examples of the Brushy Mountains Subtype appear to have high base status given that they occur on felsic rocks that normally support acidic communities.

Comments: Examples of the Brushy Mountains Subtype were treated as part of the Low Elevation Granitic Dome community in the 3rd Approximation. They resemble granitic domes more than do other glade communities, and it has been uncertain whether they are best regarded as a subtype of Low Elevation Basic Glade or of Low Elevation Granitic Dome. It appears that most of the rock outcrops in the Brushy Mountains are relatively heavily vegetated and therefore more appropriate to treat as glades, though they are less vegetated than most examples in the Montane Subtype. However, the description in Keever, et al. (1951) emphasizes bare rock and makes the site appear very similar to a Low Elevation Granitic Dome. A few of the largest outcrops in the Brushy Mountains have open areas that are better classified as Low Elevation Granitic Dome.

The floristic differences that warrant recognition of the Brushy Mountains Subtype include a greater component of Piedmont species, some affinities to Granitic Flatrock communities, the frequent occurrences of several endemic species, and long distance disjunct species not found in any other North Carolina community. The collection of rare plant species associated with this subtype is large.

Helianthus (Viguiera) porteri, an endemic species of granitic flatrocks and domes in states to the south, was introduced in an ecological experiment in one example of the Brushy Mountains Subtype. It has developed into an aggressive weedy species there.

Rare species:
Vascular plants – *Allium keeverae, Anemone berlandieri, Arabis adpressipilis, Corydalis micrantha, Cyperus granitophilus, Dichanthelium bicknellii, Fleischmannia incarnata, Hypericum radfordiorum, Pellaea wrightiana, Spiranthes lacera* var. *lacera*, and *Trichostema setaceum*.

Nonvascular plants – *Cephaloziella hampeana, Macrocoma sullivantii,* and *Orthotrichum keeverae.*

Vertebrate animals – *Crotalus horridus.*

Invertebrate animals – *Megathymus cofaqui.*

MONTANE RED CEDAR–HARDWOOD WOODLAND

Concept: Montane Red Cedar–Hardwood Woodlands are rare open-canopy woodlands of the Mountains and foothills, on shallow soils over bedrock, containing plants indicative of high pH, base-rich soil conditions. *Juniperus virginiana* is dominant or codominant, *Fraxinus americana/biltmoreana* or *Carya* spp. are abundant, and *Quercus montana* or other oaks may also be abundant.

Distinguishing Features: Montane Red Cedar–Hardwood Woodlands are distinguished from other forest and woodland communities by having an open but substantial canopy that includes abundant *Juniperus virginiana* and having lower strata that include both species needing high light levels and species typical of circumneutral soil conditions. Characteristic species include *Schizachyrium scoparium, Danthonia* spp., *Coreopsis pubescens, Physocarpus opulifolius, Philadelphus hirsutus*, and *Primula* (*Dodecatheon*) *meadia*. Montane Red Cedar–Hardwood Woodlands are distinguished from Low Elevation Basic Glades and various rock outcrop communities by vegetation structure. The rock outcrop communities may have trees on the edges and sparsely in the interior of the community but have less than 25% cover of trees. Low Elevation Basic Glade communities have more vegetation cover and usually more trees than the rock outcrop communities, but also are more open and have more bare rock than Montane Red Cedar–Hardwood Woodland. The similar Granitic Dome Basic Woodland has a denser canopy more strongly dominated by *Carya, Quercus*, and *Fraxinus,* with little *Juniperus* and has limited shade-intolerant flora.

Crosswalks: *Carya (glabra, tomentosa) - Fraxinus americana - (Juniperus virginiana)* Open Woodland (CEGL003752). Montane Red Cedar–Hardwood Woodland.
G180 Appalachian Mafic Barrens Group.
Southern and Central Appalachian Mafic Glade and Barrens Ecological System (CES202.348).
Low Elevation Granitic Dome (in part) (3rd Approximation).

Sites: Montane Red Cedar–Hardwood Woodlands occur on upper slopes with shallow but extensive soil. Rock outcrops are usually present in the community but represent a small minority of the area.

Soils: Soils are shallow accumulations of weathered rock and organic matter lying over bedrock. They are generally treated as inclusions in soil surveys or mapped as rock outcrops.

Hydrology: Moisture conditions are generally dry because of the shallow soil, and they can become extreme during drought. Some limited seepage may be present along uphill edges.

Vegetation: The vegetation is a woodland, with an open but fairly continuous canopy of small trees. Vegetation was described in detail by Small and Wentworth (1998), and earlier and later site reports and plot data are similar. *Juniperus virginiana* dominates the canopy. *Carya glabra* or *Fraxinus americana/biltmoreana* have high constancy and may have high cover. *Quercus montana, Quercus rubra, Quercus alba, Carya tomentosa,* and *Pinus virginiana* are also highly constant; they, along with *Ulmus alata,* may less often be abundant. Shrubs are sparse to moderate in density. *Chionanthus virginicus*, *Vaccinium stamineum,* and *Rubus canadensis* are most constant, and *Symphoricarpos orbiculatus* is also frequent. Vines are not extensive, but *Parthenocissus quinquefolia*, *Smilax glauca,* and *Toxicodendron radicans* are constant or frequent. The herb layer is generally dense and diverse. Species with greater than 50% constancy in Small and Wentworth (1998) plots include *Carex pensylvanica, Danthonia spicata, Dichanthelium scoparium, Potentilla canadensis, Heuchera americana* var. *americana, Schizachyrium scoparium, Stylosanthes biflora, Dichanthelium laxiflorum, Antennaria plantaginifolia, Asplenium platyneuron, Erigeron strigosus, Penstemon canescens, Polygonatum biflorum, Polypodium appalachianum, Micranthes (Hydatica) petiolaris, Eurybia divaricata, Hypericum punctatum, Campanula divaricata, Pseudognaphalium obtusifolium, Lespedeza hirta, Coreopsis pubescens* var. *pubescens, Sorghastrum nutans, Euphorbia corollata, Oxalis grandis, Phemeranthus teretifolius, Viola palmata, Eurybia undulata, Dichanthelium boscii, Houstonia lanceolata*, *Oenothera tetragona* var. *Fraseri*, *Solidago erecta*, *Danthonia sericea, Houstonia caerulea, Packera anonyma, Amphicarpaea bracteata, Andropogon gerardii, Carex normalis, Helianthus hirsutus, Lechea racemulosa, Pycnanthemum montanum, Silene virginica, Thalictrum amphibolum* (*revolutum*)*, Lobelia puberula, Viola sororia, Borodinia (Boechera) laevigata*, and *Pycnanthemum incanum*. Other herbs with slightly lower frequency but indicative of basic conditions include *Primula meadia, Myriopteris tomentosa, Tradescantia hirsuticaulis*, *Elymus hystrix,* and *Solidago sphacelata*.

Range and Abundance: Ranked G2. Examples occur in the mountains and foothills. There is a cluster of occurrences in Macon and Jackson counties and one in the Brushy Mountains of Alexander County, with only a handful of examples scattered elsewhere. The community is also believed to occur in Georgia, and plots have been attributed to it in Virginia.

Associations and Patterns: Montane Red Cedar–Hardwood Woodlands are small patch communities usually associated with one of the subtypes of Low Elevation Basic Glade, less often with some other more open community such as Low Elevation Granitic Dome. They are generally surrounded by communities of the Mountain Oak Forests theme. Though Montane Red Cedar–Hardwood Woodland has flora suggesting high base status in the soil, the surrounding oak forests often are typical acidic subtypes.

Variation: Small and Wentworth (1998) found that plot data were grouped geographically, with samples from the Brushy Mountains most distinct from those in the Blue Ridge. These are tentatively recognized as variants, though they sampled only a single Brushy Mountains site. Study of other examples in the Brushy Mountains is needed to verify that they show a similar pattern.

1. Montane Variant occurs within the Blue Ridge proper and is usually associated with the Montane Subtype of Low Elevation Basic Glade.

2. Brushy Mountains Variant occurs in the Brushy Mountains, at lower elevations and generally associated with the Brushy Mountains Subtype of Low Elevation Basic Glade. If examples are found in the South Mountains, they may belong with this variant or may fit better with the Montane Variant.

Dynamics: Montane Red Cedar–Hardwood Woodland dynamics probably are similar to those of Low Elevation Acidic Glade and Low Elevation Basic Glade. The impact of drought, though less severe than in those communities with less soil, is probably important in keeping the canopy open and allowing *Juniperus* to survive amid potentially taller hardwoods. Small and Wentworth (1998) report tree diameter data suggestive of a stable, uneven-aged population. Fire is possible at the same frequency as in the surrounding oak forests, but the less continuous litter layer would limit its intensity and the frequency at which it influences most of the community. *Juniperus virginiana* is not very resistant to fire, and its long-term persistence suggests a limited role of fire. However, fire may be important in determining boundaries between Montane Red Cedar–Hardwood Woodland and adjacent communities.

Rare species:
Vascular plants – *Allium keeverae, Calamagrostis porteri, Coreopsis grandiflora* var. *grandiflora, Corydalis micrantha, Euphorbia commutata, Fleischmannia incarnata, Hypericum radfordiorum, Matelea decipiens, Packera millefolium, Parthenium auriculatum, Primula (Dodecatheon) meadia, Sedum glaucophyllum, Silene ovata, Sisyrinchium dichotomum, Solidago simulans,* and *Trichostema setaceum*.

Nonvascular plants – *Macrocoma sullivantii, Orthotrichum keeverae,* and *Usnea angulata.*

Vertebrate animals – *Crotalus horridus.*

Invertebrate animals – *Megathymus cofaqui* and *Papilio cresphontes.*

GRANITIC DOME BASIC WOODLAND

Concept: Granitic Dome Basic Woodlands are rare open forests of *Quercus, Carya*, and *Fraxinus* associated with exfoliated rock outcrops in the Blue Ridge escarpment and foothills portions of the state. They are similar to Montane Red Cedar–Hardwood Woodlands but are denser and are dominated by hardwoods. The concept should be reserved for substantial expanses of woodland or forest, not for the small woody patches that are a normal part of Low Elevation Granitic Dome or glade communities.

Distinguishing Features: Granitic Dome Basic Woodlands are distinguished from other glades and barrens by being only slightly more open than typical forests, and by their association with foothills granitic dome exfoliated rock outcrops. They differ in canopy composition and structure from typical mountain forests in ways that suggest influence of high soil base status and effects of shallow soil and drought. Granitic Dome Basic Woodlands are distinguished from Montane Red Cedar–Hardwood Woodlands by having a denser canopy that is dominated by hardwoods, with little or no *Juniperus virginiana*, though pines may be present in either. They often have extensive grassy herb layers dominated by *Piptochaetium avenaceum* but do not have the high species richness of Montane Red Cedar–Hardwood Woodland. Granitic Dome Basic Woodlands are similar to Granitic Flatrock Border Woodland communities in vegetation structure and presumed ecological drivers, but they differ biogeographically. The Granitic Dome Basic Woodland flora is distinctly tied to the Blue Ridge; the Granitic Flatrock Border Woodland flora represents the lower Piedmont.

Crosswalks: *Fraxinus americana – Carya glabra / Symphoricarpos orbiculatus - Rhus aromatica / Piptochaetium avenaceum* Woodland (CEGL003684).
G180 Appalachian Mafic Barrens Group.
Southern Piedmont Glades and Barrens Ecological System (CES202.328).
Basic Oak–Hickory Forest (3rd Approximation).

Sites: Granitic Dome Basic Woodland communities occur on upper slopes, ridge tops, or tops of knobs underlain by massive granitic rocks that are prone to exfoliation. Though not carefully studied, they presumably have relatively shallow soils with unfractured bedrock beneath. Rock outcrops are absent or scarce within them.

Soils: Soils are continuous but are presumed to be shallow and probably are sandy. In all the known examples, the soils are mapped as “rock outcrop complex.”

Hydrology: Sites are dry both because of shallow soil and because of high topographic position. However, if the underlying bedrock is unfractured, rainwater may be retained near the surface for longer than might be expected on hilltops. These soils are sometimes the source of seepage onto adjacent Low Elevation Granitic Domes.

Vegetation: The woodland vegetation is a continuous canopy that may range from somewhat open to nearly as dense as a forest. The canopy is dominated by combinations of *Carya glabra* and *Fraxinus americana/biltmoreana*, sometimes with abundant *Quercus montana* or *Ulmus alata*. The understory generally is sparse but frequently includes some *Juniperus virginiana, Acer* *rubrum, Nyssa sylvatica, Chionanthus virginicus*, *Celtis tenuifolia, Prunus serotina, Diospyros virginiana,* and *Crataegus uniflora,* as well as canopy species. The shrub layer is generally sparse. *Vaccinium stamineum, Vaccinium pallidum,* and *Rhus aromatica* occur with high constancy in CVS plot data, and *Rosa carolina*, *Symphoricarpos orbiculatus*, *Ptelea trifoliata,* and various tree species may also occur. Vines are not prominent, but *Parthenocissus quinquefolia* occurs with high constancy. The herb layer is generally dense, often with *Piptochaetium avenaceum* strongly dominant. *Danthonia spicata* is highly constant in plot data and can be fairly abundant. Other constant or frequent species in plot data include *Dichanthelium boscii, Dichanthelium laxiflorum, Heuchera americana, Endodeca serpentaria, Verbesina occidentalis, Galium pilosum, Aquilegia canadensis, Eupatorium sessilifolium, Dryopteris marginalis, Houstonia longifolia* var. *compacta, Micranthes (Hydatica) petiolaris, Opuntia mesacantha* var. *mesacantha*, *Packera anonyma, Galium circaezans, Hieracium venosum, Phlox nivalis, Polygonatum biflorum, Schizachyrium scoparium,* and *Sanicula canadensis*.

Range and Abundance: Ranked G2, but potentially G1. Only a handful of sites are known in North Carolina, all in the Brushy Mountains and northern Blue Ridge escarpment. The association is also attributed to Georgia and could conceivably occur in South Carolina.

Associations and Patterns: Granitic Dome Basic Woodlands are small-to-large patch communities associated with Low Elevation Granitic Dome or Low Elevation Basic Glade communities. They generally occur at the highest local elevation and may grade downslope to Mountain Oak Forests or Mountain Cove Forests where rock outcrops are not present.

Variation: Little is known about variation.

Dynamics: Granitic Dome Basic Woodland communities likely have dynamics similar to other barrens communities, or intermediate between glades and forests. Canopies probably are largely uneven-aged, with tree reproduction in gaps, but natural disturbance and regeneration may be more severe and more episodic than in most forests because of the greater effects of drought and shallow soil. Given the continuous litter layer and often continuous grass layer in these communities, natural fire likely is as frequent as in most oak forests and may be an important influence.

Comments: This community was called Montane Red Cedar–Hardwood Woodland (Piedmont Dome Subtype) in earlier drafts of the 4th Approximation. It is closely related to that community but has a dense canopy and largely or completely lacks *Juniperus virginiana*.

As with the Low Elevation Basic Glade community, the presence of flora of high-base sites in Granitic Dome Basic Woodland is mystifying. The substrate usually is felsic rock that otherwise tends to produce acidic soils. The associated forest communities generally are acidic.

Quercus montana - Quercus stellata - Carya glabra / Vaccinium arboreum - Viburnum rufidulum Forest (CEGL004416) is an association with a somewhat confusing description, which may partly overlap this community type and the association synonymized above.

Rare species:
Vascular plants – *Fleischmannia incarnata* and *Spiraea corymbosa.*

ULTRAMAFIC OUTCROP BARREN (PITCH PINE SUBTYPE)

Concept: Ultramafic Outcrop Barrens are very rare woodlands with distinctive structure and floristic composition associated with soils developed on ultramafic rock substrates such as serpentinite, peridotite, or dunite. Characteristics include low overall plant species richness due to exclusion of some species by soil chemistry, unusual combinations of plants with different typical moisture tolerances, and generally, unusually open, grassy vegetation. The Pitch Pine Subtype covers the more extremely developed examples at elevations above about 3000 feet, where *Pinus rigida* dominates or codominates a generally open canopy. A well-developed herb layer dominated by prairie grasses is generally present.

Distinguishing Features: Ultramafic Outcrop Barrens are distinguished by an unusually open, barren vegetation structure unexpected for the topographic setting and soil depth, unusual vegetation composition that includes combinations of species with different moisture tolerances, endemic species such as *Symphyotrichum rhiannon*, and association with ultramafic rock. Not all recognizable ultramafic rock bodies support these communities. The Pitch Pine Subtype is distinguished from the Virginia Pine Subtype by the predominance of *Pinus rigida* and scarcity of *Pinus virginiana*. It is distinguished from the White Oak Subtype by having a more open canopy with *Pinus rigida* dominant or codominant.

Crosswalks: *Pinus rigida - Quercus alba / Sporobolus heterolepis - Andropogon gerardii* Woodland (CEGL003768).
G180 Appalachian Mafic Barrens Group.
Eastern Serpentine Woodland Ecological System (CES202.347).

Sites: Ultramafic Outcrop Barrens occur on substrates of ultramafic rock such as dunite, peridotite, and serpentinite. The Pitch Pine Subtype occurs on convex slopes at moderate elevation, around 3000 feet. It is presently known only at Buck Creek Barrens and is unlikely to be found elsewhere.

Soils: Soils derived from ultramafic rocks are known for their unusual chemistry, which includes high levels of magnesium, low calcium to magnesium ratio, and high levels of nickel and chromium. The soils at the one known occurrence are mapped as Evard-Cowee complex (Typic Hapludults) but Mansberg (1981) described them as a Mollisol. If true, it would be one of very few occurrences of this soil order in North Carolina.

Hydrology: The Pitch Pine Subtype is dry to dry-mesic, generally occurring on well-drained slopes. Local seepage areas may be present.

Vegetation: The Pitch Pine Subtype is an open woodland or savanna dominated by *Pinus rigida*. *Quercus alba* is abundant. The only other trees with high constancy, though limited cover, in CVS plot data are *Acer rubrum* and *Tsuga canadensis*, species that probably would be reduced by more frequent fire. Shrubs may have sparse to dense cover. *Kalmia latifolia, Vaccinium stamineum, Physocarpus opulifolius, Viburnum cassinoides, Sassafras albidum, Lyonia ligustrina, Gaylussacia baccata, Vaccinium pallidum*, and *Vaccinium simulatum* have high constancy in plots, and the first five also can have moderate to high cover. *Smilax glauca* and *Smilax rotundifolia* are constant and may be fairly extensive. The herb layer is dense wherever shrubs are not too abundant. Grasses dominate, particularly *Andropogon gerardii*, *Schizachyrium scoparium*, and *Sporobolus heterolepis*. *Dichanthelium dichotomum, Elymus trachycaulus, Danthonia spicata, Sorghastrum nutans, Dichanthelium commutatum, Dichanthelium laxiflorum, Panicum virgatum* var. *virgatum*, and *Muhlenbergia glomerata* also occur with high constancy. Other herbs with high constancy and sometimes moderate cover include *Packera serpenticola, Thalictrum macrostylum, Pteridium latiusculum*, *Sanguisorba canadensis*, *Carex echinata* ssp. *echinata*, and an apparent undescribed species of *Hexastylis* resembling *H. ruthii*. Additional less abundant herbs that are constant or moderately frequent in plots include *Solidago bicolor, Coreopsis major, Oenothera fruticosa, Prunella vulgaris, Asplenium platyneuron, Campanula divaricata, Polygaloides pauciflora, Epigaea repens, Helianthus microcephalus, Houstonia serpyllifolia, Lobelia puberula, Parnassia grandifolia, Solidago nemoralis, Symphyotrichum phlogifolium, Zizia trifoliata, Goodyera pubescens, Phlox ovata, Festuca subverticillata, Gillenia trifoliata, Packera anonyma, Polystichum acrostichoides, Symphyotrichum laeve*, and *Viola sagittata*.

Range and Abundance: Ranked G1. Only one occurrence is known and no more are likely to be discovered.

Associations and Patterns: The Pitch Pine Subtype is a large patch community. It occurs in conjunction with the White Oak Subtype.

Variation: The one known example is heterogeneous in canopy and shrub layer density, perhaps reflecting variations in soil depth, rockiness, or recent fire history.

Dynamics: Ultramafic Outcrop Barrens, the Pitch Pine Subtype in particular, remain open woodlands in the absence of natural disturbance, due to the extreme soil conditions. The presence of endemic and long-distance disjunct plant species that require high light levels attests to the persistence of open conditions through a variety of climate changes. However, fire appears to be important to maintaining the natural structure of this community. The grassy herb layer should readily carry fire. Given the small size of the occurrence, with ignition primarily by spread of fire from adjacent areas, the community likely burned no more frequently than the surrounding landscape. As with many barrens and woodland communities, extreme site conditions allow fire to have a greater effect on vegetation structure than it does in adjacent forests with the same fire regime. As with other barrens communities, in the absence of fire the canopy becomes denser, shrub cover increases, and herb cover is reduced. It has been suggested that vegetation of the White Oak Subtype spreads at the expense of the Pitch Pine Subtype in the absence of fire.

Comments: Ultramafic rocks are associated with unusual barren vegetation in many places, including Georgia, Virginia, Maryland, and Maine, as well as Oregon, California, and more distant locations. However, the distance between sites in and near North Carolina leads to extreme differences among them. The Pitch Pine Subtype and the White Oak Subtype likely are unique to the single known site because no ultramafic rock sites comparable in elevation and climate exist in the eastern half of the continent. However, some known occurrences of ultramafic rock do not have distinctive vegetation, perhaps due to alteration of the rock so that its distinctive influence on soils is not effective.

Buck Creek has long been recognized in the botanical community as a distinctive place. Detailed studies of Buck Creek Barrens (Mansberg 1981; Mansberg and Wentworth 1984) appear to focus primarily on the Pitch Pine Subtype. Radford (1948) did earlier floristic work here. The vegetation also is well characterized by seven CVS plots. Despite early study and recognition of unusual flora, the endemic species were slow to be recognized. *Symphyotrichum rhiannon*, the first formally recognized, was published in 2004, *Packera serpenticola* in 2014. Several other populations initially treated as disjunct species or recognized as odd forms are under study and may turn out to be additional endemic taxa.

Rare species:

Vascular plants – *Calamagrostis porteri, Cypripedium parviflorum* var. *parviflorum, Deschampsia cespitosa ssp. glauca, Elymus trachycaulus ssp. trachycaulus, Gentianopsis crinita, Muhlenbergia glomerata, Packera serpenticola, Parnassia grandifolia, Poa saltuensis, Ranunculus fascicularis, Sporobolus heterolepis, Symphyotrichum concinnum, Symphyotrichum rhiannon, Thalictrum macrostylum,* and *Viola appalachiensis.*

Nonvascular plants – *Drepanolejeunea appalachiana, Frullania appalachiana, Macrocoma sullivantii,* and *Schlotheimia lancifolia.*

Vertebrate animals – *Certhia americana, Myotis lucifugus, Myotis septentrionalis, Perimyotis subflavus,* and *Sylvilagus obscurus*.

Invertebrate animals – *Celastrina nigra, Chlosyne gorgone, Erynnis martialis,* and *Phyciodes batesii maconensis*.

ULTRAMAFIC OUTCROP BARREN (WHITE OAK SUBTYPE)

Concept: Ultramafic Outcrop Barrens are very rare woodlands with distinctive structure and floristic composition associated with soils developed on ultramafic rock substrates. Characteristics include low overall plant species richness due to exclusion of some species by soil chemistry, unusual combinations of plants with different typical moisture tolerances, and, generally, unusually open, grassy vegetation. The White Oak Subtype covers the more mesic, less barren examples at elevations above about 3000 feet, where *Quercus alba* or other more mesophytic species form an open to nearly closed canopy.

Distinguishing Features: Ultramafic Outcrop Barrens are distinguished by an unusually open, barren vegetation structure unexpected for the topographic setting and soil depth, unusual vegetation composition that includes combinations of species with different moisture tolerances, endemic species such as *Symphyotrichum rhiannon*, and association with ultramafic rock. The White Oak Subtype is distinguished from the Pitch Pine Subtype and the Virginia Pine Subtype by a greater canopy density and by the predominance of *Quercus alba* in the canopy, with only a minority of *Pinus rigida, Pinus virginiana*, or other more xerophytic species.

Crosswalks: *Quercus alba / Physocarpus opulifolius / Packera plattensis - Hexastylis arifolia var. ruthii* Woodland (CEGL007296).
G180 Appalachian Mafic Barrens Group.
Eastern Serpentine Woodland Ecological System (CES202.347).

Sites: Ultramafic Outcrop Barrens occur on substrates of ultramafic rock such as dunite, peridotite, and serpentinite. The White Oak Subtype occurs on concave and more sheltered slopes at moderate elevation, around 3000 feet. It is presently known only at Buck Creek Barrens and is unlikely to be found elsewhere.

Soils: Soils derived from ultramafic rocks are known for their unusual chemistry, which includes high levels of magnesium, low calcium to magnesium ratio, and high levels of nickel and chromium. The soils at the one known occurrence are mapped as Evard-Cowee complex (Typic Hapludults) but probably are some kind of Alfisol or Mollisol.

Hydrology: The White Oak Subtype probably is dry-mesic to mesic. Local seepage areas create wetter conditions.

Vegetation: The White Oak Subtype is an open woodland or savanna, ranging to nearly closed forest. In the only known example the canopy is nearly closed, but it probably existed as an open savanna or woodland under the natural fire regime. The canopy is dominated by *Quercus alba*, with lesser amounts of *Tsuga canadensis* or *Pinus rigida*. The understory may include *Magnolia acuminata, Acer rubrum, Amelanchier arborea, Betula lenta*, *Oxydendrum arboreum,* or other species, in addition to canopy species. The shrub layer ranges from moderate to dense. *Kalmia latifolia* dominates dense patches under current conditions. *Physocarpus opulifolius, Vaccinium stamineum, Viburnum cassinoides,* or *Sassafras albidum* may occur. The herb layer ranges from a dense grassy bed in openings to sparse beneath dense shrubs. Prairie grasses such as *Andropogon gerardii, Schizachyrium scoparium, Sporobolus heterolepis*, and *Elymus trachycaulus* may be abundant in patches, as may *Packera serpenticola*. Other herbs include *Polygaloides paucifolia, Asplenium platyneuron, Pteridium latiusculum, Thalictrum macrostylum, Epigaea repens, Mitchella repens, Phlox stolonifera, Carex appalachica, Chamaelirium luteum, Coreopsis major, Dichanthelium dichotomum, Dichanthelium commutatum, Dichanthelium boscii, Packera anonyma, Helianthus microcephalus, Gillenia trifoliata, Prunella vulgaris, Uvularia puberula, Thaspium barbinode*, and an apparent undescribed species of *Hexastylis* resembling *H. ruthii*. Seepage areas may contain additional species such as *Osmunda spectabilis, Oxypolis rigidior, Parnassia grandifolia*, and *Gentianopsis crinita*.

Range and Abundance: Ranked G1. Only one occurrence is known and no more are likely to be discovered.

Associations and Patterns: The White Oak Subtype occurs as a large patch community, in association with the Pitch Pine Subtype.

Variation: Variation is not well known. The one known example is heterogeneous in canopy density, which may reflect recent fire history. The seepage areas need further study; they may warrant recognition as a different community.

Dynamics: Ultramafic Outcrop Barrens in general remain open in the absence of natural disturbance, due to the extreme soil conditions. This appears to be less true for the White Oak Subtype than other subtypes, presumably because of more mesic conditions. It may thus be more dependent on fire to maintain its natural structure. As with many barrens and woodland communities, extreme site conditions allow fire to have a greater effect on vegetation structure than it does in adjacent forests with the same fire regime. In its absence the canopy becomes denser, shrub cover increases, and herb cover is reduced. It is possible that vegetation of the White Oak Subtype spreads at the expense of the Pitch Pine Subtype in the absence of fire.

Comments: The White Oak Subtype is less well documented than the Pitch Pine Subtype at the same single site. Only one CVS plot is definitively attributed to this subtype. Because the two communities are only recently distinguished and their distribution within the site is not well mapped, it is difficult to tell what descriptive material applies to which. Mansberg (1981) and Mansberg and Wentworth (1984) did not mention a separate second community and focused on the pine-dominated vegetation.

Rare species:
Vascular plants – *Calamagrostis porteri, Cypripedium parviflorum* var. *parviflorum, Deschampsia cespitosa ssp. glauca, Elymus trachycaulus ssp. trachycaulus, Gentianopsis crinita, Muhlenbergia glomerata, Packera serpenticola, Parnassia grandifolia, Poa saltuensis, Ranunculus fascicularis, Sporobolus heterolepis, Symphyotrichum concinnum, Symphyotrichum rhiannon, Thalictrum macrostylum,* and *Viola appalachiensis.*

Nonvascular plants – *Drepanolejeunea appalachiana, Frullania appalachiana, Macrocoma sullivantii,* and *Schlotheimia lancifolia.*

Vertebrate animals – *Certhia americana, Myotis lucifugus, Myotis septentrionalis, Perimyotis subflavus,* and *Sylvilagus obscurus.*

Invertebrate animals – *Celastrina nigra, Chlosyne gorgone, Erynnis martialis,* and *Phyciodes batesii maconensis*.

ULTRAMAFIC OUTCROP BARREN (VIRGINIA PINE SUBTYPE)

Concept: Ultramafic Outcrop Barrens are very rare woodlands with distinctive structure and floristic composition associated with soils developed on ultramafic rock substrates. Characteristics include low overall plant species richness due to exclusion of some species by soil chemistry, unusual combinations of plants with different typical moisture tolerances, and generally, unusually open, grassy vegetation. The Virginia Pine Subtype covers lower elevation Blue Ridge examples with *Pinus virginiana* or other low elevation species as major parts of the canopy.

Distinguishing Features: Ultramafic Outcrop Barrens are distinguished by occurrence on ultramafic rock substrate and unusually open, barren vegetation structure. The Virginia Pine Subtype is distinguished from the higher elevation subtypes by occurrence in the Mountains at elevations below about 3000 feet and abundance of typically lower elevation plants such as *Pinus virginiana, Pinus echinata*, and *Quercus stellata*. It is distinguished from the Piedmont Subtype by the abundance of *Pinus virginiana* as well as by location in the Blue Ridge.

Crosswalks: *Pinus virginiana - Pinus rigida - Quercus stellata / Ceanothus americanus - Kalmia latifolia / Thalictrum revolutum* Woodland (CEGL007721).
G180 Appalachian Mafic Barrens Group.
Eastern Serpentine Woodland Ecological System (CES202.347).

Sites: Ultramafic Outcrop Barrens occur on substrates of ultramafic rock such as dunite, peridotite, and serpentinite. The Virginia Pine Subtype occurs at lower elevations in the Blue Ridge, at 3000 feet or lower. The one known remaining site occurs on a south-facing lower slope adjacent to a large river.

Soils: Soils derived from ultramafic rocks are known for their unusual chemistry, which includes high levels of magnesium, low calcium to magnesium ratio, and high levels of nickel and chromium. The soils at the one remaining North Carolina occurrence are mapped as Ellijay, a Rhodic Kanhapludalf.

Hydrology: The Virginia Pine Subtype is dry through most of its extent, but local seepage areas may be present.

Vegetation: The Virginia Pine Subtype is an open woodland or savanna where *Pinus virginiana*, *Pinus echinata*, *Quercus stellata*, *Quercus falcata*, or other species of lower elevations are important. *Pinus rigida*, *Quercus alba, Quercus coccinea, Quercus velutina*, even *Quercus imbricaria* may also be present. Understory species may include *Acer rubrum, Betula lenta, Nyssa sylvatica*, *Benthamidia* (*Cornus*) *florida*, and *Oxydendrum arboreum*, as well as canopy species. Shrubs may include *Kalmia latifolia, Ceanothus americanus, Rhododendron maximum, Rhododendron calendulaceum, Pyrularia pubera, Castanea pumila*, *Lyonia ligustrina*, and *Vaccinium stamineum*. Vines, particularly *Smilax rotundifolia* and *Smilax glauca*, are locally abundant. Where shrubs are not dense, the herb layer is well developed. Species reported at the one North Carolina site include *Schizachyrium scoparium, Andropogon ternarius, Sorghastrum nutans, Sporobolus heterolepis, Danthonia spicata, Danthonia sericea, Aristida virgata, Dichanthelium* spp., *Thalictrum revolutum, Solidago odora, Chrysopsis mariana, Silphium* *asteriscus* var. *trifoliatum, Eurybia cordifolia, Pteridium latiusculum, Polystichum acrostichoides, Myriopteris lanosa, Sitobolium* (*Dennstaedtia*) *punctilobulum*, and *Viola* sp. Additional species in the Georgia example that could be found in North Carolina include *Osmunda spectabilis, Asclepias verticillata, Helianthus microcephalus, Panicum virgatum* var. *virgatum, Ageratina aromatica, Allium cernuum, Apocynum cannabinum, Arnoglossum atriplicifolium, Baptisia tinctoria, Clitoria mariana, Eryngium yuccifolium* var. *yuccifolium*, *Galactia regularis, Mimosa microphylla, Parthenium integrifolium, Silphium compositum*, and *Tephrosia spicata*.

Range and Abundance: Ranked G1. Only one remaining example is known in North Carolina but several others may once have occurred. At least one example exists in Georgia.

Associations and Patterns: The Virginia Pine Subtype, at least in North Carolina, occurs as a small patch community. The natural context has been lost in the remaining example but likely was some Mountain Oak Forest or Mountain Cove Forest community at the edge of the ultramafic rock body.

Variation: There are substantial differences in flora between the remaining North Carolina example and the one plot in Georgia. It is uncertain how much these differences are due to biogeography and how much they are due to differences in alteration or in fire history.

Dynamics: The natural dynamics of the Virginia Pine Subtype are probably similar to those of the Pitch Pine Subtype. Fire probably is important in maintaining the natural vegetation structure and composition. However, since *Pinus virginiana* is not very tolerant of fire, the composition of the community may have been different under a more natural fire regime, with the more tolerant *Pinus echinata* and oaks more important. The canopy is expected to stay somewhat open in the absence of disturbance due to extreme soil conditions, but the openness may be marginal. The known site has one long distance disjunct species and only one of the potential new endemic plants. This may be sufficient to suggest that, like the other subtypes, it has remained open through a long history.

Comments: The one occurrence remaining in North Carolina is less well known than the other subtypes of Ultramafic Outcrop Barrens. No plots have been sampled there. It also appears to be more altered. It is unclear if the smaller number of rare species and lack of endemic species is due to one of these factors or if the site is less distinctive.

Pinus rigida - Quercus stellata / Andropogon gerardii - Packera paupercula Woodland (CEGL004968) is a related community of Virginia.

Rare species:
Vascular plants – *Sporobolus heterolepis* and *Viola walteri.*

ULTRAMAFIC OUTCROP BARREN (PIEDMONT SUBTYPE)

Concept: Ultramafic Outcrop Barrens are very rare woodlands with distinctive structure and floristic composition associated with soils developed on ultramafic rock substrates. The Piedmont subtype covers the one known distinct Piedmont example in North Carolina.

Distinguishing Features: Ultramafic Outcrop Barrens are distinguished by occurrence on ultramafic rock substrate along with unusually open, barren vegetation structure. Some ultramafic rock bodies in the Piedmont have vegetation that is not distinguishable structurally or floristically from those of ordinary mafic rock substrates, and these should not be classified here. The one known Piedmont example has an open canopy of *Quercus velutina* and *Pinus echinata*, with an herb layer that includes *Piptochaetium avenaceum, Dichanthelium boscii*, and *Chasmanthium latifolium*, but any additional Piedmont occurrence of unusually open vegetation on ultramafic substrate should also be classified as this type.

Crosswalks: *Pinus echinata - Quercus velutina - Quercus marilandica / Piptochaetium avenaceum* Ultramafic Woodland (CEGL007045).
G180 Appalachian Mafic Barrens Group.
Eastern Serpentine Woodland Ecological System (CES202.347).

Sites: Ultramafic Outcrop Barrens occur on substrates of ultramafic rock such as dunite, peridotite, and serpentinite. The one known example of the Piedmont Subtype occurs on a convex upper north-facing slope.

Soils: Soils derived from ultramafic rocks are known for their unusual chemistry, which includes high levels of magnesium, low calcium to magnesium ratio, and high levels of nickel and chromium. The soils at the one known North Carolina occurrence are mapped as Wilkes, a Typic Hapludalf.

Hydrology: The known site is dry or mesic. The northerly aspect may mitigate the convex upper slope position to some degree.

Vegetation: The Piedmont Subtype, as it currently exists, is a slightly open forest. It is likely to have existed as a more open woodland in the past. The canopy consists primarily of *Quercus marilandica, Quercus stellata, Quercus alba, Quercus velutina*, and *Pinus echinata*. Some *Acer rubrum* and *Fagus grandifolia* also are present. The understory additionally includes *Oxydendrum arboreum, Sassafras albidum*, *Nyssa sylvatica*, *Benthamidia* (*Cornus*) *florida, Juniperus virginiana*, and *Crataegus collina*. Shrub cover is low, but some *Vaccinium pallidum* is present, along with small individuals of tree species. Vines, particularly *Muscadinia rotundifolia* and *Vitis labrusca* may be locally abundant, primarily on the ground. The herb layer is patchy, ranging from moderate to dense. *Piptochaetium avenaceum, Schizachyrium scoparium, Dichanthelium boscii, Chasmanthium latifolium*, and *Podophyllum peltatum* are fairly abundant. Other herbs include *Clematis ochroleuca, Danthonia spicata, Scleria oligantha, Polystichum acrostichoides, Dichanthelium commutatum, Euphorbia pubentissima, Hexastylis minor, Houstonia tenuifolia, Sphenopholis obtusata*, and *Viola primulifolia*.

Range and Abundance: Ranked G2?, but presumably G1. Only one example is known in North Carolina, in Wake County, and the synonymized association is not attributed to any other state.

Associations and Patterns: The Piedmont Subtype occurs as a small patch community. It is bordered by Mesic Mixed Hardwood Forest and Dry-Mesic Oak–Hickory Forest on different rock types.

Variation: The one known example shows some evidence of a moisture gradient from the uphill to downhill side.

Dynamics: Ultramafic Outcrop Barrens in general remain open in the absence of natural disturbance, due to the extreme soil conditions. This may be less true for the Piedmont Subtype than for the other subtypes, due to greater weathering of the rock. The Piedmont Subtype may thus be more dependent on fire to maintain its natural structure, with woody cover increasing and herbs being reduced in the absence of burning. The specific history of the one example is not well known. The lack of rare plant species contained there may suggest it was not able to remain open in past climates, but this dearth may also be due to its small size or to greater alteration. Related Piedmont ultramafic communities of states to the north also seem to suffer increases of woody vegetation (Tyndall 2005). As with many barrens and woodland communities, extreme site conditions are expected to allow fire to have a greater effect on vegetation structure than it does in adjacent forests with the same fire regime.

Comments: This subtype appears to be distinct from the more diverse Piedmont serpentine barrens of Maryland and from the examples in Georgia and Alabama. A single CVS plot represents it. The one known example is small. Its flora is depauperate compared to other subtypes, and this may be partly because of its small size and partly because it is more heavily altered.

Rare species:
Vascular plants – *Polygala senega*.

ACIDIC SHALE SLOPE WOODLAND

Concept: Acidic Shale Slope Woodlands are rare open woodlands of steep slopes on shale or similar acidic, fine-bedded, crumbly rock which form an unstable surface of small rock fragments. *Pinus virginiana* is dominant or codominant. There is generally only sparse cover in the herb layer, but more stable patches may have well-developed grassy ground cover. Ruderal species are usually present, presumably because of periodic disturbance by movement of the unstable substrate.

Distinguishing Features: Acidic Shale Slope Woodlands are distinguished from all other communities by the combination of unstable, crumbled rock surface, pine dominance or codominance, open canopy, and lack of substantial flora suggestive of calcareous conditions. *Pinus virginiana* dominates in all examples known, but other species are possible.

Crosswalks: *Pinus virginiana / Vaccinium pallidum / Schizachyrium scoparium - Carex pensylvanica* Woodland (CEGL003624).
G976 Piedmont-Cumberland Acidic Glade and Barrens Group.
Appalachian Shale Barrens Ecological System (CES202.598).
Dry Rocky Slope (3^{rd} Approximation).

Sites: Acidic Shale Slope Woodlands occur on steep river bluffs where shale or fine-bedded siltstone is fragmented into a thick, unstable cover of flat rock fragments. The fine-bedded rock and steep slope are both necessary to create the distinctive site conditions. Most known examples occur on dry slope aspects, and dry conditions may be necessary to limit soil development.

Soils: Soils are poorly developed and are channery. The substrate consists of a thick layer of small, flat rock fragments with limited finer-texture material. Most known examples are mapped as complexes involving the Cataska series (Typic Dystrudept), some as rock outcrops.

Hydrology: Examples are probably excessively drained because of the coarse texture of the rock fragments and lack of well-developed soil.

Vegetation: Acidic Shale Slope Woodlands have a somewhat open to very open canopy of small trees. *Pinus virginiana* generally dominates, sometimes strongly, sometimes with a large minority of *Quercus montana*. Other trees present in most examples are *Carya glabra* and *Quercus rubra*. There is no well-developed understory, and the canopy may be little taller than a typical forest understory, but *Amelanchier arborea* is often present and *Nyssa sylvatica, Ulmus alata, Carya pallida,* or *Juniperus virginiana* sometimes occur. The sparse shrub layer includes *Vaccinium pallidum, Vaccinium stamineum, Rhus copallinum*, with occasional *Kalmia latifolia* and a little *Philadelphus hirsutus*. The herb layer is patchy and is sparse overall. *Andropogon virginicus* usually dominates; *Andropogon gerardii* or *Schizachyrium scoparium* may have almost as much cover, and one plot has *Carex pensylvanica* as the most abundant species. Other herbs with high constancy in the few CVS plots include *Danthonia spicata, Hieracium venosum, Campanula divaricata, Coreopsis major, Asclepias tuberosa, Asplenium platyneuron, Chimaphila maculata, Houstonia longifolia*, and *Solidago* spp. Other herbs sometimes present include *Antennaria parlinii* ssp. *fallax, Clitoria mariana, Dichanthelium acuminatum, Dichanthelium dichotomum,* *Euphorbia corollata/pubentissima, Houstonia purpurea, Lespedeza virginica, Potentilla canadensis, Ambrosia artemisiifolia,* and *Helianthus* sp.

Range and Abundance: Ranked G2. Only a few examples are known in North Carolina. The largest number is in the Hot Springs Window geologic area, a few in other parts of the Unaka Mountains or western Blue Ridge. This community occurs in adjacent Tennessee and may be more abundant there.

Associations and Patterns: Acidic Shale Slope Woodlands occur as small patches, sometimes associated with rock outcrop communities or Calcareous Shale Slope Woodland. Otherwise, they are surrounded by Mountain Oak Forests on more stable parts of the slope; they may border Montane Alluvial Forest or Mountain Cove Forests at their downhill edge.

Variation: No variants have been recognized. Individual occurrences are heterogeneous in vegetation density in response to slope stability and recentness of movement. *Pinus virginiana - Quercus montana - Quercus rubra / Vaccinium pallidum - Kalmia latifolia* Forest (CEGL007539) was an association in the NVC formerly defined as a closely related community in the Hot Springs area. It has been lumped with the association above and is viewed as marginal or poorly developed Acidic Shale Slope Woodland.

Dynamics: The dynamics of Acidic Shale Slope Woodlands have not been studied. While dryness and limited soil development likely contribute to the openness and small stature of their woody vegetation, the lack of herb and shrub cover despite the open canopy appears to be due to the unique soil environment. The flat shale fragments shift readily with the passage of animals, and perhaps to some degree in response to weather, making an unstable substrate that must make seedling establishment and survival difficult. Moisture conditions are not well known, but the coarse substrate may lead to excessive drainage of rainfall, leading to xeric conditions. However, the softness of the rock and its tendency to yield clay may offset this. While soils are apparently acidic, cation exchange capacity and fertility probably are not extremely low.

Given the sparseness of vegetation and discontinuous litter, fire could not spread through these communities and probably is of little ecological significance in them.

Comments: Though the distinctive vegetation of the Hot Springs geologic window has been recognized by the North Carolina botanical community for many decades, shale slope woodlands have not had substantial study. Three CVS plots have been sampled in them. Given the possible role of slope instability, they would be particularly interesting for long term study. However, the same instability would make it difficult to study them without altering the community.

Acidic Shale Slope Woodlands are related to the shale barrens of Virginia and West Virginia. While recognizable as distinct communities, the name shale barren has not been used for them because their vegetation and environment appear not to be as extreme. No endemic species have been recognized in them.

Rare species:
Vascular plants – *Adlumia fungosa, Buckleya distichophylla,* and *Croton monanthogynus.*

CALCAREOUS SHALE SLOPE WOODLAND

Concept: Calcareous Shale Slope Woodlands are very rare open woodlands of steep slopes on calcareous shale or similar fine-bedded, crumbly rock that forms an unstable surface of small rock fragments. They are comparable to Acidic Shale Slope Woodland but show influence of higher pH and higher calcium levels in the flora.

Distinguishing Features: Calcareous Shale Slope Woodlands are distinguished from all other North Carolina communities by the combination of unstable, crumbled rock surface, presence of plants characteristic of circumneutral or basic soils, open canopy, hardwood and *Juniperus* dominance, and occurrence in the Blue Ridge.

Crosswalks: *Quercus montana - Juniperus virginiana - (Pinus virginiana) / Philadelphus hirsutus - Celtis occidentalis* Woodland (CEGL007720).
G180 Appalachian Mafic Barrens Group.
Appalachian Shale Barrens Ecological System (CES202.598).
Dry Rocky Slope (3rd Approximation).

Sites: Calcareous Shale Slope Woodlands occur on steep river bluffs where shale or fine-bedded siltstone is fragmented into a thick, unstable cover of flat rock fragments. The fine-bedded rock and steep slope are both necessary to create the distinctive site conditions. Examples occur on dry slope aspects, and dry conditions may be necessary to limit soil development.

Soils: Soils are poorly developed and are channery. The substrate consists of a thick layer of small, flat rock fragments with little finer-texture material. The known examples are mapped as complexes involving the Cataska series (Typic Dystrudept), some as rock outcrops.

Hydrology: Examples are probably excessively drained because of the coarse texture of the rock fragments and lack of well-developed soil.

Vegetation: Calcareous Shale Slope Woodlands have a somewhat open to very open canopy of small trees. *Juniperus virginiana* is abundant and may dominate. *Carya glabra, Pinus virginiana, Quercus montana*, *Quercus rubra*, *Ulmus alata*, and *Fraxinus biltmoreana* or *americana* may be abundant. In one example, *Pinus strobus* and *Tsuga canadensis* are abundant. *Cercis canadensis, Celtis tenuifolia*, *Amelanchier* sp., *Crataegus* sp., and *Ostrya virginiana* may be abundant as small stems. Shrubs tend to be sparse. *Philadelphus hirsutus* may be the most abundant species, and *Rhus copallinum, Rosa carolina*, and sometimes *Vaccinium pallidum* or *Vaccinium stamineum* may be present. The herb layer is patchy, ranging from nearly absent in the most unstable areas to dense in some areas. Where dense, *Piptochaetium avenaceum, Carex pensylvanica, Andropogon gerardii*, or *Danthonia spicata* may dominate. Other herbs that can be locally abundant or widely present include *Myriopteris Cheilanthes* (*lanosa*)*, Myriopteris tomentosa, Campanula americana, Clitoria mariana, Commelina erecta* var. *erecta, Helianthus microcephalus, Helianthus divaricatus, Danthonia spicata, Coreopsis major, Draba ramosissima, Euphorbia corollata/pubentissima, Houstonia longifolia* var. *compacta, Lespedeza intermedia, Lespedeza stuevei, Danthonia sericea, Melica nitens, Opuntia mesacantha* ssp. *mesacantha, Paronychia canadensis, Solidago sphacelata, Tradescantia ohiensis, Verbesina occidentalis*, *Woodsia obtusa*, *Ambrosia artemisiifolia,* and *Dichanthelium depauperatum*. Additional herbs that may be characteristic include *Elymus virginicus, Ruellia purshiana, Asplenium platyneuron, Asclepias tuberosa, Andropogon virginicus, Andropogon ternarius, Liatris squarrosa* var. *gracilenta*, *Fleischmannia incarnata, Taenidia integerrima, Sedum ternatum, Penstemon canescens, Parietaria pensylvanica, Erigeron strigosus, Galactia volubilis, Cyperus retrorsus, Eurybia undulata*, *Acalypha gracilens,* and *Ionactis linariifolia*.

Range and Abundance: Ranked G2. Only two examples are known in North Carolina. Initially defined only from North Carolina, the equivalent NVC association was later merged with related types in Virginia and Tennessee. The expanded concept of the association may now be broader than conceived in North Carolina, and it may be more broadly defined than the parallel Acidic Shale Slope Woodland.

Associations and Patterns: Calcareous Shale Slope Woodlands occur as small patches, sometimes associated with rock outcrop communities or Acidic Shale Slope Woodland. Otherwise, they are surrounded by Mountain Oak Forests on more stable parts of the slope; they may border Montane Alluvial Forest or Mountain Cove Forests at their downhill edge.

Variation: No variants have been recognized. Individual occurrences are heterogeneous in vegetation density in response to slope stability and recentness of movement.

Dynamics: Dynamics of Calcareous Shale Slope Woodlands can be expected to be similar to those of Acidic Shale Slope Woodlands. The instability of the loose rock fragments on steep slopes is important in creating their distinctive character, but excessive drainage in the substrate may also contribute. Fire is unlikely to be important because of the sparse and patchy vegetation.

Comments: This community appears to have high species richness but may be very heterogeneous. Two CVS plots and several site descriptions for the two known sites report a range of different dominant species and substantial differences in overall flora. The vegetation description above is a composite of them.

Rare species:
Vascular plants – *Adlumia fungosa, Arabis patens, Draba ramosissima, Fleischmannia incarnata, Matelea obliqua, Melica nitens, Myriopteris alabamensis, Oligoneuron rigidum, Packera paupercula* var. *appalachiana, Ruellia purshiana, Symphyotrichum oblongifolium,* and *Thaspium pinnatifidum*.

PIEDMONT ACIDIC GLADE

Concept: Piedmont Acidic Glades are open, generally grassy, heterogeneous woodlands or savannas of shallow soils over irregular bedrock (not exfoliated granitic rocks), lacking species indicative of higher pH or higher base richness. These are generally moderately to steeply sloping, occurring on dry slope aspects. They have more vegetation cover, especially in the herb layer, than the sparsely vegetated cliff communities but are prevented from forming a closed forest by shallow soil and associated xeric conditions. Vegetation is generally patchy and open but often contains substantial tree cover as well as herb- or low-shrub-dominated areas. Open rock areas are limited.

Distinguishing Features: All the glade communities are distinguished from forest communities by having a persistently open tree canopy, ranging from woodland structure to sparser. The combination of tree species, generally *Quercus montana* along with *Quercus stellata* or xerophytic pines, is distinctive. This community is distinguished from Xeric Piedmont Slope Woodland by having more open canopy, shallow soil, and greater influence of rock.

Piedmont Acidic Glades are distinguished from Piedmont Cliff, Granitic Flatrock, and Low Elevation Rocky Summit by having soil with substantial herbaceous or shrub cover over most of the area and limited areas of bare rock. Plants characteristic of bare rock, such as *Phemeranthus (Talinum) teretifolius, Croton willdenowii (Crotonopsis elliptica), Selaginella rupestris*, and crustose lichens, may be present but are scarce and limited to the small areas of open rock outcrop.

Piedmont Acidic Glades are distinguished from Piedmont Basic Glades by lacking flora characteristic of circumneutral or basic sites. Generally, the undergrowth is dominated either by grasses or by short clonal shrubs such as *Vaccinium pallidum* or *Gaylussacia baccata*. Grassy areas are generally dominated by *Schizachyrium scoparium* but may include *Danthonia spicata, Piptochaetium avenaceum, Andropogon gerardii, Andropogon ternarius, Andropogon gyrans*, and *Sorghastrum nutans*. Species characteristic of less acidic soils, such as *Cercis canadensis, Rhus aromatica, Fraxinus americana, Cheilanthes tomentosa*, or *Aquilegia canadensis* are absent or extremely scarce. Species such as *Vaccinium arboreum, Chionanthus virginicus*, and *Carya* spp. may be present but occur in smaller proportions than in basic glades.

Crosswalks: *Quercus montana - Quercus stellata - Pinus echinata) / Vaccinium pallidum / Schizachyrium scoparium* Scrub (CEGL004910).
G976 Piedmont-Cumberland Acidic Glade and Barrens
Southern Piedmont Glades and Barrens Ecological System (CES202.328).

Sites: Piedmont Acidic Glades usually occur on moderate to steep slopes that face south or west, but they may occur on other aspects or may be flat. Bedrock is near the surface beneath most of the community, but shallow soil covers most of it. The geologic substrate is generally felsic igneous or metamorphic rocks such as rhyolite, dacite, granite, gneiss, phyllite, or schist, but it can potentially be meta-sedimentary rock.

Soils: Glade soils are shallow, with bedrock near the surface. The soil material includes rock fragments and early weathering products along with organic matter and washed-in material. These soils may consist of shallow mats or deep fill in crevices and are often extremely heterogeneous. They generally represent inclusions in soil map units.

Hydrology: The shallow soils dry quickly between rains and are prone to extreme drought stress. There is a possibility of small seepage patches on the edges, but this appears to be rare.

Vegetation: The vegetation of Piedmont Acidic Glades is usually patchy and heterogeneous; it may range from an open woodland or savanna to nearly treeless. The herb layer is generally the dominant stratum, though a few examples may have limited herb cover. Most have small openings with bare rock. *Schizachyrium scoparium* is most often dominant, but *Danthonia spicata, Danthonia sericea*, or *Piptochaetium avenaceum* may dominate patches. Other herbs that are at least fairly frequent in the grassy vegetation in CVS plot data or site descriptions include *Dichanthelium depauperatum, Andropogon virginicus, Tephrosia virginiana, Pityopsis graminifolia, Coreopsis verticillata, Dichanthelium dichotomum, Sorghastrum nutans, Dichanthelium commutatum, Cunila origanoides, Oxalis stricta* or *dillenii*, and *Euphorbia pubentissima*. Many other herbs of dry open communities are found at low frequency but may once have been more common, including *Solidago odora, Scleria oligantha, Scleria ciliaris, Ionactis linariifolia, Sericocarpus linifolius, Yucca flaccida, Andropogon gerardii, Pteridium latiusculum, Parthenium integrifolium, Baptisia tinctoria, Iris verna*, and *Helianthus divaricatus*. Species of rock outcrops, such as *Krigia virginica, Phemeranthus teretifolius, Hypericum gentianoides*, and mosses and lichens, are often present with small cover on the embedded open rock. Ruderal species such as *Ambrosia artemisiifolia*, *Conyza canadensis*, and *Andropogon virginicus* are often present, though all but the latter with limited cover.

In the tree canopy, *Quercus montana, Pinus virginiana*, or *Pinus echinata* are most constant and most often dominant in both plot data and site descriptions, but *Quercus stellata* may dominate. Other frequent trees that often have moderate cover include *Quercus marilandica, Carya pallida, Carya glabra*, and *Juniperus virginiana*. Less frequent trees include *Oxydendrum arboreum, Nyssa sylvatica, Ulmus alata, Quercus alba, Diospyros virginiana, Sassafras albidum*, and other species that may not be characteristic, such as *Acer rubrum*. Shrubs may be sparse or moderately dense in different examples or in patches within a community. *Vaccinium arboreum* and *Vaccinium pallidum* are most frequent, but *Gaylussacia baccata* may dominate. Other shrubs may include *Toxicodendron pubescens, Vaccinium stamineum, Gaylussacia frondosa, Hypericum hypericoides,* or *Hypericum stragulum*. Vines, particularly *Muscadinia rotundifolia* or *Smilax glauca* but also occasionally *Gelsemium sempervirens*, may dominate patches.

Range and Abundance: Ranked G2. Examples are scattered in the central Piedmont and could occur in more portions of the Piedmont, but the majority occur in the Uwharrie area and Montgomery, Stanly, and Randolph counties. The equivalent association is uncertainly attributed to South Carolina and Georgia.

Associations and Patterns: Piedmont Acidic Glades occur as small patches. They are surrounded by forest communities, usually Dry Oak–Hickory Forest or Piedmont Monadnock Forest.

Variation: Variants are not defined. There is usually more heterogeneity within examples than there is among examples.

Dynamics: Drought may be an important part of the dynamics of these communities. Drought is more likely to kill trees with limited rooting depth, and periodic mortality may be an important cause of the open structure of these communities. The author has observed a number of cases of substantial tree mortality in glades during droughts which, while fairly severe, did not kill any trees in the adjacent forest. Though less obvious, mortality of tree seedlings in drought may be an even more important contributor to openness. It may take a series of unusually moist years to allow new trees to mature in these communities. Because of these dynamics, tree stands in these communities may be more even aged than typical natural forests, with most trees limited to one or a few cohorts.

Piedmont Acidic Glades, as small patches, would naturally be subject to fire whenever the surrounding forest burned. The irregular vegetation can be expected to lead to heterogeneous fire behavior, but vegetation is continuous enough that most parts would burn. Fire may be an important factor under natural conditions in structuring the vegetation, but some patches in the interior may rarely, perhaps never, burn. Some glades likely have developed heavier tree cover and perhaps become smaller because of fire suppression, but these communities are generally capable of staying open in the absence of fire.

As with all shallow-rooted trees, wind may cause more disturbance than in a typical deep forest soil, but trees rooted in crevices may be quite well anchored.

Comments: No published literature pertaining to Piedmont Acidic Glades has been identified, but the community is well documented in both plots and site descriptions. As with other glade and barrens communities, it can be difficult to confidently assign plots to them if the vegetation structure and substrate are not recorded in detail.

Quercus montana - Quercus stellata - Carya glabra / Vaccinium arboreum - Viburnum rufidulum Forest (CEGL004416) is a xeric forest association that in some parts of its description sounds similar to Piedmont Acidic Glade or to Xeric Piedmont Slope Woodland. It was apparently originally defined based on two CVS plots in the area of greatest development of both of these communities, and the data from the two plots suggest they are transitional between the two.

Rare species:
Vertebrate animals – *Crotalus horridus*

PIEDMONT BASIC GLADE (TYPIC SUBTYPE)

Concept: Piedmont Basic Glades are open, generally grassy, heterogeneous woodlands or savannas of shallow soils over irregular bedrock (not exfoliated granitic rocks), with flora suggesting higher pH and higher base saturation than typical. They are generally moderately to steeply sloping and on dry slope aspects. They have more vegetation cover, especially in the herb layer, than the sparsely vegetated cliff communities but are prevented from forming a closed forest by shallow soil and associated xeric conditions. Vegetation is generally patchy and open but often contains substantial tree cover as well as herb- or low-shrub-dominated areas. Open rock areas are limited.

The Typic Subtype covers all examples not fitting the distinctive characteristics of the Falls Dam Slope Subtype.

Distinguishing Features: All of the glade communities are distinguished from forest communities by having a persistently open tree canopy, ranging from woodland structure to sparser. The abundance of *Juniperus virginiana* in most examples is also not characteristic of forest communities. Glades are distinguished from Xeric Hardpan Forest by having less tree cover and having substantial shallow soil and bedrock. They are distinguished from Piedmont Cliff, Granitic Flatrock, and Low Elevation Rocky Summit communities by having soil with substantial herbaceous or shrub cover over most of the area, with limited area of bare rock. Plants characteristic of bare rock, such as *Phemeranthus (Talinum) teretifolius, Croton wildenowii (Crotonopsis elliptica), Selaginella rupestris*, and crustose lichens, may be present but are scarce and limited to the small areas of open rock outcrop.

Piedmont Basic Glades are distinguished from Piedmont Acidic Glades by having multiple species characteristic of circumneutral or basic sites. Multiple species characteristic of less acidic soils, such as *Fraxinus americana/biltmoreana, Cercis canadensis, Rhus aromatica, Myriopteris tomentosa*, and *Myriopteris lanosa* are present. Species such as *Chionanthus virginicus* and *Carya* spp. are typically more abundant.

The Typic Subtype constitutes all but one of the known examples. The Falls Dam Slope Subtype is distinguished from it by having lower herb cover, extensive ground cover by slate fragments, and evidence of substrate instability. A few examples of the Typic Subtype have slate or shale substrate and have some ground cover by rock fragments but it is less extensive.

Crosswalks: *Juniperus virginiana - Ulmus alata / Schizachyrium scoparium* Woodland (CEGL004443).
G180 Appalachian Mafic Barrens Group.
Southern Piedmont Glades and Barrens Ecological System (CES202.328).
Piedmont Mafic Cliff (in part), Piedmont Calcareous Cliff (in part) (3rd Approximation).

Sites: Piedmont Basic Glade (Typic Subtype) communities usually occur on moderate to steep slopes that face south or west, but they may occur on other aspects or may be flat. Bedrock is near the surface beneath most of the community, but shallow soil covers most of it. The geologic substrate is generally mafic igneous or metamorphic rocks such as basalt, meta-basalt, diabase, or gabbro. Less frequently, examples may occur on meta-mudstone or even on felsic rocks such as rhyolite or granite. The source of the basic character in those sites is not clear but may come from intrusions, xenoliths, or leaching of material from adjacent substrates.

Soils: Glade soils are shallow, with bedrock near the surface. The soil material includes rock fragments and early weathering products along with organic matter and washed-in material. These soils may consist of shallow mats or deep fill in crevices and are often extremely heterogeneous. Vegetation suggests relatively high pH and base saturation, but this is not well documented. Soils in glades generally are not distinguished in soil mapping but are treated as inclusions in other map units.

Hydrology: The shallow soils dry quickly between rains and are prone to extreme drought stress. There is a possibility of small seepage patches on the edges but this appears to be uncommon.

Vegetation: The vegetation of Piedmont Basic Glades is usually patchy and heterogeneous; it may range from an open woodland or savanna to nearly treeless. The herb layer is generally the dominant stratum, though a few examples may have limited herb cover and most have small openings with bare rock. *Schizachyrium scoparium* is most often dominant, but *Danthonia spicata, Danthonia sericea*, or less often *Piptochaetium avenaceum, Melica mutica*, or other species may dominate large patches. The most constant herbs in CVS plot data are *Asplenium platyneuron, Hieracium venosum, Dichanthelium dichotomum* var. *dichotomum*, *Dichanthelium depauperatum*, *Pleopeltis michauxiana* (*Polypodium polypodioides*), and in rocky areas, *Myriopteris tomentosa* and *Myriopteris lanosa*. Other herbs at least fairly frequent in CVS plot data or in site descriptions include *Commelina erecta* var. erecta*, Cunila origanoides, Tephrosia virginiana, Coreopsis verticillata, Micranthes virginiensis, Opuntia mesacantha* var. *mesacantha* (*humifusa*), *Hypericum gentianoides, Antennaria plantaginifolia, Ruellia carolinensis, Oxalis dillenii, Oxalis stricta, Lespedeza virginica, Linaria (Nuttallanthus) canadensis, Dichanthelium laxiflorum*, and *Andropogon gerardii*. The flora often includes small numbers of both species of rock outcrops, such as *Phemeranthus teretifolius* or *Croton willdenowii*, and ruderal species, such as *Ambrosia artemisiifolia*, *Conyza canadensis*, or *Phytolacca americana*. Other widespread species of open areas, such as *Solidago odora, Ionactis linariifolia, Parthenium integrifolium*, and *Scleria oligantha* may be present and may sometimes be abundant.

The open to sparse tree layer is usually dominated by *Juniperus virginiana. Quercus stellata, Carya glabra, Fraxinus biltmoreana/americana*, or *Quercus montana* may be codominant or occasionally dominant. Other frequent trees include *Ulmus alata, Pinus virginiana, Carya glabra, Carya tomentosa, Chionanthus virginicus, Acer leucoderme, Acer rubrum, Pinus echinata*, and *Ostrya virginiana*. Less frequent but characteristic tree species include *Quercus marilandica, Cercis canadensis, Diospyros virginiana, Carya cordiformis*, and *Acer floridanum*. Shrubs are generally sparse but may form denser patches. *Vaccinium arboreum* is the most frequent species, and *Rhus aromatica, Styrax grandifolia, Viburnum rufidulum, Celtis tenuifolia,* and many other species may be present. Vines may be abundant in parts, especially *Muscadinia rotundifolia*, but also *Gelsemium sempervirens, Toxicodendron radicans*, *Parthenocissus quinquefolius, Smilax bona-nox*, *Lonicera sempervirens*, and others.

Range and Abundance: Ranked G2. Examples are scattered through the Piedmont, excepting the foothills, but are most abundant in the Carolina Slate Belt geologic region. This community is also known in Virginia. It has not been reported in South Carolina but should be sought.

Associations and Patterns: Piedmont Basic Glades occur as small patches. They are surrounded by forest communities, usually Dry Basic Oak—Hickory Forest or Dry-Mesic Basic Oak—Hickory Forest. They may less often be associated with acidic communities such as Dry Oak—Hickory Forest.

Variation: The Typic Subtype appears to be variable among sites as well as very heterogeneous within sites. Variants have not been recognized but are likely with further study. Some of the known occurrences that may warrant distinct variants or even subtypes are those on slate slopes in Stanley and Anson counties and on Cedar Mountain in Rockingham County. Both show some of the slope instability that characterizes the Falls Dam Slope Subtype but do not seem to fit well with it.

Dynamics: Dynamics are likely to be similar to those in the Piedmont Acidic Glade and to glades and barrens in general. This includes potentially an important role for drought in keeping woody vegetation from becoming dense, and also an important role for fire.

Comments: The Typic Subtype is well documented in both plot data and site descriptions. As with other glade and barrens communities, it can be difficult to confidently assign plots to them if the vegetation structure and substrate are not recorded in detail. Though rare, these communities appear to be more numerous than the Piedmont Acidic Glades, despite the much greater abundance of acidic rocks. It is unclear why this is true.

The relationship of the two subtypes and of the variation associated with slate and shale substrates needs further investigation.

Rare species:
Vascular plants – *Anemone berlandieri, Baptisia aberrans, Baptisia alba, Borodinia missouriensis, Buchnera americana, Eurybia mirabilis, Gillenia stipulata, Helianthus laevigatus*, *Sedum glaucophyllum*, and *Solidago radula*.

PIEDMONT BASIC GLADE (FALLS DAM SLOPE SUBTYPE)

Concept: Piedmont Basic Glades are open, generally grassy, heterogeneous woodlands or savannas of shallow soils over irregular bedrock (not exfoliated granitic rocks), with flora suggesting higher pH and higher base saturation than typical. The Falls Dam Slope Subtype is a distinctive occurrence, apparently unique, with substantial *Pinus echinata* and with a high species richness that includes a number of plants of prairie affinities. The cause of the distinctive character of this subtype is believed to be related to a loose substrate of slate fragments as well as to fire.

Distinguishing Features: All the glade communities are distinguished from forest communities by having a persistently open tree canopy, ranging from woodland structure to sparser. Piedmont Basic Glades are distinguished from Piedmont Acidic Glades by having multiple species characteristic of higher pH, higher base status sites. Species characteristic of less acidic soils, such as *Cercis canadensis, Rhus aromatica, Fraxinus americana/biltmoreana, Myriopteris (Cheilanthes) tomentosa*, or *Aquilegia canadensis,* are present. Species such as *Chionanthus virginicus* and *Carya* spp. are usually abundant. The Falls Dam Slope Subtype is distinguished by having low herb cover, an unstable substrate of rock fragments, and evidence of slope instability. A few examples of the Typic Subtype have slate or shale substrate and have some ground cover by rock fragments, but it is less extensive.

Crosswalks: *Pinus echinata - Quercus stellata - Quercus marilandica / Andropogon gyrans - Chrysopsis mariana* Woodland (CEGL004447).
G180Appalachian Mafic Barrens Group.
Southern Piedmont Glades and Barrens Ecological System (CES202.328).

Sites: The only known example occurs on a steep-to-moderate, west-facing slope with a substrate of thin-bedded slate-like rock.

Soils: The soil is a very channery clay loam, with a large fraction of flat rock fragments. These fragments also cover most of the surface. There are frequent small outcrops of the thin-bedded rock. The soft and fragmented rock leads to an uncertain distinction between soil and bedrock.

Hydrology: This community is dry to xeric, given its west-facing slope aspect. Water likely drains rapidly through the rock fragments, but the high cover of flat rocks on the soil surface must reduce evaporation.

Vegetation: The vegetation is an open woodland or savanna dominated by *Quercus stellata, Pinus virginiana,* and *Pinus echinata,* with abundant *Quercus marilandica*. Other trees include *Carya tomentosa, Carya carolinae-septentrionalis,* and in canopy gaps, *Liquidambar styraciflua* and *Robinia pseudo-acacia*. Smaller numbers of *Cercis canadensis*, *Diospyros virginiana*, *Carya glabra, Fraxinus biltmoreana*, and other species are present. The shrub layer is open to sparse. *Vaccinium arboreum* is the most abundant species, but some *Rhus aromatica* and *Rhus copallinum* are present. The herb layer is patchy. Substantial areas are largely bare slate fragments, but patches of dense grass also occur. *Phaseolus polystachyos* is abundant in parts. A high diversity of other herbs is present, including *Schizachyrium scoparium, Andropogon gyrans, Solidago odora, Antennaria plantaginifolia*, *Clitoria mariana* var. *mariana*, *Dichanthelium depauperatum,* *Cirsium carolinianum, Helianthus divaricatus, Helianthus schweinitzii, Silene virginica, Andersonglossum* (*Cynoglossum*) *virginianum, Desmodium rotundifolium*, and numerous others.

Range and Abundance: Ranked G1? but appropriately G1. Only a single example is known and few, if any, more are likely to be found.

Associations and Patterns: This community occurs as a small patch. It is surrounded by Piedmont Monadnock Forest and Dry Oak–Hickory Forest.

Variation: The one known example is quite heterogeneous. It is difficult to tell how much of the variation is enduring and how much was caused by the variable behavior of recent fires. Heterogeneity could also be contributed by slumps of varying age.

Dynamics: Dynamics are not well known. The abundant flat rock fragments create an unstable substrate on the steep slope, and this is believed to be responsible for the distinctive character of the community. The abundance of *Pinus virginiana* is shared with Acidic Shale Slope Woodland, a community of more unstable substrates. The greater abundance of ruderal species, compared to the Typic Subtype, may also be related to this. Besides a tendency to slip, the numerous parallel rock fragments presumably are a barrier to root penetration and may favor some species while excluding others.

The site burned in the 1980s or early 1990s, and this fire created abundant canopy gaps. It is unclear how much the community may depend on fire in the long term. It is also difficult to tell which of its current characteristics are transient responses to the fire.

Comments: This community needs more work to clarify its relationship to other glades. Monitoring over time is also needed to describe its long-term character and dynamics.

Rare species:
Vascular plants – *Cirsium carolinianum* and *Helianthus schweinitzii*.

DIABASE GLADE

Diabase Glade is an extremely rare, naturally open, patchy glade community of flatrock-like pavement outcrops of mafic rock in the Piedmont mafic rock outcrops, containing a diverse herbaceous flora that combines species of granitic flatrocks and of mafic and ultramafic rock communities.

Distinguishing Features: The Diabase Glade type is distinguished from all other open glade and rock outcrop communities by having a flora that combines high abundance of rock outcrop species, including granitic flatrock species such as *Portulaca smallii*, *Cyperus granitophilus*, and *Isoetes piedmontana*, with a large number of obligate base-loving species such as *Ruellia humilis, Berberis canadensis, Symphoricarpos orbiculatus, Matelea decipiens, Lithospermum canescens* and *Clematis ochroleuca*. The prairie-like Xeric Hardpan Forest subtypes and other basic woodlands have little area with open rock and lack this component of the flora.

Crosswalks: *Sporobolus vaginiflorus var. ozarkanus - Diodia teres - Croton michauxii* var. *ellipticus - Ruellia humilis* Glade (CEGL004276).
G180 Appalachian Mafic Barrens Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: Diabase Glades occur on flat upland sites with mafic bedrock beneath a shallow soil and with small, patchy, flatrock-like outcrops. The rock in both of North Carolina's examples is diabase but one in South Carolina occurs on gabbro.

Soils: Soils are heterogeneous but generally shallow. Deeper pockets may exist in fractures or pits in the bedrock surface. The soil contains abundant fine gravel-size nodules of manganese, and these cover the surface of some of the open bedrock patches. The pH is circumneutral and base saturation is high.

Hydrology: Diabase Glades are xeric because of the shallow soil, but water may pool locally over the impermeable bedrock for brief periods after rains.

Vegetation: The vegetation is a fine-scale mosaic of scrubby tree patches, dense herbaceous patches, and moderate to sparse vegetation over rock. Woody patches are dominated by *Juniperus virginiana*, with *Quercus stellata, Ulmus alata,* or *Fraxinus biltmoreana* sometimes codominant. The most abundant shrubs include *Rhus aromatica, Symphoricarpos orbiculatus*, and *Rosa carolina*, but *Berberis canadensis* is sometimes present. Abundant herbs in the open areas include *Hexasepalum (Diodia) teres, Tragia urticifolia, Chamaecrista nictitans* var. *nictitans, Dichanthelium boscii, Dichanthelium sphaerocarpon, Euphorbia corollata/pubentissima, Helianthus divaricatus, Oenothera fruticosa* var. *fruticosa*, *Panicum dichotomiflorum* var. *dichotomiflorum*, *Verbena simplex, Lolium arundinaceum, Carex muhlenbergii* var. *muhlenbergii*, *Croton willdenowii, Galactia volubilis* var. *volubilis, Lespedeza repens, Polypremum procumbens,* and *Scleria pauciflora*. Species shared with Granitic Flatrock also include *Portulaca smallii, Cyperus granitophilus*, and *Isoetes piedmontana*. Species shared with Xeric Hardpan Forest (Northern Prairie Barren Subtype) also include *Liatris squarrulosa, Lithospermum canescens, Matelea decipiens, Packera paupercula* var *paupercula, Parthenium auriculatum, Ruellia humilis,* *Ruellia purshiana, Scutellaria nervosa, Symphyotrichum depauperatum,* and *Trichostema brachiatum*. Among the high diversity of additional herbaceous species are *Commelina virginica, Asclepias verticillata, Eragrostis spectabilis, Erigeron strigosus, Polygala verticillata, Rhynchosia tomentosa, Scleria ciliata, Stylosanthes biflora, Sisyrinchium angustifolium, Symphyotrichum pilosum*, *Symphyotrichum undulatum, Scleria oligantha*, *Scutellaria integrifolia*, *Andropogon ternarius*, and *Agave* (*Manfreda*) *virginica*.

Range and Abundance: Ranked G1. North Carolina has only two known examples, both near the town of Butner in Granville County. One occurrence is known in South Carolina, close to Mecklenburg County.

Associations and Patterns: Diabase Glades are associated with forest communities of mafic rock areas, including Xeric Hardpan Forest and Dry Basic Oak—Hickory Forest.

Variation: The few known occurrences are locally heterogeneous on a fine scale.

Dynamics: Diabase Glades are maintained primarily by shallow soil. As in other glade communities, drought may be important in maintaining the open vegetation in the long term by killing established trees as well as limiting seedling establishment. The importance of fire is uncertain. Some component species are shared with frequently burned communities but at least a few are not. The irregular and heterogeneous vegetation would not carry fire well, but edges and denser vegetation patches could burn. Given the stressful site, even infrequent or mild fire may have significant effects.

Comments: Much of the area of the Diabase Glades is in shrub and tree patches. The NVC write-up for this association suggests that a separate association (*Juniperus virginiana - Ulmus alata - Fraxinus americana - Carya glabra* Forest) was intended for the woody component, but that association was not added to the NVC. Given the close association and complex intermixture of herbaceous and woody patches in the few known examples, no subdivision seems necessary.

Rare species:
Vascular plants – *Berberis canadensis, Cyperus granitophilus, Eleocharis compressa* var. *compressa, Dichanthelium bicknellii, Isoetes piedmontana, Liatris squarrulosa, Lithospermum canescens, Nabalus albus, Packera paupercula* var *paupercula, Panicum flexile, Parthenium auriculatum, Phemeranthus piedmontanus, Portulaca smallii, Ruellia ciliosa, Ruellia humilis, Ruellia purshiana, Scutellaria leonardii, Symphyotrichum depauperatum,* and *Trichostema brachiatum*.

XERIC HARDPAN FOREST (BASIC HARDPAN SUBTYPE)

Concept: Xeric Hardpan Forests are woodlands with open vegetation influenced by restricted rooting caused by dense or shrink-swell clay. Surface or shallow rock may be present but is limited in extent and is not the primary cause of openness. The vegetation is an open woodland or savanna dominated by *Quercus stellata*, with or without *Pinus echinata, Quercus marilandica,* or *Carya carolinae-septentrionalis*. It may contain other drought-tolerant species but has little *Quercus alba* or more mesophytic tree presence. The vegetation and flora of these communities indicates a drier environment than that of Dry Oak–Hickory Forest and the trees are often somewhat stunted. Canopy density is less than in dry forests and depends more on fire and disturbance history.

The Basic Hardpan Subtype covers examples on upland flats developed over mafic rocks, where acid-loving flora such as *Vaccinium* is absent or scarce and some basic indicator species are present.

Distinguishing Features: Xeric Hardpan Forests are distinguished from Dry Oak–Hickory Forest and Dry Basic Oak–Hickory Forest by having a canopy of more xerophytic composition, with *Quercus stellata* dominant or codominant. *Pinus echinata, Carya carolinae-septentrionalis*, or *Quercus marilandica* may codominate, but *Quercus alba* and more mesophytic oaks are scarce or absent. Fire-suppressed, degraded examples of Piedmont Longleaf Pine Forest may be dominated by *Quercus stellata* and other xerophytic species, but they will not occur on flat hardpan soils or rocky mafic ridges, will generally have evidence of the past presence of *Pinus palustris* and its associates, and will have a flora with more Coastal Plain affinities. Xeric Hardpan Forests are distinguished from Montane Red Cedar–Hardwood Woodland and other rock-outcrop-related woodlands by clayey soils and the absence of characteristic rock outcrop flora. Piedmont Basic Glades may share some species but are associated with shallow soils and rock.

The Basic Hardpan Subtype is distinguished from the Northern and Southern Prairie Barren Subtypes by a more limited component of the characteristic flora of prairie affinities (see the Prairie Barren Subtype for this flora), though widespread prairie species such as *Schizachyrium scoparium* should be present. Given the pervasive alteration of these communities, location and flora evident in nearby open areas may need to be used as a guide. Both Prairie Barren subtypes have a narrow geographic range and are associated with a large number of rare species in roadsides, corridors, and pastures. The Basic Hardpan Subtype is distinguished from the Basic Rocky Subtype by occurrence on broad upland flats, generally without rock outcrops, rather than on bouldery ridge tops or steep slopes. No plants are known to be exclusive to the Basic Rocky Subtype, but *Carya carolinae-septentrionalis* and *Acer leucoderme* generally are much more abundant there. No frequent species are known to be exclusive to the Basic Hardpan Subtype, though *Clematis ochroleuca* may be primarily in it. *Quercus phellos* or other species typical of wetter conditions are generally present in small numbers in the Basic Hardpan Subtype.

The Basic Hardpan Subtype is distinguished from the Acidic Hardpan Subtype by a flora indicative of soils with higher pH and higher base abundance. Acid-loving flora such as *Chimaphila maculata, Vaccinium* species (other than *V. arboreum* and some *V. stamineum*), *Gaylussacia* spp., and *Oxydendrum arboreum* are absent or scarce. More base-loving flora such as *Clematis* *ochroleuca, Viburnum* spp., *Symphoricarpos orbiculatus, Rhus aromatica, Cercis canadensis, Fraxinus americana/biltmoreana*, and *Ulmus alata* are usually common.

Crosswalks: *Quercus stellata – Quercus marilandica - Carya (carolinae-septentrionalis, glabra)/ Schizachyrium scoparium* Woodland (CEGL003714).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: Xeric Hardpan Forest (Basic Hardpan Subtype) occurs on broad upland ridgetops or flats underlain by diabase, gabbro, amphibolite, or other mafic rocks. The sites are often unusually flat, with more subdued topography than typical Piedmont uplands. Such flat areas are commonly associated with mafic rocks.

Soils: Soils of the Basic Hardpan Subtype are generally mapped as Alfisols. Iredell (Vertic Hapludalf) is the most commonly mapped. Picture (Vertic Argiaquoll), a more recently defined series, might be applied to more if sites were reexamined. Some examples are mapped as Enon (Ultic Hapludalf), a few as Helena (Aquic Hapludult) or other Ultisols. These soils have montmorillonite as the primary clay mineral; the vertic properties of these soils, shrinking and swelling in response to changing water content, is an important characteristic even though no true Vertisols have been identified in North Carolina. Damage to fine roots combines with impermeability of the clay pan to restrict rooting depth and create xeric conditions for plants.

Hydrology: Xeric Hardpan Forests are xerohydric but with a predominance of xeric conditions. The soils are effectively drier than is typical in the driest Piedmont topography because of restricted water penetration. However, they may perch water and even pond water locally after heavy rains.

Vegetation: The vegetation in the least altered remaining examples is an open forest or woodland dominated by *Quercus stellata*, often with *Pinus echinata*, *Carya carolinae-septentrionalis, Carya glabra,* or *Ulmus alata* abundant. *Quercus marilandica* may be present. *Quercus alba* and *Carya tomentosa* may be present in small amounts. In more altered examples, *Pinus virginiana, Pinus taeda*, or other species may be abundant. Under more natural conditions, *Quercus stellata*, *Pinus echinata*, and *Quercus marilandica* are likely to be more dominant, the other species less so. The understory often is dominated by *Juniperus virginiana* or *Ulmus alata*, and often contains *Diospyros virginiana, Cercis canadensis, Chionanthus virginicus,* and *Benthamidia* (*Cornus*) *florida*. The shrub layer consists primarily of tree saplings, but may include abundant *Viburnum prunifolium*, *Rhus aromatica, Rosa carolina,* or *Symphoricarpos orbiculatus*. Vines, including *Parthenocissus quinquefolia, Smilax bona-nox, Smilax rotundifolia, Toxicodendron radicans*, and *Muscadinia rotundifolia* are frequent though not usually dense. Under more natural conditions, these lower woody strata would be sparse, though the same species might be present. The herb layer generally is sparse to moderate in density in known examples. *Danthonia spicata* is the most frequent species, and *Piptochaetium avenaceum* or *Scleria oligantha* sometimes dominate patches, but *Schizachyrium scoparium* might dominate with more frequent fire. Frequent herbs in CVS plot data include *Dichanthelium boscii, Galium circaezans, Asplenium platyneuron, Dichanthelium laxiflorum*, and *Endodeca serpentaria*. Also fairly frequent are *Galium pilosum, Antennaria plantaginea, Potentilla canadensis, Polygonatum biflorum, Ruellia carolinensis,* and

Scutellaria integrifolia. Less frequent but characteristic species in plot data or noted in literature (Batson 1952, Oosting 1942, Peet and Christensen 1980) and site reports include *Clematis ochroleuca, Sericocarpus linifolius, Coreopsis major, Lespedeza virginica, Physalis virginiana, Agave* (*Manfreda*) *virginica, Symphyotrichum undulatum, Symphyotrichum dumosum, Stylosanthes biflora, Pycnanthemum tenuifolium, Desmodium paniculatum, Parthenium integrifolium, Oenothera fruticosa, Tragia urticifolia*, *Ruellia purshiana*, and a number of species of *Carex*. Under more natural conditions of frequent fire and more open canopy, the herb layer is expected to be dense and more diverse. *Schizachyrium scoparium* is likely to be dominant or codominant. Though rarely found now, many of the suite of fire-tolerant herbs of open woodland might also be present, including *Solidago odora, Tephrosia virginiana, Baptisia tinctoria, Liatris squarrosa, Lespedeza procumbens, Andropogon gerardii, Sorghastrum nutans, Pityopsis graminifolia, Ionactis linariifolia, Sericocarpus asteroides,* and *Hypoxis hirsuta*.

Range and Abundance: Ranked G2G3. This community is scattered throughout the lower and middle Piedmont of North Carolina. It ranges from Virginia to Georgia.

Associations and Patterns: All remaining occurrences are small patches but some may originally have been large patches. They are usually naturally associated with Dry Basic Oak–Hickory Forest and often with Upland Depression Swamp Forest. Piedmont Headwater Stream Forest (Hardpan Subtype) bands may form or run through them.

Variation: No variants are defined. The variants recognized in the 3rd Approximation are now treated as subtypes.

Dynamics: Dynamics are similar to most of the Piedmont barrens. Open canopy structure is maintained by dry soil conditions, but the natural fire regime would produce a much more open canopy and understory than is seen at present. Because these communities occur as small to large patches, fires would primarily spread from the surrounding landscape, so fire frequency must largely match that of the prevailing oak forests. However, because of the extreme site conditions, the effects of this fire frequency would be greater and would maintain a more open woodland structure. With a denser grass-dominated herb layer, burning would be more complete and fire somewhat more intense than in the current hardwood litter. Fires would probably not be hot enough to harm mature oak or pine trees but would top-kill seedlings and saplings. Most sensitive plant species would be excluded. The existence of old oaks and pines in some remaining sites suggests that these communities existed as open savannas or woodlands rather than as treeless prairies, though later clearing and increased fire frequency after settlement may have left some treeless. See additional discussion under the Northern and Southern Prairie Barren subtypes and in the theme description.

Under natural conditions of open canopy and frequent fire, tree regeneration would be less dependent on canopy gaps and more on favorable fire intervals than in the present forests or in the surrounding oak-hickory forests.

Historical references (e.g., Logan 1859) describe extensive prairies and open, grassy woodlands in the vicinity of Rock Hill, South Carolina, where Iredell soils are common. They note that such areas had later grown up in blackjack. That area likely represented the Southern Prairie Barren Subtype but some may have been the Basic Hardpan Subtype.

Comments: Though Xeric Hardpan Forests make up only a small portion of the landscape in most parts of the Piedmont, their distinct vegetation and its relationship to dense clay soils, restricted rooting depth, mafic rocks, and the Iredell soil series has long been recognized. Oosting (1942) called them preclimax forests, maintained indefinitely in less than climax condition by the extreme soils. Peet and Christensen (1980) found what they called montmorillonite forests to be a distinctive vegetation group, separating from oak-hickory forest communities at the highest level of their progressive ordinations. Dayton's (1965) study of vegetation of Iredell soils in Granville County likely included both the Basic Hardpan Subtype and Northern Prairie Barren Subtype. The same vegetation is described as distinctive in Wharton (1977) in Georgia.

While early descriptions are recognizable as the Xeric Hardpan Forests we see today, these descriptions hint at continued change in vegetation with the removal of fire, even in recent decades. *Quercus marilandica* is usually mentioned prominently, often described as abundant and sometimes used in the naming of the vegetation. Present examples often have none and never have much of this species. *Symphyotrichum dumosum* was frequently mentioned, yet only 2 out of 48 plots of this community in three states have any of it. *Oenothera fruticosa, Sericocarpus linifolius*, *Stylosanthes biflora*, and species of *Liatris* are additional species that are mentioned as characteristic by Oosting (1942) and other earlier studies, but which have very low frequency in recent plot data and site descriptions alike.

The relationship between the Basic Hardpan Subtype and the Northern and Southern Prairie Barren subtypes needs further clarification. All occur on similar flat montmorillonitic hardpan soils and all can look similar in altered remnants. The two Prairie Barren subtypes are recognized for the two areas where hardpan soils are extensive and where remaining open areas have a much more diverse flora of prairie affinities. The distinction is presumed to be a biogeographic one – the large areas have an extensive pool of species of open woodlands or prairies while naturally small patches have a limited pool. However, it is unclear how many species of open conditions may have been lost in small patches as they became dense. There likely was a difference in dynamic processes as well. Large areas of Xeric Hardpan Forest likely increased fire frequency and intensity to some degree, and this could contribute to the more diverse prairie flora and perhaps to more open vegetation.

Rare species:
Vascular plants – *Acmispon helleri, Baptisia aberrans, Baptisia alba, Berberis canadensis, Desmodium ochroleucum, Echinacea laevigata, Helianthus laevigatus, Helianthus schweinitzii, Lithospermum canescens, Rhus michauxii,* and *Symphyotrichum georgianum*.

XERIC HARDPAN FOREST (NORTHERN PRAIRIE BARREN SUBTYPE)

Concept: Xeric Hardpan Forests are woodlands with open vegetation influenced by restricted rooting caused by dense or shrink-swell clay. The Northern Prairie Barren Subtype covers examples on mafic rock-derived soils in the Durham Triassic basin and adjacent areas, which contain a diverse and distinctive herbaceous flora of prairie affinities. They generally have a higher species richness than the Basic Hardpan Subtype. The suite of prairie herbs is different for this region than for the range of the Southern Prairie Barren Subtype, apparently for biogeographic reasons.

Distinguishing Features: The Northern Prairie Barren Subtype is distinguished from the closely related Southern Prairie Barren Subtype by a suite of different species. Species characteristic of the Northern and absent in the Southern include *Echinacea laevigata, Solidago ptarmicoides*, *Lithospermum canescens*, and *Baptisia aberrans*. Species characteristic of the Southern and absent in the Northern include *Symphyotrichum georgianum*, and *Helianthus schweinitzii*. Both subtypes are distinguished from the closely related Basic Hardpan Subtype and from all other subtypes by the presence of a substantial flora of prairie affinities, beyond widespread species such as *Schizachyrium scoparium*. *Silphium terebinthinaceum, Cirsium carolinianum, Elymus canadensis, Eryngium yuccifolium, Liatris squarrosa, Parthenium auriculatum, Parthenium integrifolium, Tragia urticifolia*, and *Sorghastrum nutans* are typical of both Prairie Barren subtypes and not the other subtypes.

Crosswalks: *Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Echinacea laevigata - Oligoneuron album* Woodland (CEGL003558).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).
Diabase Barren (common usage).

Sites: The Northern Prairie Barren Subtype occurs on broad upland ridgetops or flats underlain by the large diabase sills northeast of the city of Durham.

Soils: Most areas of the Northern Prairie Barren Subtype are mapped as Iredell (Vertic Hapludalf). The more recently defined Picture series (Vertic Argiaquoll) might be applied more widely if the areas are reexamined. As in all the Xeric Hardpan Forests, montmorillonite is the primary clay mineral and vertic properties are believed to be important in creating a stressful environment for woody plants.

Hydrology: Xeric Hardpan Forests are xerohydric but with a predominance of xeric conditions. The soils are drier than is typical in the driest Piedmont sites because of restricted water penetration. However, they may perch water and even pond water locally after heavy rains.

Vegetation: All remaining examples are now heavily altered, but the natural vegetation of this subtype presumably was a savanna or open woodland with a dense grassy herb layer. Treeless patches may have been present but this is unclear. The canopy likely was dominated by *Quercus stellata*, with *Pinus echinata* and possibly *Quercus marilandica* abundant or codominant. Other trees such as *Carya carolinae-septentrionalis, Carya tomentosa, Carya glabra*, *Ulmus alata*, or

Fraxinus biltmoreana may have been present in smaller numbers, perhaps in groves. In remnants, these species and others such as *Quercus alba* and *Pinus taeda* may be abundant. The understory presumably was sparse in frequently burned examples but is often fairly dense in remnants. Besides the canopy species, *Juniperus virginiana, Cercis canadensis, Diospyros virginiana,* or *Acer floridanum* may be abundant, and less characteristic species such as *Prunus serotina* or *Liquidambar styraciflua* may have become abundant. Shrubs in remnants and probably characteristic of natural examples include *Rosa carolina*, *Ceanothus americanus*, *Celtis tenuifolia*, and *Rhus aromatica*. The more ruderal *Rhus copallinum* is common in remnants and may also have been present in natural examples. The herb layer is generally dense where tree cover is not heavy. Under a more natural fire regime, it would presumably be very dense and diverse. *Schizachyrium scoparium* probably dominated under such conditions, and *Sorghastrum nutans* may have been abundant. However, these species are not usually strongly dominant in remnants, so this is somewhat uncertain. Herbs found in remnants that likely are characteristic of the natural community include *Danthonia spicata, Scleria oligantha, Silphium terebinthinaceum, Echinacea laevigata, Baptisia aberrans, Parthenium auriculatum, Parthenium integrifolium, Lespedeza virginica, Lespedeza hirta, Ruellia carolinensis, Ruellia humilis, Dichanthelium laxiflorum, Andropogon gyrans, Clematis ochroleuca, Oenothera fruticosa* var. *fruticosa, Scutellaria integrifolia, Scutellaria leonardii, Tragia urticifolia, Silphium asteriscus* var. *asteriscus*, and the additional rare species listed below. Species that appear more ruderal, such as *Apocynum cannabinum* and *Salvia lyrata,* are often abundant now and may or may not have been part of the more natural condition.

Range and Abundance: Ranked G1. The subtype appears to be a narrow endemic community confined to the extensive diabase sill area in Durham and Granville counties. No pristine examples remain, though remnants altered to varying degrees are present in this area. The association may conceivably have occurred in nearby Virginia and a newly discovered large hardpan area there may be related to this subtype.

Associations and Patterns: This subtype once occurred as a large patch community within its range. It grades to Dry Basic Oak–Hickory Forest, possibly to Upland Depression Swamp Forest. Piedmont Headwater Stream Forest (Hardpan Subtype) bands may form or run through it.

Variation: Nothing is known of natural variation, but vegetation may have varied along a moisture gradient.

Dynamics: Because the few remaining examples are so heavily altered, natural dynamics are particularly hard to discern. Walker (2009) found almost exclusively ruderal species in the soil seed bank, suggesting dominant herbs persist as long-lived individuals rather than in a seed bank. However, recent canopy thinning and burning resulted in a flush of *Scleria*, presumably *oligantha*, one of the characteristic herbs.

Dynamics presumably are similar to most of the Piedmont barrens but may be more extreme. Somewhat open canopy structure is maintained by dry soil conditions, but the natural fire regime would produce a much more open canopy and understory than is seen at present. Because this subtype occurred as larger patches than the Basic or Acidic Hardpan subtypes, with larger area of continuous grass cover, fires may have been more intense and somewhat more frequent. However, most ignitions likely still spread from the surrounding landscape rather than originating within the community. Thus, as with other Xeric Hardpan Forests, fire frequency was presumably similar to that of oak-hickory forests, with the open structure coming from greater fire effects and more hostile conditions for tree seedling establishment.. Most areas of this subtype likely were savannas rather than treeless prairie but trees may have been less dense than in most other subtypes and treeless areas may have been larger under natural conditions.

Lori Sigmon-Chatham's (2015) dendrochronology study at the largest remnant of this subtype shows a dramatic shift in tree regeneration that corresponds with a change in land ownership and can only be due to fire suppression. *Pinus taeda* and *Quercus alba* all date to after this time. The older *Pinus echinata* and *Quercus stellata* remained but these species almost completely stopped reproducing at the same time.

The warmer, drier Hypsithermal period several thousand years ago may have created more open vegetation across larger parts of the Piedmont. However, the distinctive soils that create Xeric Hardpan Forest were not more widespread. If the characteristic species of the Northern Prairie Barren Subtype once ranged widely, their current rarity and absence in open areas beyond its current range suggest they became restricted long ago. Their survival in the area of this subtype may be due to the larger size of the community patches and their ability to support larger populations. The floristic differences between the Northern Prairie Barren and Southern Prairie Barren subtypes suggests a long separation.

Comments: This subtype is conceived as a richer community than the more widely scattered Basic Hardpan Subtype, probably associated with a center of diversity where hardpans were more extensive. A similar large expanse of habitat on the gabbros of Mecklenburg County and adjacent South Carolina has a diverse but somewhat different flora. It is treated as the Southern Prairie Barren Subtype. This needs further investigation, but study is difficult because of the altered condition of all remnants.

Rare species:
Vascular plants – *Acmispon helleri, Agastache nepetoides, Asclepias purpurascens, Baptisia aberrans, Berberis canadensis, Callitriche terrestris, Carex meadii, Delphinium exaltatum, Dichanthelium annulum, Echinacea laevigata, Fleischmannia incarnata, Liatris squarrulosa, Linum sulcatum, Lithospermum canescens, Marshallia legrandii, Oligoneuron album* (*Solidago ptarmicoides*), *Oligoneuron* (*Solidago*) *jacksonii, Packera paupercula* var. *paupercula, Panicum flexile, Panicum philadelphicum* ssp. *lithophilum, Parthenium auriculatum, Prunus susquehanae, Pseudognaphalium helleri, Rhus michauxii, Ruellia humilis, Scirpus pendulus, Scutellaria leonardii, Silphium terebinthinaceum, Symphyotrichum concinnum, Symphyotrichum depauperatum,* and *Trifolium reflexum*.

Invertebrate Animals – *Neonympha helicta* and *Bombus affinis.*

XERIC HARDPAN FOREST (SOUTHERN PRAIRIE BARREN SUBTYPE)

Concept: Xeric Hardpan Forests are woodlands with open vegetation influenced by restricted rooting caused by dense or shrink-swell clay. The Southern Prairie Barren Subtype covers examples on gabbro-derived soils in the area of Mecklenburg County and adjacent South Carolina, which contain a diverse and distinctive herbaceous flora of prairie affinities. No well-developed remnants are known in North Carolina but flora in the area suggests they were once locally extensive. They generally have a higher species richness than the Basic Hardpan Subtype. The suite of prairie herbs is different for this region than for the range of the Northern Prairie Barren Subtype, apparently for biogeographic reasons.

Distinguishing Features: The Southern Prairie Barren Subtype is distinguished from the closely related Northern Prairie Barren Subtype by a suite of different species. Species characteristic of the Northern and absent in the Southern include *Solidago ptarmicoides*, *Lithospermum canescens*, *Baptisia aberrans*, and in all but a couple remnants, *Echinacea laevigata,* Species characteristic of the Southern and absent in the Northern include *Symphyotrichum georgianum* and *Helianthus schweinitzii*. Both subtypes are distinguished from the closely related Basic Hardpan Subtype and from all other subtypes by the presence of a substantial flora of prairie affinities, beyond widespread species such as *Schizachyrium scoparium*. *Silphium terebinthinaceum, Cirsium carolinianum, Elymus canadensis, Eryngium yuccifolium, Liatris squarrosa, Parthenium auriculatum, Parthenium integrifolium, Tragia urens*, and *Sorghastrum nutans* are typical of both Prairie Barren subtypes and not the other subtypes.

Crosswalks: *Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Symphyotrichum georgianum* Woodland (CEGL003711).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: The Southern Prairie Barren Subtype occurs on broad upland ridgetops or flats underlain by large gabbro plutons.

Soils: Soils are generally mapped as Iredell (Vertic Hapludalf). It is unclear if further investigation might recognize the Picture series (Vertic Argiaquoll), more recently defined in the Durham area. As in all the Xeric Hardpan Forests, montmorillonite is the primary clay mineral and vertic properties are believed to be important in creating a stressful environment for woody plants.

Hydrology: As in other Xeric Hardpan Forests, sites are effectively drier than is typical in the driest Piedmont sites because of restricted water penetration.

Vegetation: All remaining examples are now heavily altered, but the natural vegetation of this subtype presumably was a savanna or open woodland with a dense grassy herb layer. Treeless patches may have been present and possibly were extensive. The canopy likely was dominated by *Quercus stellata*, with *Pinus echinata* and *Quercus marilandica* abundant or codominant. Other trees such as *Carya tomentosa, Carya glabra*, *Ulmus alata*, or *Fraxinus biltmoreana* may have been present in smaller numbers, perhaps in groves. In remnants, these species and others such as *Pinus taeda* or *Liquidambar styraciflua* may have become abundant. The understory presumably was sparse in frequently burned examples but is often fairly dense in remnants. Besides the canopy species, *Juniperus virginiana, Diospyros virginiana*, or *Cercis canadensis* may be abundant, and less characteristic species such as *Prunus serotina* or *Liquidambar styraciflua* may be present. Shrubs in remnants and probably characteristic of natural examples include *Rosa carolina*, *Celtis tenuifolia*, and *Rhus aromatica*. *Rhus copallinum* may also have been characteristic. The herb layer would presumably have been very dense and diverse under a more natural fire regime. *Schizachyrium scoparium* probably dominated under such conditions, and *Sorghastrum nutans* may have been abundant. However, these species are not frequent or dominant in remnants, so this is uncertain. Herbs found in remnants and probably characteristic of natural conditions include *Silphium terebinthinaceum, Oenothera fruticosa* var. *fruticosa*, *Penstemon laevigatus, Ruellia humilis, Asclepias verticillata, Scutellaria integrifolia, Dichanthelium laxiflorum, Danthonia spicata, Piptochaetium avenaceum, Rudbeckia fulgida, Solidago ptarmicoides, Liatris aspera, Agave* (*Manfreda*) *virginica, Pycnanthemum tenuifolium, Scleria oligantha*, and *Symphyotrichum dumosum*. Species with more ruderal ecology, such as *Mecardonia acuminata, Setaria parviflora, Paspalum laeve,* and *Eupatorium hyssopifolium,* present in remnants now, may or may not have been part of more natural composition.

Range and Abundance: Ranked G1. This community is believed to be a narrow endemic community that ranged through the large gabbro plutons in Mecklenburg County and adjacent South Carolina. Only degraded remnants are known in North Carolina. The altered but more intact Rock Hill Blackjacks Preserve in South Carolina is the only known well-developed example remaining.

Associations and Patterns: This subtype once occurred as a large patch community within its range. It grades to Dry Basic Oak–Hickory Forest, possibly to Upland Depression Swamp Forest. Piedmont Headwater Stream Forest (Hardpan Subtype) bands may form or run through it.

Variation: Nothing is known of natural variation, but vegetation may have varied along a moisture gradient.

Dynamics: As in the Northern Prairie Barren Subtype, dynamics are similar to the other Xeric Hardpan Forests but may be more extreme. Open canopy structure is maintained by dry soil conditions, but the natural fire regime would produce a much more open canopy and understory than is seen at present. Because this subtype occurred as larger patches than the Basic or Acidic Hardpan subtypes, with a larger area of continuous grass cover, fires may have been more intense and somewhat more frequent. However, most ignitions likely still spread from the surrounding landscape rather than originating within the community. Thus, as with other Xeric Hardpan Forests, fire frequency was presumably similar to that of oak-hickory forests. The open character came primarily from greater fire effects and the difficulty of tree seedling establishment.

Additional dynamic issues discussed for the Northern Prairie Barren Subtype and in theme description also apply to this subtype.

Comments: This subtype is analogous to the Northern Prairie Barren Subtype. It is conceived as a richer community than the more widely scattered Basic Hardpan Subtype, probably associated with a center of diversity where hardpans were more extensive. The Northern Prairie Barren Subtype has a diverse but somewhat different flora.

This subtype is probably the largest of the historic prairie areas discussed by Barden (1997), though it is unclear if the reported extensive lack of trees was the natural state or the result of clearing in the recent past. Historical references (e.g., Logan 1859) describe extensive prairies and open, grassy woodlands in the vicinity of Rock Hill, South Carolina, where Iredell soils are extensive. They note that such areas had later grown up in blackjack.

Rare species:
Vascular plants – *Acmispon helleri, Anemone berlandieri, Cirsium carolinianum, Delphinium exaltatum, Desmodium sessilifolium, Dichanthelium annulum, Echinacea laevigata, Echinacea pallida, Helianthus schweinitzii, Mnesithea* (*Manisurus*) *cylindrica, Parthenium auriculatum, Pseudognaphalium helleri, Rhus michauxii, Silphium terebinthinaceum, Symphyotrichum georgianum,* and *Thermopsis mollis*.

Animals – *Bombus affinis*.

XERIC HARDPAN FOREST (ACIDIC HARDPAN SUBTYPE)

Concept: Xeric Hardpan Forests are woodlands with open vegetation related to restricted rooting caused by dense or shrink-swell clay. The Acidic Hardpan Subtype covers Xeric Hardpan Forests on acidic clays, having an exclusively acid-tolerant flora.

Distinguishing Features: The Acidic Hardpan Subtype can be distinguished from all other subtypes by the substantial presence of acid-tolerant flora, with species such as *Vaccinium tenellum, Vaccinium pallidum, Gaylussacia* spp., *Oxydendrum arboreum*, and *Chimaphila maculata* abundant. The strongest basic indicators, such as *Symphoricarpos orbiculatus, Rhus aromatica, Clematis ochroleuca*, and the prairie species are absent, and weaker indicators such as *Cercis canadensis* and *Ulmus alata* are much less common. *Quercus falcata* may be abundant.

Crosswalks: *Quercus stellata - (Quercus marilandica) / Gaylussacia frondosa* Acidic Hardpan Woodland (CEGL004413).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: The Acidic Hardpan Subtype occurs on broad upland ridges or flats underlain by clay-rich shale or slate. The properties of the rock that lead to development of hardpan conditions in a few places and not more widely on similar rocks are not clear.

Soils: The most frequently mapped soils are Misenheimer (Aquic Dystrudept) and Zion (Typic Hapludalf). Lignum (Aquic Hapludult) is mapped less often, and a variety of other series are mapped in single examples. The soils are not characterized as montmorillonitic as those in the previous Xeric Hardpan Forests are. An argillic horizon seems to be responsible for the shallow rooting depth and xeric conditions for plants.

Hydrology: Soils are normally xeric due to limited water penetration; however, they may be poorly drained and even pond some water during wet periods.

Vegetation: The vegetation in the least altered remaining examples is an open forest or woodland dominated by *Quercus stellata*, often with *Quercus marilandica* or *Pinus echinata* codominant. *Quercus falcata, Carya carolinae-septentrionalis*, or other *Carya* species are often present. *Quercus phellos* is often present in small numbers. Other species, such as *Quercus alba, Quercus coccinea, Pinus virginiana*, and *Liquidambar styraciflua,* may be present but probably are not characteristic of natural conditions. The understory likely was sparse under natural conditions but often is dense now. Common species are *Juniperus virginiana, Nyssa sylvatica, Acer rubrum, Diospyros virginiana*, and *Oxydendrum arboreum*. Shrubs are patchy but generally abundant. *Vaccinium tenellum* is most frequent but *Vaccinium stamineum, Gaylussacia frondosa, Gaylussacia dumosa*, or *Vaccinium pallidum* may dominate in individual examples. Other species that may be present include *Vaccinium corymbosum, Vaccinium fuscatum*, *Vaccinium arboreum*, and occasionally *Lyonia ligustrina* or *Lyonia mariana*. The herb layer generally is sparse to moderate in density in present remnant examples. *Danthonia spicata* or *Danthonia sericea* usually is one of the most abundant herbs. *Cladonia* sp., *Schizachyrium scoparium, Tephrosia virginiana, Coreopsis major, Dichanthelium* spp., and *Andropogon virginicus* are often noted. Less frequently noted species that likely are characteristic include *Scleria oligantha, Liatris pilosa, Chimaphila maculata, Pycnanthemum tenuifolium, Houstonia tenuifolia, Solidago odora, Sorghastrum nutans*, and *Symphyotrichum dumosum*. Under a more natural fire regime and more open canopy, the herb layer likely was dense and more diverse. *Schizachyrium scoparium* most likely dominated, but since it is scarce in remnants, this is unclear. Species found on roadsides near remnants give a hint of the diversity that might be present in natural examples. Such species include *Acmispon helleri, Agalinis tenuifolia, Andropogon ternarius, Arnica acaulis, Aristida oligantha, Aristida purpurascens, Carex complanata, Euphorbia curtisii, Helianthus divaricatus, Helianthus schweinitzii, Marshallia obovata, Muhlenbergia capillaris, Oenothera fruticosa* var. *fruticosa, Pityopsis aspera, Sericocarpus linifolius, Sporobolus junceus, Stylosanthes biflora, Symphyotrichum concolor*, *Symphyotrichum patens*, and a number of others.

Range and Abundance: Ranked G2. Examples are scattered through the central Piedmont, largely confined to the Carolina Slate Belt geologic region. They seem to have been rarer than the Basic Hardpan Subtype. The only known large concentration occurred in the vicinity of Gold Hill in Rowan and Stanley counties. The Acidic Hardpan Subtype appears to be endemic to North Carolina.

Associations and Patterns: Occurrences are usually small patches, with the Gold Hill area having large patches. The Acidic Hardpan Subtype is often associated with Upland Depression Swamp Forest and Dry Oak–Hickory Forest of the Hardpan Variant.

Variation: Variation is not well known. No variants are recognized.

Dynamics: Dynamics are believed to be similar to those in the Basic Hardpan Subtype and other subtypes. Open canopy structure is maintained by dry soil conditions, but the natural fire regime would produce a much more open canopy and understory than is seen at present. Because these communities occur as small-to-large patches, fires would primarily spread from the surrounding landscape, so fire frequency must largely match that of the prevailing oak forests. However, because of the extreme site conditions, the effects of this fire frequency would be greater and would maintain a more open woodland structure. With a denser grass-dominated herb layer, burning would be more complete and fire somewhat more intense than in the current hardwood litter. Fires would probably not be hot enough to harm mature oak or pine trees but would top-kill seedlings and saplings. Most fire sensitive plant species would be excluded. The existence of old oaks and pines in some remaining sites suggests that these communities existed as open savannas or woodlands rather than as treeless prairies, though later clearing and increased fire frequency after settlement may have left some treeless.

Rare species:
Vascular plants – *Acmispon helleri, Baptisia alba, Dichanthelium neuranthum, Helianthus laevigatus, Helianthus schweinitzii, Pseudognaphalium helleri,* and *Symphyotrichum georgianum.*

XERIC HARDPAN FOREST (BASIC ROCKY SUBTYPE)

Concept: Xeric Hardpan Forests are woodlands with open vegetation related to restricted rooting caused by dense or shrink-swell clay. The Basic Rocky Subtype covers the rare communities with Xeric Hardpan Forest composition on rocky ridge tops and steep slopes over mafic rocks. Soils between the rocks appear to have dense shrink-swell clay layers and to restrict water movement and root penetration. The composition is somewhat different from examples on basic hardpan flats.

Distinguishing Features: Xeric Hardpan Forests are distinguished from Dry Oak–Hickory Forest and Dry Basic Oak–Hickory Forest by having a canopy of more xerophytic composition, with *Quercus stellata* dominant or codominant. The Basic Rocky Subtype is distinguished from the other basic subtypes by its occurrence on steep slopes or ridge tops and the presence of abundant rocks. The species indicative of wetter conditions, such as *Quercus phellos*, which are usually present in small numbers in the hardpan subtypes, are absent. No frequent plants are known to be exclusive to the Basic Rocky Subtype, but *Carya carolinae-septentrionalis, Piptochaetium avenaceum, Acer leucoderme, Muscadinia rotundifolia*, and *Parthenocissus quinquefolia* are generally much more abundant than in the Basic Hardpan or Prairie Barren subtypes. This subtype may grade conceptually into some of the glade communities. It is distinguished from them by its deep clayey soils between any rocks and by absence of any characteristic rock outcrop flora.

Crosswalks: *Quercus stellata - Carya carolinae-septentrionalis / Acer leucoderme / Piptochaetium avenaceum - Danthonia spicata* Woodland (CEGL003713).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Piedmont Hardpan Woodland and Forest Ecological System (CES202.268).

Sites: The Basic Rocky Subtype occurs on narrow ridge top and upper-to-middle slopes on substrates of gabbro, meta-basalt, or potentially diabase. The sites may have abundant cover of boulders but most of the ground surface is soil.

Soils: Most examples are mapped as Enon (Ultic Hapludalf) or Wilkes (Typic Hapludalf), a few as Iredell (Vertic Hapludalf) or other series. The soils have a dense clay layer despite their frequent high rock cover and occurrence on steep slopes. The dense clay layer and the xeric vegetation suggest that rooting depth is restricted as it is in other Xeric Hardpan Forests.

Hydrology: Soils appear to be xeric due to limited water penetration, which may be exacerbated by their occurrence on slopes.

Vegetation: The vegetation in the least altered remaining examples is an open forest or woodland dominated by *Quercus stellata* and *Carya carolinae-septentrionalis*, sometimes with *Quercus marilandica* or *Fraxinus biltmoreana* codominant. *Pinus echinata, Pinus virginiana, Carya glabra*, or occasionally other species are abundant. The understory is generally open. Besides canopy species, frequent species include *Cercis canadensis, Ulmus alata, Acer leucoderme, Juniperus virginiana*, *Benthamidia* (*Cornus*) *florida*, and *Diospyros virginiana*. Less frequent are *Prunus umbellata, Vaccinium arboreum, Crataegus uniflora, Ulmus alata*, and a variety of other species. Shrubs generally are sparse. *Rosa carolina, Rhus aromatica, Viburnum rufidulum, Viburnum prunifolium, Ceanothus americanus*, and *Symphoricarpos orbiculatus* are characteristic. Vines may have substantial ground cover, especially in the most rocky areas. *Muscadinia rotundifolia* is most often dominant, but *Toxicodendron radicans, Parthenocissus quinquefolia, Lonicera sempervirens, Smilax rotundifolia*, and *Smilax bona-nox* may also be extensive. The herb layer is generally dense. *Piptochaetium avenaceum, Schizachyrium scoparium*, or *Danthonia spicata* dominate. Herbs at least fairly frequent in CVS plot data and site descriptions include *Melica mutica, Scleria oligantha, Tragia urticifolia, Dichanthelium boscii, Dichanthelium laxiflorum, Symphyotrichum patens, Lespedeza procumbens,* and *Lespedeza virginica.* Less frequent but likely characteristic species include *Scutellaria integrifolia, Acalypha gracilescens, Dichanthelium annulum, Coreopsis major, Dichanthelium depauperatum, Lespedeza repens, Lespedeza violacea, Stylosanthes biflora, Ruellia caroliniana, Phlox nivalis, Symphyotrichum undulatum, Symphyotrichum orbiculatus*, *Clematis ochroleuca, Pycnanthemum tenuifolium, Allium canadense, Allium cernuum, Asclepias verticillata, Clitoria mariana, Centrosema virginiana, Cunila origanoides, Andropogon gerardii*, and *Andropogon gyrans*. With a more natural fire regime, the canopy would likely be more open, the understory much sparser, and the herb layer more diverse.

Range and Abundance: Ranked G2. North Carolina examples are almost all in the Carolina Slate Belt geologic region, concentrated in the area of Montgomery and Stanley counties. It is unclear if this subtype occurs in any other states.

Associations and Patterns: The Basic Rocky Subtype occurs as small patches. It usually is surrounded by Dry Basic Oak–Hickory Forest. Upland Depression Swamp Forest patches may be adjacent or nearby.

Variation: No variants are defined. The variants recognized in the 3rd Approximation are now treated as subtypes.

Dynamics: Dynamics are similar to those of other Xeric Hardpan Forests, with fire having once maintained a more open canopy and a more diverse herb layer than at present due to greater fire effects rather than much more frequent fire. Fire effects appears to be somewhat less extreme than for other subtypes, perhaps due to topography and small patch sizes. The reason for the greater abundance of *Carya carolinae-septentrionalis* in this subtype is not clear but may be related to fire behavior or rock content.

Remaining examples of this subtype appear to be less altered than other subtypes. Most examples retain a dense grassy herb layer. This may be because the rockiness and steep topography contribute more to keeping woody cover low, or it may be because land use was less intense on the slopes and ridge tops where they occur. Nevertheless, canopies probably have become denser and herb diversity declined due to fire suppression.

Comments: No published literature is known pertaining to this subtype. It is well covered by CVS plots, given its rarity. This description is based both on CVS plot data and site observations.

Rare species:
Vascular plants – *Eupatorium saltuense, Hexalectris spicata, Parthenium auriculatum, Solidago radula,* and *Symphyotrichum concinnum.*

XERIC PIEDMONT SLOPE WOODLAND

Concept: Xeric Piedmont Slope Woodland is a rare woodland or open forest community of xeric microsites such as steep upper slopes on dry aspects, but with less continuous shallow soil, less bedrock, and denser vegetation than Piedmont Acidic Glade. It is dominated by drought-tolerant species, including *Pinus echinata, Quercus stellata, Quercus marilandica*, and *Quercus montana*, and has either a dense shrub layer or an herbaceous layer of drought-tolerant and sun-loving species.

Distinguishing Features: Xeric Piedmont Slope Woodland is recognizable by a canopy composition more xerophytic than Dry Oak–Hickory Forest or Piedmont Monadnock Forest (*Quercus stellata, Pinus echinata*, *Quercus marilandica*, sometimes *Quercus montana*, without *Quercus alba* or more mesophytic species) in environments that don't have the characteristics of Piedmont Acidic Glade or Xeric Hardpan Forest. Sites are usually rocky, but dry slope aspect appears more important than continuous bedrock or shallow soil, and a clay hardpan is not present. Xeric Piedmont Slope Woodland is distinguished from Piedmont Acidic Glade by denser vegetation (open forest or fairly dense woodland if not recently disturbed), deeper soil, and limited role of rock. Xeric Hardpan Forest (Basic Rocky Subtype) has a xerophytic canopy in upper slope settings but occurs on mafic rock, has evidence of a dense or shrink-swell clay subsoil, and generally has abundant *Carya carolinae-septentrionalis*.

Crosswalks: *Pinus echinata - Quercus marilandica / Kalmia latifolia - Symplocos tinctoria* Woodland (CEGL004446). This association is a marginal fit for the concept of this community type, which might almost as well be regarded as having no NVC analogue.
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southern Piedmont Dry Oak-(Pine) Forest Ecological System (CES202.339).

Sites: Xeric Piedmont Slope Woodlands occur on steep or convex upper slopes that face west or south.

Soils: Soils may potentially be any dry acidic upland soil. The known examples are mapped as Georgeville (Typic Kanhapludult).

Hydrology: Sites are very dry due to strong solar heating and rapid drainage of rainfall from the steep convex slopes.

Vegetation: The vegetation is an open forest or woodland dominated by *Quercus stellata, Quercus montana,* and *Pinus echinata*, with *Quercus marilandica* abundant in the understory. Shrubs such as *Kalmia latifolia* or *Vaccinium arboreum* may be abundant. The herb layer, where shrubs are not dense, is dominated by grasses, primarily *Piptochaetium avenaceum* or *Danthonia spicata*. With more frequent fire, additional species such as *Schizachyrium scoparium, Tephrosia virginiana, Solidago odora*, and *Pteridium latiusculum* might be abundant.

Range and Abundance: Ranked G2? but much uncertainty remains about its abundance. It may be G1. It is known in North Carolina only in the most rugged part of the Uwharrie National Forest.

Associations and Patterns: Where it is known, Xeric Piedmont Slope Woodland occurs on the driest slope aspects and grades to Piedmont Monadnock Forest (Pine Subtype) on other dry slope aspects and to Piedmont Monadnock Forest (Typic Subtype) on ridge tops and east-facing slopes. Piedmont Acidic Glade and potentially Dry Piedmont Longleaf Pine Forest occur as additional small patch communities in this landscape.

Variation: Variation is not well known at present.

Dynamics: Dynamics are not well known. The factors that produce this community where it occurs are presumed to be the very dry microsites, but steep south-facing slopes in other parts of the Piedmont do not appear to support this community. Fire probably is very influential, as it is in the other barrens communities, but occurrence in rugged topography may limit fire spread from surrounding landscapes.

Comments: This community is one of the least well understood in the 4th Approximation, and confusion remains about its true character and ecological affinities. The history of nomenclature illustrates the confusion. It was called Xeric Piedmont Pine Heath in earlier drafts of the 4th approximation. It was also called Piedmont Monadnock Forest (Xeric Subtype) at one stage. The synonymized NVC association is a poor fit for the observed vegetation of places identified as Xeric Piedmont Slope Woodland. It describes a dry or xeric woodland with a dense shrub layer suggestive of sheltering from fire, but the setting suggests an important natural role for fire. Further confusing the picture, *Quercus marilandica* is in the name but is not mentioned in the vegetation description. The vegetation, as described in the NVC, suggests a dry phase of Piedmont/Coastal Plain Heath Bluff. It was based on two rather different CVS plots.

The concept used in the Fourth Approximation is based on field observations of rocky acidic upper south-facing slope positions in the most rugged part of the Uwharrie Mountains, initially suggested by Alan Weakley and Allison Weakley (personal comm. 2011). Their observations, and the author's, are of vegetation that is not densely shrubby and has a fairly diverse herbaceous layer. The dense shrub layer in the xeric plots may be an artifact of fire suppression. At present, this rare community is not known outside of the southeastern Badin unit of Uwharrie National Forest, an area of unusually extensive and diverse development of dry, acidic communities. These communities are likely partially dependent on fire for their natural character. With more frequent burning, comparable to that which occurred in most Piedmont forests, these dry sites would have more open canopies, less shrub cover, and would support diverse herbaceous layers.

The relationship of this community to Dry Piedmont Longleaf Pine Forest also needs further clarification. The Mountain Variant of Dry Piedmont Longleaf Pine Forest occurs in similar topographic and geologic settings in close proximity to the known occurrences.

Quercus montana - Quercus stellata - Carya glabra / Vaccinium arboreum - Viburnum rufidulum Forest (CEGL004416) is another xeric forest association, initially based on two other plots in the same vicinity. It could fit this type's concept as well but may alternatively fit Piedmont Acidic Glade better.

Rare species: No rare species are known in this community.

MARITIME GRASSLANDS THEME

Concept: Maritime Grasslands are dry-to-moist communities of barrier island and similar coastal sites that are not dominated by shrubs or trees. Most communities have sparse-to-moderate herbaceous vegetation, but one is dominated by dense vines.

Distinguishing Features: Maritime Grasslands are distinguished by the combination of herbaceous, vine-dominated, or sparse vegetation in a non-wetland site on a barrier island or coastal spit.

Sites: Maritime Grasslands occur on barrier islands or spits, on sand dunes or sand flats. Salt spray and sometimes sand movement or overwash by sea water during storms are important environmental stresses.

Soils: Soils are sandy and are generally lacking horizon development. Soils are less acidic and nutrient-poor than inland sandy soils because of the presence of shell material in the sand and because of nutrient input by salt spray.

Hydrology: Maritime Grasslands are generally dry to xeric, with excessive drainage due to the coarse sandy texture and lack of clay or organic matter. A few may be moist but not wet. Moisture comes from rainfall, which rapidly infiltrates into the sand.

Vegetation: The vegetation of Maritime Grasslands is dominated by herbs or, rarely, vines. The floristic diversity is limited, confined to species tolerant of salt spray as well as of excessive soil drainage. It may range from sparse to dense. One or two species of sand-binding or salt-tolerant grasses, *Spartina patens, Uniola paniculata, Calamagrostis* (*Ammophila*) *breviligulata*, or *Schizachyrium littorale*, dominate most of the communities. One unique community is dominated by dense tangles of *Smilax auriculata* or other woody vines. Other communities have sparse vegetation of distinctive species such as *Hudsonia tomentosa* or other species of dry sandy sites. All communities are low in species richness, but a small suite of species tolerant of the harsh environment, such as *Hydrocotyle bonariensis, Panicum amarum, Oenothera humifusa, Cenchrus tribuloides, Strophostyles helvola*, *Heterotheca subaxillaris*, and *Euphorbia polygonifolia*, are present in many.

Dynamics: Maritime Grasslands are among the most naturally dynamic communities in North Carolina. Natural disturbances, including overwash by sea water, heavy salt spray during storms, and aeolian sand movement are frequent, with different disturbances predominating in different communities. Exposure to these disturbances can change quickly as a result of erosion or deposition. Locally, environments may become suitable for Maritime Grassland communities, or unsuitable, due to changes in landforms or as a result of a single storm. As long as the environment remains suitable, Maritime Grasslands recover readily from natural disturbances. They can develop quickly in new sites if the environment becomes suitable. Their habitat is some of the newest land in North Carolina, with some surfaces only a few years old and some whole islands only a few centuries old.

The individual community types each have distinctive dynamics, which are discussed in detail in their descriptions. Common to all is the degree to which they are subject to the natural forces of storms and the chronic stress of salt spray. All can be readily altered by human actions, both directly and indirectly, including both artificial disturbance and artificial stabilization.

KEY TO MARITIME GRASSLANDS

1. Rare community dominated by large patches of *Smilax auriculata, Toxicodendron radicans*, or other vines standing at least one meter tall, with few or no shrubs; patches at least 10 meters in size. ....**Maritime Vine Tangle**

1. Community not dominated by large patches of vines, though patches of sprawling vines a few meters in size may be present.

  2. Community dominated by *Spartina patens*; occurring on low, though dry, sandy areas rather than on active or stabilized dunes, often visibly on overwash deposits …………………………… …………………………………………………………………… **Maritime Dry Grassland**

  2. Community not dominated by *Spartina patens*; dominated by large sand-binding grasses such as *Uniola paniculata, Calamagrostis* (*Ammophila*) *breviligulata*, or *Schizachyrium littorale*, or vegetation sparse and dominated by other species.

    3. Site one of the few large, unstabilized medaño dunes such as Jockey's Ridge or Run Hill; vegetation very sparse, with large portions lacking any vascular plants….. **Live Dune Barren**

    3. Site foredunes or stable interior dunes, with only local unstable areas; vegetation moderate to sparse in density but without large areas devoid of vascular plants.

      4. Community on foredunes or stable interior dunes; vegetation dominated by *Uniola paniculata, Calamagrostis breviligulata*, or *Schizachyrium littorale*.

        5. Community dominated by *Calamagrostis breviligulata* …………………………… ……...**Dune Grass (Northern Subtype)**

        5. Community dominated by *Uniola paniculata* or *Schizachyrium littorale*.

          6. Community dominated by *Uniola paniculata*, with *Schizachyrium littorale* absent.... ....**Dune Grass (Southern Subtype)**

          6. Community dominated by *Schizachyrium littorale* or a mix of it with *Uniola paniculata*. ....**Dune Grass (Bluestem Subtype)**

      4. Community on stable interior dunes; *Uniola paniculata, Calamagrostis breviligulata*, and *Schizachyrium littorale* scarce or absent; vegetation sparse over most of the community; vegetation containing species such as *Hudsonia tomentosa, Lechea maritima* var. *virginica*, *Dichanthelium* spp., *Hexasepalum (Diodia) teres, Polypremum procumbens*, and *Hypericum gentianoides* that are absent on foredunes; community generally surrounded by Maritime Evergreen Forest or Maritime Shrub

        7. Community north of Cape Hatteras; *Hudsonia tomentosa* and *Lechea maritima* var. *virginica* usually present and abundant... **Stable Dune Barren (Beach Heather Subtype)**

        7. Community south of Cape Hatteras; south of the range of *Hudsonia tomentosa* and *Lechea maritima* var. *virginica*. ....**Stable Dune Barren (Southern Subtype)**

DUNE GRASS (SOUTHERN SUBTYPE)

Concept: Dune Grass communities are sparse-to-dense grasslands of coastal foredunes and some interior dunes, dominated by large sand-binding grasses and containing a small set of specialized plants such as *Panicum amarum, Hydrocotyle bonariensis, Strophostyles helvola*, *Smilax auriculata*, and *Solidago mexicana*. The Southern Subtype encompasses communities dominated by *Uniola paniculata,* where *Calamagrostis* (*Ammophila*) *breviligulata* and *Schizachyrium littorale* are absent, scarce, or present only because they were planted. Most occur on the seaward side of barrier islands, as a continuous or discontinuous line of foredunes. However, patches also occur on stabilized sand dunes in barrier island interiors, where they can be distinguished by vegetation.

Distinguishing Features: Dune Grass communities in natural condition are distinguished from all other communities by the dominance of the above species, particularly *Uniola paniculata, Schizachyrium littorale,* or *Calamagrostis* (*Ammophila*) *breviligulata*. Live Dune Barren and Stable Dune Barren communities also occur on sand dunes in barrier island interiors but are not dominated by these grasses and usually contain little grass. Maritime Dry Grasslands may be interspersed with Dune Grass patches in island interiors but can be distinguished by the absence of *Uniola paniculata*.

The Southern Subtype is distinguished by the natural absence of *Schizachyrium littorale* and *Calamagrostis breviligulata*, though the latter may be present in small amounts in northerly examples. However, extensive planting of both *Uniola* and *Calamagrostis* confuses the distinction in some areas. The Northern Subtype does not occur south of Cape Hatteras and the Southern Subtype does not occur north of Nags Head. Dunes in the area between are typically the Southern Subtype. However, local zones of *Calamagrostis* dominance near Cape Hatteras, occurring seaward of *Uniola* dominance, may be a natural disjunct example of the Northern Subtype.

Crosswalks: *Uniola paniculata - Hydrocotyle bonariensis* Grassland (CEGL004040).
G494 South Atlantic & Gulf Coastal Dune Grassland Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Dune Grass communities occur on foredunes and on short-to-tall dunes in the interior of some barrier islands. The dunes are relatively stable but may contain unstable blowouts.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Dune Grass sites are excessively drained. Rainwater infiltrates and drains through the soil rapidly.

Vegetation: Dune Grass (Southern Subtype) is dominated by *Uniola paniculata*, which may range locally from sparse to dense. Other species that occur with high frequency in CVS plot data are *Oenothera humifusa, Hydrocotyle bonariensis, Spartina patens, Heterotheca subaxillaris, Cenchrus tribuloides, Panicum amarum*, *Iva imbricata, Euphorbia polygonifolia*, *Opuntia mesacantha*, and *Erigeron pusillus* (*Conyza canadensis* var. *pusilla*). Other species that are less frequent in plot data but are often observed in sites include *Strophostyles helvola, Physalis walteri,* *Solidago mexicana* (*sempervirens* var. *mexicana*), and *Croton punctatus*. *Smilax auriculata*, *Chrysopsis gossypina*, *Trichostema nesophilum*, and *Euphorbia bombensis* are less frequent but are characteristic.

Range and Abundance: Ranked G3? but likely reliably G3. In North Carolina, the Southern Subtype occurs throughout the length of the coast but is absent and replaced by the Bluestem Subtype on certain barrier islands. This community ranges southward to Florida.

Associations and Patterns: Dune Grass may be regarded as a matrix community, occurring as a predictable part of the landscape mosaic in the limited extent of the barrier islands. Occurrences may be fairly narrow but are continuous along miles of coastline. They occur in association with Upper Beach, Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, and Maritime Evergreen Forest.

Variation: Dune Grass communities are heterogeneous on a fine scale, with grass density varying in response to microtopography and local disturbance. The composition of the vegetation is fairly uniform throughout, though areas on younger dunes may be lower in species richness. There is a recognizable difference in vegetation between foredunes and interior Dune Grass communities, and these may warrant recognition as variants.

Dynamics: Sand dunes and Dune Grass communities have distinctive dynamics. Sand movement may locally bury vegetation or uproot it. Storm erosion can destroy dunes locally or over long stretches of coast. *Uniola paniculata* plays an important geomorphic as well as biological role, colonizing loose sand, stabilizing it, and catching moving sand to build dunes. Dunes can grow rapidly. On the Fort Fisher spit, the author observed that dunes completely flattened by hurricane erosion and overwash had redeveloped in just a few years. The accumulation of sand around individual surviving or newly established clumps of *Uniola* was visible very soon after the storm, and it can be seen in overwash passes and on newly deposited sand spits in many places.

Because the dunes affect the frequency and extent of overwash, Dune Grass communities influence the dynamics of all barrier island communities. Godfrey and Godfrey (1976) emphasized the role of dune configuration and the effect of artificial modification of dunes. They described dunes as discontinuous and relatively short on unmodified barrier islands such as Core Banks. They indicated that dune enhancement activities such as sand fencing and planting of grasses on other islands led to taller and more continuous dunes that blocked overwash. They also noted natural variation, with barrier islands oriented perpendicular to the prevailing winds having better developed dunes. This appears to be the case on many east-west oriented barrier islands in North Carolina. Goldstein et al. (2018) noted that there is also a belief that *Uniola paniculata* and *Calamagrostis* (*Ammophila*) *breviligulata* tend to form different configurations of dunes, with the latter leading to hummocky and less continuous dunes.

Artificial dune enhancement has been done in many places, to protect roads or houses behind the dunes, and relatively few dune systems other than Core Banks and islands with naturally extensive dunes may be free from it. There was an earlier belief, (e.g. Cobb 1906), that unstable dunes and actively moving sand had resulted from clearing of forest or grazing during early settlement. However, most such dune building was done before 1976, much of it in the 1930s and 1950s, and it appears not to have been maintained, at least on undeveloped barrier islands. It may be questioned how long the effects of these activities would persist in such a dynamic environment. Goldstein et al. (2018) mention reports of plantings of *Calamagrostis* being displaced by native *Uniola* in six to ten years, suggesting such altered places may naturalize quickly. The author observed that Core Banks in the 2000s had fairly continuous dunes, with few overwash passes, despite no history of modification. It may be that the extent and continuity of dunes changes over periods of years in response to storm frequency or other variations in climate.

Interior dunes may support Dune Grass, Stable Dune Barren, or Live Dune Barren communities. The distinction may be related to stability and age of the dunes. The largest active dunes, with vegetation kept sparse by ongoing lack of stability, are Live Dune Barrens. Recently stabilized dunes support Dune Grass communities very similar to those on the foredunes. Stable Dune Barrens appear to be of greater age and to have little tendency for sand movement. Woody vegetation has often filled the adjacent swales. They are probably maintained more by excessive soil drainage.

Salt Spray is an additional distinctive environmental factor important to dynamics. Oosting and Billings (1942) brought attention to its importance to barrier island plants. Dune Grass communities, at least on the foredunes, are among the most heavily exposed to it. Salt spray is an ongoing stress that excludes most species from the environment, and heavy deposition in storms may act as a natural disturbance. Salt spray is also an important source of nutrients. Gormally and Donovan (2010) found that many plant nutrients decreased with distance from the shore, even as saltiness of the sand decreased. *Uniola paniculata* plants were taller, had higher tissue concentrations of nutrients, and flowered more in the ten meters closest to the shoreline than farther back.

Comments: The vegetation of this subtype is well studied in North Carolina. Publications by Au (1974) and Godfrey and Godfrey (1976) provided earlier characterizations, focusing on Cape Lookout and Cape Hatteras National Seashore, and Wagner (1964) addressed the behavior of the dominant species. A thesis by Rosenfeld (2004) revealed the distinctness of this community at the southern end of North Carolina. Numerous CVS plots and plots collected by NatureServe for the National Park Service represent it.

Uniola paniculata Herbaceous Vegetation (CEGL004038) was defined as a more depauperate dune grass association of the Outer Banks. It was provisionally accepted as the Outer Banks Subtype in earlier drafts of the 4th approximation but has been dropped. It is now inactive in NVC. All Dune Grass subtypes are floristically depauperate because of the harsh environment, and their flora consists mostly of specialist species not in mainland communities. Local species richness within Dune Grass communities is extremely variable over short distances. Examples on the most remote dunes of the Outer Banks do not appear to be more depauperate than many examples closer to the mainland.

Rare species:
Vascular plants – *Chenopodiastrum berlandieri* var. *boscii, Dichanthelium caerulescens, Dichanthelium neuranthum, Euphorbia bombensis, Ipomoea imperati, Solanum pseudogracile, Trichostema nesophilum,* and *Yucca gloriosa.*

Nonvascular plants – *Archidium tenerrimum.*

Vertebrate animals – *Columbina passerina*.

DUNE GRASS (BLUESTEM SUBTYPE)

Concept: Dune Grass communities are sparse-to-dense grasslands of coastal foredunes and some interior dunes, dominated by large sand-binding grasses and containing a small set of specialized plants such as *Panicum amarum, Hydrocotyle bonariensis, Strophostyles helvola*, *Smilax auriculata*, and *Solidago mexicana*. The Bluestem Subtype covers rare examples in which *Schizachyrium littorale* is a significant component in addition to *Uniola paniculata* and other species.

Distinguishing Features: The Bluestem Subtype is distinguished from all other communities by having *Schizachyrium littorale* as a significant component in combination with *Uniola paniculata*. *Schizachyrium* is occasionally present in some other communities, but not in combination with *Uniola paniculata* on sand dunes.

Crosswalks: *Uniola paniculata* - *Schizachyrium littorale* - *Panicum amarum* Grassland (CEGL004039).
G494 South Atlantic & Gulf Coastal Dune Grassland Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Dune Grass sites are excessively drained. Rainwater infiltrates and drains through the soil rapidly.

Vegetation: The Bluestem Subtype is generally codominated by *Uniola paniculata* and *Schizachyrium littorale*, which may range from moderate to dense. Locally, *Uniola* may be scarce and *Schizachyrium* strongly dominant. *Hydrocotyle bonariensis* and *Oenothera humifusa* are also nearly constant. Other species that occur with high frequency in CVS plot data include *Heterotheca subaxillaris, Erigeron pusillus* (*Conyza canadensis* var. *pusillus*), and *Smilax auriculata*. Less frequent but characteristic species include *Cenchrus tribuloides, Solidago mexicana, Euphorbia bombensis, Strophostyles helvola*, *Croton punctatus, Commelina erecta, Opuntia mesacantha, Opuntia drummondii, Spartina patens,* and *Triplasis purpurea*.

Range and Abundance: Ranked G3. In North Carolina, the Bluestem Subtype is the predominant Dune Grass community on several barrier islands scattered along the coast. It is locally extensive, but it is much less abundant than the Southern Subtype. It also is attributed to Virginia, South Carolina, and possibly Georgia, and occurs in a similar discontinuous range in those states.

Associations and Patterns: The Bluestem Subtype may be best regarded as a Large Patch community. Occurrences are tens to hundreds of acres but are scattered in only a few places. However, where present, it resembles a matrix community, making up a significant part of the landscape. The Bluestem subtype occurs in association with Upper Beach, Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, and Maritime Evergreen Forest. Areas on the foredunes may be low in *Schizachyrium* and some may be interpreted as the Southern Subtype.

Variation: Dune Grass communities are heterogeneous on a fine scale, with grass density varying in response to microtopography and local disturbance. There is a recognizable difference in vegetation between foredunes and interior Dune Grass communities, and these may warrant recognition as variants.

Dynamics: Dynamics of the Bluestem Subtype are similar to the Southern Subtype. The factors that lead to occurrence of the Bluestem Subtype rather than the Southern Subtype are unclear. The known examples tend to be on east-running barrier islands, and it is possible that the relationship with the prevailing wind, or the presence of taller and wider dune systems on these islands, contributes to the presence of the defining species or to the development of this community. The Bluestem Subtype is somewhat more species-rich than the Southern Subtype. Unlike *Uniola*, *Schizachyrium* also will sometimes occur in Maritime Wet Grassland or Maritime Dry Grassland, suggesting it benefits from somewhat more moisture or that it is more competitive.

Comments: This subtype has not been the subject of specific published studies in North Carolina. However, a number of CVS plots represent it.

There has been some confusion of the concepts of Dune Grass subtypes. The Bluestem Subtype was initially characterized as being more southern, but *Schizachyrium littorale* has a patchy distribution rather than simply being indicative of more southern locations. It is absent from much of South Carolina but present farther south. It is unclear if its presence or absence correlates with the environment or with broader aspects of the community. The nomenclature of NVC associations also appears to have caused confusion. *Panicum amarum* is a nominal in the association equivalent to the Bluestem Subtype but not in the Southern Subtype. Though the species may be present in either, it is not present in any of the North Carolina plots for the Bluestem Subtype but is in many plots of the Southern Subtype.

Rare species:
Vascular plants – *Dichanthelium neuranthum, Euphorbia bombensis, Ipomoea imperati, Solanum pseudogracile, Trichostema nesophilum, Yucca gloriosa.*

Nonvascular plants – *Archidium tenerrimum.*

Vertebrate animals – *Columbina passerina*.

Invertebrate animals – *Atrytonopsis quinteri* and *Dargida aleada*.

DUNE GRASS (NORTHERN SUBTYPE)

Concept: Dune Grass communities are sparse-to-dense grasslands of coastal foredunes and some interior dunes, dominated by large sand-binding grasses and containing a small set of specialized plants such as *Panicum amarum, Hydrocotyle bonariensis, Strophostyles helvola*, *Smilax auriculata*, and *Solidago mexicana*. The Northern Subtype covers examples in the northern part of the state, north of Cape Hatteras, where *Calamagrostis* (*Ammophila*) *breviligulata* is dominant.

Distinguishing Features: The Northern Subtype is distinguished from all other communities by the natural dominance or codominance of *Calamagrostis breviligulata*. If *Uniola paniculata* is present, it is a minor species. The Northern Subtype is limited to the islands north of Cape Hatteras, and it is unclear how widespread it is there, as *Uniola* dominates most of the dunes from there to Virginia. Dunes dominated by *Calamagrostis* much south of Cape Hatteras should be treated as altered examples of one of the other subtypes rather than this subtype. The natural subtype of many northern sites may be impossible to determine because of the widespread planting of both species for dune stabilization, but see below for more discussion of the relationship between the two species and the two subtypes.

Crosswalks: *Ammophila breviligulata* - *Panicum amarum* var. *amarum* Grassland (CEGL004043).
G493 North Atlantic Coastal Dune & Grassland Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Dune Grass communities occur on foredunes and on short-to-tall dunes in the interior of some barrier islands. The dunes are relatively stable but may contain unstable blowouts.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Dune Grass sites are excessively drained. Rainwater infiltrates and drains through the soil rapidly, leaving the site dry.

Vegetation: The Northern Subtype is dominated by *Calamagrostis* (*Ammophila*) *breviligulata*, which may be locally sparse or fairly dense. *Uniola paniculata* or *Schizachyrium littorale* may be present in small amounts. *Panicum amarum* may codominate or be abundant. Other species may include *Strophostyles helvola, Hydrocotyle bonariensis, Cakile harperi, Triplasis purpurea, Cenchrus tribuloides, Euphorbia polygonifolia, Oenothera humifusa, Solidago mexicana, Hexasepalum (Diodia) teres*, *Spartina patens*, *Heterotheca gossypina, Smilax bona-nox* var. *littoralis*, *Smilax auriculata*, and *Iva imbricata*.

Range and Abundance: Ranked G2. This subtype's distribution in North Carolina is poorly documented. It appears to be rare and limited to small patches in North Carolina, but its abundance is confused by widespread alteration by planting. The association ranges northward to New York.

Associations and Patterns: In North Carolina, the Northern Subtype appears to be a small patch community, though it is a matrix community farther north. It sometimes occurs in close association with the Southern Subtype, but this relationship needs further investigation. Otherwise, it may be associated with Upper Beach, Maritime Shrub, and Maritime Evergreen Forest.

Variation: Nothing is known of the range of variation in North Carolina.

Dynamics: Dynamics of the Northern Subtype are presumably generally similar to the Southern Subtype. Sand movement and storm activity are important natural disturbances, while salt spray is an environmental stress that gives the community its character.

Goldstein et al. (2018) noted that there is a belief that *Uniola paniculata* and *Calamagrostis* (*Ammophila*) *breviligulata* tend to form different configurations of dunes, with the latter leading to hummocky and less continuous dunes. This cannot be observed in North Carolina, where all the dunes within the range of the Northern Subtype are continuous, but all may have been subject to artificial enhancement. However, as with the Southern Subtype, while artificial enhancement of dunes has been widespread, it is unclear that the current stable continuous dunes are completely of artificial origin. Given the dynamic environment and the long timespan since stabilization and planting was done, artificial structure may not have persisted. Since unaltered examples of the Southern Subtype appear to be more continuous and stable than in the past, this may be a natural trend.

The global distribution of the Northern and Southern subtypes presumably is related to climate in a broad sense. The dominant species have very different overall ranges. Goldstein et al. (2018) complied literature on the range of both species and suggest there is evidence that *Uniola* is moving northward as the climate warms. However, they also found reports of *Calamagrostis* present well south of the widely cited Cape Hatteras limit and showing *Uniola* present throughout the eastern shore of Virginia. They note that the widespread planting of both species confuses the picture of their native ranges. However, they also cite reports of *Calamagrostis* plantings in North Carolina being overtaken by *Uniola* in six to ten years, suggesting altered areas can potentially naturalize fairly quickly.

Where the author has observed both species in close proximity, such as near Cape Hatteras, *Calamagrostis* dominated on younger seaward dunes along the accreting coast, while *Uniola* dominated on better developed older dunes close behind. This relationship should be sought on the Currituck Banks, as it may offer a clue to the patterns of occurrence of the two subtypes in their region of overlap.

Comments: This subtype is well studied in states to the north but is not well studied in North Carolina. Several CVS plots represent it.

Rare species:
No rare species are known to be specifically associated with this community.

LIVE DUNE BARREN

Concept: Live Dune Barrens are sparsely vegetated communities of rare large, unstabilized medaño dunes in the interior of barrier islands. In contrast to Dune Grass, the vegetation is affected more strongly by sand movement and less by salt spray. The vegetation consists largely of scattered patches of pioneer herbs, vines, and sub-shrubs in sheltered microsites. There is a distinctive invertebrate community.

Distinguishing Features: Live Dune Barrens are distinguished by very sparse vegetation associated with large unstabilized sand dunes. Dune Grass communities have denser vegetation dominated by *Uniola paniculata* or *Calamagrostis* (*Ammophila*) *breviligulata*.

Crosswalks: *Vitis rotundifolia / Triplasis purpurea - Panicum amarum - Schizachyrium littorale* Mid-Atlantic Coastal Medaño Sparse Vegetation (CEGL004397).
G494 South Atlantic & Gulf Coastal Dune Grassland.
Northern Atlantic Coastal Plain Dune and Swale Ecological System CES203.264).

Sites: Live Dune Barrens occur on the few large, unstabilized medaño dunes.

Soils: The soil consists of deep loose sand.

Hydrology: Live Dune Barrens are excessively drained. Rainwater rapidly sinks into the sand, leaving the upper portions dry.

Vegetation: The vegetation of Live Dune Barrens is very sparse, with large areas devoid of plants. Small amounts of plants typical of Dune Grass communities are present, including *Uniola paniculata, Calamagrostis* (*Ammophila*) *breviligulata, Schizachyrium littorale, Panicum amarum, Chrysopsis gossypina,* and *Oenothera humifusa*. Other herbs of open sandy areas may also be present, such as *Paronychia baldwinii* ssp. *riparia* and *Hexasepalum teres*. Woody species may also be present. *Smilax bona-nox* var. *littoralis, Muscadinia rotundifolia, Morella cerifera*, and shrub-sized *Prunus serotina* have been noted.

Range and Abundance: Ranked G1. Only two examples are known to remain, at Jockeys Ridge and Run Hill. Another may possibly remain on northern Currituck Banks. This community is endemic to North Carolina. Other states in the region lack large active dunes.

Associations and Patterns: Live Dune Barrens are large patch communities. Examples cover hundreds of acres. They are associated with a variety of other maritime communities, including Dune Grass, Maritime Wet Grassland, Maritime Shrub, and Maritime Deciduous Forest. The mobile dunes may be burying adjacent communities along their edges.

Variation: Little is known about variation. Vegetation presumably varies locally with variation in stability and with accidents of rare plant establishment.

Dynamics: Live Dune Barrens are maintained in a largely unvegetated state by instability and movement of the sand. Human traffic may also contribute to barrenness. Medaños can migrate across the landscape or can shift back and forth over time, in response to changes in prevailing winds.

Comments: Live Dune Barrens were not recognized as distinct in the 3rd Approximation but were treated as a subset of Dune Grass.

Rare species:

Vascular plants – *Hudsonia tomentosa*.

Invertebrate animals – *Ellipsoptera lepida*.

STABLE DUNE BARREN (SOUTHERN SUBTYPE)

Concept: Stable Dune Barrens are sparsely- to moderately-vegetated communities of inactive dunes and high sand flats of barrier island interiors, not dominated by *Uniola paniculata*, *Calamagrostis* (*Ammophila*) *breviligulata*, or *Schizachyrium littorale*. While *Uniola paniculata* and other Dune Grass species may be present in small amounts, the vegetation is predominantly species that are not found in Dune Grass communities. The community often includes substantial bare sand but also may include open or patchy cover of woody vines, shrubs, and even trees. It occurs on broader barrier islands, in association with Maritime Evergreen Forest and Maritime Shrub.

The Southern Subtype encompasses those examples from Cape Hatteras southward, which are outside the native range of *Hudsonia tomentosa*.

Distinguishing Features: Stable Dune Barrens are distinguished from Maritime Dry Grassland and Dune Grass by the scarcity of the grasses characteristic of those types. They are distinguished from Live Dune Barrens by a stable substrate and well-established, if sparse, vegetation. They are distinguished from all other barrier island communities by low plant cover and abundant dry, bare sand. These communities often occur in fine-scale mosaics with Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, Maritime Vine Tangle, and young Maritime Evergreen Forest in the heterogeneous environment created by irregular interior dunes. They may contain small inclusions of less barren woody or herbaceous vegetation.

The Southern Subtype is distinguished by occurrence from Cape Hatteras southward and by the absence of *Hudsonia tomentosa*.

Crosswalks: *Smilax auriculata / Heterotheca subaxillaris - Strophostyles helvola - (Uniola paniculata)* Grassland (CEGL004234).
G494 South Atlantic & Gulf Coastal Dune Grassland.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Stable Dune Barrens occur on the tops of stabilized interior dunes that are somewhat sheltered from salt spray. They are well behind the foredunes and usually are also not close to the sound side of the island. They occur only on the broader barrier islands.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Stable Dune Barren sites are excessively drained. Rainwater infiltrates and drains through the soil rapidly, leaving the site dry.

Vegetation: Stable Dune Barrens have sparse vegetation in the center, though they may have more plant cover around the edges. Plants include *Dichanthelium aciculare, Commelina erecta, Euphorbia (Chamaesyce)* sp., *Pycnanthemum flexuosum, Polypremum procumbens, Opuntia humifusa*, *Opuntia pusilla*, and occasionally *Trichostema nesophilum*. *Uniola paniculata* may be present in small amounts. *Smilax auriculata* is common in sprawling patches, most probably representing a single individual. These patches grade into larger patches that can be recognized as

Maritime Vine Tangle occurrences. Occasional individuals of *Morella cerifera, Ilex vomitoria*, or *Quercus virginiana* may occur. Near the edges of patches, clumps of *Quercus virginiana* are common; these appear to be trees from the adjacent forest spreading by layering.

Range and Abundance: Ranked G2G3. Only a couple of examples are known in North Carolina, on Ocracoke Island, but a few more may be found southward. The NVC association ranges southward to Florida, but it is unclear how precisely equivalent it is to this subtype.

Associations and Patterns: Stable Dune Barrens are small patch communities. Individual patches are usually just a of couple acres. They tend to occur as a series of openings surrounded by Maritime Evergreen Forest or large expanses of Maritime Shrub.

Variation: This community is very variable, and the variation is not well characterized. Examples can be very heterogeneous over short distances. Patches may have heavy cover of *Smilax auriculata* only a few centimeters tall, may have substantial cover by *Dichanthelium aciculare*, or may have sparse vegetation dominated by any of several herbaceous species.

Dynamics: The dynamics of Stable Dune Barrens and the environmental factors that lead to their occurrence are not well known. Interior dunes may support Dune Grass, Stable Dune Barren, or Live Dune Barren communities, or may be covered in Maritime Shrub or Maritime Evergreen Forest. The distinction probably is related to stability and age of the dunes. The largest of active dunes, with vegetation kept sparse by ongoing sand movement, are Live Dune Barrens. Recently stabilized dunes support Dune Grass communities very similar to those on the foredunes. Stable Dune Barrens appear to be of greater age and to have little tendency for sand movement. Woody vegetation has developed in the lower areas around them. Known examples occur in areas where alteration of dunes may have blocked overwash, but their location high on dunes would protect them from overwash anyway.

Stable Dune Barrens remain open without sand movement or overwash, despite succession in adjacent lower areas. They are probably maintained by excessive soil drainage, but greater stress from salt spray at their relatively high location may contribute. They probably are undergoing slow primary succession and will eventually become more vegetated. Edges of patches often appear to be being invaded by vegetative reproduction from adjacent trees or shrubs.

Comments: Stable Dune Barrens were not well accommodated in the 3rd Approximation, where they were unclearly covered under Dune Grass or Maritime Dry Grassland. The Southern Subtype was not included in early drafts of the 4th Approximation Guide, though the Beach Heather Subtype was recognized. It was added later to accommodate the discovery of related communities farther south and linked to the NVC association first described in Florida. In North Carolina at least, it appears to be a more depauperate version of the Beach Heather Subtype, lacking the distinctive northern species but without corresponding addition of southern species.

It is not certain that the synonymy to the *Smilax auriculata / Heterotheca subaxillaris - Strophostyles helvola - (Uniola paniculata)* Herbaceous Vegetation association is appropriate. That association appears to be more like Dune Grass than the well-developed examples of Stable

Dune Barren in North Carolina. Multiple CVS plots attributed to that association in South Carolina also appear not to be as distinctive as well-developed Stable Dune Barrens.

Rare species:
Vascular plants – *Crocanthemum carolinianum, Crocanthemum corymbosum, Crocanthemum georgianum, Solanum pseudogracile, Trichostema nesophilum,* and *Yucca gloriosa*.

STABLE DUNE BARREN (BEACH HEATHER SUBTYPE)

Concept: Stable Dune Barrens are sparsely- to moderately-vegetated communities of inactive dunes and high sand flats of barrier island interiors, not dominated by *Uniola paniculata*, *Calamagrostis* (*Ammophila*) *breviligulata*, or *Schizachyrium littorale*. While *Schizachyrium littorale* and other Dune Grass species may be present in small amounts, the vegetation is predominantly species not found in Dune Grass communities. The community often includes substantial bare sand, but also may include open or patchy cover of woody vines, shrubs, and even trees. It occurs on broader barrier islands, in association with Maritime Evergreen Forest and Maritime Shrub.

The Beach Heather Subtype covers examples from Bodie Island northward, where *Hudsonia tomentosa* is a prominent component.

Distinguishing Features: Stable Dune Barrens are distinguished from Maritime Dry Grassland and Dune Grass by the scarcity of the grasses characteristic of those types. They are distinguished from Live Dune Barrens by a stable substrate and well-established, if sparse, vegetation. They are distinguished from all other barrier island communities by low plant cover and abundant dry, bare sand. These communities often occur in fine-scale mosaics with Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, Maritime Vine Tangle, and young Maritime Evergreen Forest in the heterogeneous environment created by irregular interior dunes. They may contain small inclusions of less barren woody or herbaceous vegetation.

The Beach Heather Subtype is distinguished by the presence of *Hudsonia tomentosa*, *Lechea maritima* var. *virginica*, or other species confined to more northern locations.

Crosswalks: *Hudsonia tomentosa* / *Panicum amarum* var. *amarulum* Dwarf-shrubland (CEGL003950).
G493 North Atlantic Coastal Dune & Grassland Group.
Northern Atlantic Coastal Plain Dune and Swale Ecological Systems (CES203.264).

Sites: Stable Dune Barrens occur on the tops of stabilized interior dunes that are somewhat sheltered from salt spray. They are well behind the foredunes and usually are also not close to the sound side of the island. They occur only on the broader barrier islands.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Stable Dune Barren sites are excessively drained. Rainwater infiltrates and drains through the soil rapidly, leaving the site dry.

Vegetation: Stable Dune Barrens have sparse vegetation in the center, though they may have more plant cover around the edges. *Hudsonia tomentosa* and *Lechea maritima* var. *virginica* are in all or most examples. Herbaceous species frequent in CVS plot data or site reports include *Crocanthemum canadense, Hypericum gentianoides, Hexasepalum (Diodia) teres*, and *Schizachyrium littorale*. Other characteristic herbs include *Panicum amarum, Chrysopsis gossypina, Polypremum procumbens, Krigia virginica, Cyperus grayi, Dichanthelium* spp.

(including *arenicoloides* and *fusiforme*), *Rumex acetosella, Oenothera humifusa, Euphorbia polygonifolia*, and *Opuntia drummondii*. A few species notable for their inland affinities, such as *Stipulicida setacea, Bulbostylis coarctata*, or *Pityopsis graminifolia,* may occur. *Smilax auriculata* or *Smilax bona-nox* var. *littoralis* are common in sprawling patches, most representing a single individual. These patches grade into larger patches that can be recognized as Maritime Vine Tangle occurrences. Occasional individuals of shrubs or vines may occur, including *Quercus virginiana, Pinus taeda, Diospyros virginiana, Quercus hemisphaerica, Morella cerifera*, and *Morella pensylvanica*.

Range and Abundance: Ranked G2G3. Fewer than ten examples occur in North Carolina, scattered from Currituck Banks to northern Bodie Island. The equivalent association ranges northward to New Jersey.

Associations and Patterns: Stable Dune Barrens are small patch communities. Many are complexes of multiple patches, individually mostly a couple acres or less, but sometimes adding up to dozens of acres. They are generally surrounded by Maritime Evergreen Forest or Maritime Shrub.

Variation: This community is very variable, and the variation is not well characterized. Examples can be heterogeneous over short distances.

Dynamics: The dynamics of Stable Dune Barrens and the environmental factors that lead to their occurrence are not well known. See the discussion for the Southern Subtype.

Comments: These communities were not well accommodated in the 3rd Approximation, where they did not quite fit Dune Grass or Maritime Dry Grassland.

Rare species:
Vascular plants – *Crocanthemum carolinianum, Crocanthemum corymbosum, Crocanthemum georgianum, Dichanthelium fusiforme, Hudsonia tomentosa,* and *Lechea maritima* var. *virginica*.

MARITIME DRY GRASSLAND

Concept: Maritime Dry Grasslands are communities of sand flats in the interior and back side of barrier islands, where periodic saltwater overwash in storms and salt spray prevent woody vegetation development. Vegetation is typically sparse- to moderate-density grassland dominated by *Spartina patens* or other grasses not in the Dune Grass type.

Distinguishing Features: Maritime Dry Grasslands are distinguished from all other communities by the dominance of *Spartina patens* in a dry, if often low-lying, setting. Wetland plants such as *Muhlenbergia filipes*, *Rhynchospora colorata*, *Fimbristylis castanea*, and *Juncus* spp., which indicate Maritime Wet Grassland, are absent or only incidentally present. Species that indicate Brackish Marsh, such as *Juncus roemerianus* and *Distichlis spicata*, are also scarce or absent. Maritime Dry Grassland sites may be overwashed during storms but do not show evidence of being flooded by tides. Despite the NVC name, *Schoenoplectus pungens* is not characteristic of this community in North Carolina but may sometimes spread from wetter communities nearby.

Maritime Dry Grasslands have very limited presence of species dominant in Dune Grass, such as *Uniola paniculata*, *Calamagrostis* (*Ammophila*) *breviligulata*, and *Schizachyrium littorale*, though they may share other species such as *Panicum amarum* and *Heterotheca subaxillaris*. Live Dune Barren and Stable Dune Barren communities may share some species but lack appreciable *Spartina patens* and occur on obvious dune topography.

Some areas where dunes have become more continuous may have vegetation transitional between Maritime Dry Grassland and Maritime Shrub, with substantial cover of woody shrubs. These may be classified by the predominant vegetation but may need to be regarded as naturally transitioning or artificially altered examples.

Crosswalks: *Spartina patens* - *Schoenoplectus pungens* - *Solidago sempervirens* Grassland (CEGL004097).
G493 North Atlantic Coastal Dune & Grassland Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Maritime Dry Grasslands occur on sand surfaces that are well above the seasonal high water table but tend to be flat and lower than the dunes. They may be in broad expanses at the back of barrier islands, in overwash passes between dunes, in dry dune swales, or potentially covering much of the area of low barrier islands.

Soils: Maritime Dry Grassland soils are sandy, often with abundant shells or shell fragments. They are typically the Corolla series (Aquic Quartzipsamment).

Hydrology: Maritime Dry Grasslands are dry to mesic but are not saturated for appreciable periods of time. Most, but not all, are subject to overwash by sea water during storms, or were at times in the past.

Vegetation: Maritime Dry Grassland vegetation is generally moderate to low in density. *Spartina patens* is constant and is usually dominant in CVS plots. *Hydrocotyle bonariensis* is frequent and sometimes abundant. Other fairly frequent species in plot data include *Oenothera humifusa, Heterotheca subaxillaris, Solidago mexicana, Croton punctatus, Cenchrus tribuloides, Fimbristylis castanea, Strophostyles helvola, Eustachys petraea,* and *Erigeron pusillus* (*Conyza canadensis* var. *pusilla*). *Uniola paniculata* may be present in small amounts, often forming incipient dunes that appear to be small inclusions in the community. Other species that are often observed include *Panicum amarum, Commelina erecta, Gaillardia pulchella, Eragrostis spectabilis, Setaria parviflora, Physalis walteri, Cakile harperi, Cakile edentula, Opuntia mesacantha*, and *Opuntia drummondii*. Shrubs may be present in small to moderate amounts. These may include species indicative of developing Maritime Shrub, such as *Morella cerifera* and *Ilex vomitoria*, or species shared with wetlands, such as *Iva imbricata* and *Baccharis halimifolia*. In examples that are undergoing succession, trees, especially *Juniperus silicicola*, may be present.

Range and Abundance: Ranked G2G3. Maritime Dry Grasslands are present intermittently throughout the coast of North Carolina. The synonymized association reaches its southern range limit in North Carolina and ranges northward to Massachusetts. Unlike many northern maritime communities which end their range near Cape Hatteras, Maritime Dry Grassland is present throughout the coast, down to the South Carolina line. It is similar enough throughout this range that it is hard to imagine that it is different in adjacent South Carolina.

Associations and Patterns: Maritime Dry Grasslands appear best regarded as large patch communities. Occurrences potentially range from a few acres to over 100 acres, but they are not a predicable part of the landscape of barrier islands.

Variation: Maritime Dry Grasslands are highly variable and heterogeneous, but no variants have been recognized. Plots and local patches vary with the transition to adjacent communities, and inclusions of both wetter and drier vegetation are common. Some examples are successional to Maritime Shrub and contain substantial woody vegetation. Examples also vary with recency of overwash and amount of recent sand deposition. Where a Maritime Dry Grassland has formed by burial of a marsh by overwash, some wetland species may grow through the sand deposit and be present in the community.

Dynamics: Maritime Dry Grasslands have distinctive dynamics among maritime communities. In addition to salt spray and sand movement, which are less intense than in Dune Grass, overwash is a crucial natural disturbance and environmental factor. Silander and Antonovics (1979, 1985) suggested that *Spartina patens* is most successful in the marshes, that populations in dry grasslands are peripheral and can be limited by competition, but that they ae successful through high phenotypic plasticity. Godfrey and Godfrey (1976) emphasized the importance of overwash in maintaining the character of Maritime Dry Grasslands. Overwash sand deposits may temporarily bury the vegetation, but *Spartina patens* is well adapted to both the salt exposure and the burial and quickly grows up through all but the thickest sand deposits. Many other species are short-lived and reestablish on new deposits.

Without overwash, shrubs can establish and Maritime Dry Grasslands can begin succession to Maritime Shrub and Maritime Evergreen Forest. The sand flats where Maritime Dry Grasslands occur can also begin developing dunes, with sand accumulating around individual clumps of *Uniola paniculata* that become established. Overwash may set back this succession as well.

Conversely, if the protecting dunes are eroded and overwash increases, woody maritime communities can be killed and marshes may be buried, and Maritime Dry Grassland can develop quickly.

Overwash dynamics depend both on storm frequency and on the configuration of the dunes. Godfrey and Godfrey (1976) emphasized that on islands where sand fencing and grass planting had occurred, the dunes were larger and more continuous than on the unaltered Core Banks, and that this had halted natural overwash and led to artificially induced woody succession behind the dunes. However, most of the artificial enhancement of dunes was done long ago, in the 1930s and 1950s, and it is unclear how well its effects would persist in this dynamic environment. The author has observed that, in recent years, Core Banks has fairly continuous dunes despite lack of enhancement, and that woody vegetation is widely established on the sand flats behind them. This may be a natural trend in response to climate patterns or a period with few storms.

Comments: Maritime Dry Grasslands are often not distinguished from Maritime Wet Grasslands in site descriptions, and the relative abundance of these two types is not well known. The nature of the transition to Maritime Wet Grassland needs further investigation. While there has been less scientific interest in Maritime Dry Grasslands than Dune Grass, they were well described by Au (1974) and Godfrey and Godfrey (1976), focusing on the middle Outer Banks, and were included in Rosenfeld (2004) at Bird Island. A moderate number of CVS plots and plots collected by NatureServe for the National Park Service represent them.

The synonymized NVC association name is somewhat misleading. Though *Schoenoplectus pungens* is part of the name, this species is uncommon in North Carolina examples, and generally indicates wetter conditions here. The NVC description indicates that it represents remnant individuals where sand movement has buried a dune swale, suggesting it may be of low constancy throughout the range of this association.

The synonymy of this subtype with a northern association may not be entirely appropriate. It is not clear that Maritime Dry Grasslands have more northern affinities than other North Carolina maritime communities, which are linked to associations that range to the south. However, it is possible that different overwash dynamics in the Sea Islands of South Carolina and Georgia creates a natural break.

Morella (pensylvanica, cerifera) / Schizachyrium littorale - *Eupatorium hyssopifolium* Shrub Herbaceous Vegetation (CEGL004240) is another northern maritime grassland community that was treated as a Northern Subtype in earlier drafts of the 4th Approximation. This has been dropped because it does not appear that any distinct examples are present in North Carolina. A couple of CVS plots attributed to it appear to be better treated as other communities.

Rare species:
Vascular plants – *Eleocharis halophilus, Eupatorium maritimum, Euphorbia bombensis, Paspalum vaginatum, Solanum pseudogracile,* and *Trichostema nesophilum.*

Vertebrate animals – *Charadrius melodus* and *Columbina passerina*.

MARITIME VINE TANGLE

Concept: Maritime Vine Tangles are communities of barrier island sand flats or stable interior dunes, dominated by woody vines but persistently lacking more than a few trees and shrubs. Patches are small but can be larger than would typically be regarded as a simple inclusion in another community.

Distinguishing Features: Maritime Vine Tangles are distinguished from all other communities by the dominance of *Smilax*, sometimes codominant with *Toxicodendron,* in tangles a meter or more tall. Sparse shrubs may be present beneath the vines, but many tangles appear to be self-supporting masses of vines that may be up to 2 meters tall. Maritime Shrub communities and canopy gaps in Maritime Evergreen Forest often have heavy vine cover, but Maritime Vine Tangles should be recognized only for apparently persistent vegetation consisting almost solely of vines. Barren sand areas with only small patches of vines running along the ground should not be classified here; they should be treated as part of the grassland or dune community.

These communities often occur in fine-scale mosaics with Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, Stable Dune Barren, or Maritime Evergreen Forest, in the heterogeneous environment created by irregular interior dunes. Interpretation of communities will depend on the scale at which these areas are viewed, with the smaller clumps of vines best regarded as part of the surrounding community.

Crosswalks: *Smilax auriculata - Toxicodendron radicans* Vine-Shrubland (CEGL003885).
G494 South Atlantic & Gulf Coastal Dune Grassland.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Maritime Vine Tangles occur in the interior of barrier islands, on stabilized dunes or sand flats that are somewhat sheltered from salt spray.

Soils: Soils are coarse sands that are dry to moist. This community might occur on Newhan (Typic Quartzipsamment) or Corolla (Aquic Quartzipsamment).

Hydrology: Sites for Maritime Vine Tangles potentially range from moist to xeric, varying with height above the seasonal high water table. They are in areas not subject to overwash or tidal flooding.

Vegetation: Maritime Vine Tangle vegetation consists of a dense mass of vines, usually predominantly *Smilax auriculata*, potentially mixed with *Toxicodendron radicans, Muscadinia rotundifolia,* or other vines. The vines stand at least a meter tall, and potentially 2 meters or more, primarily supported by the mass of vines itself. Sparse shrubs such as *Morella cerifera*, or trees, such as *Juniperus silicicola*, may be present but do not dominate the ground cover or provide most of the support for the vines. Species of other communities may be present in small numbers in openings.

Range and Abundance: Ranked GNRQ but probably G1? if valid. The range and abundance in North Carolina are not well known. Well-developed examples have been found only on Ocracoke

Island. Abundance will depend heavily on the interpretation of marginally developed examples and of what size is accepted as an occurrence. This community is presently known only in North Carolina but may be sought in other south Atlantic or mid-Atlantic states.

Associations and Patterns: Maritime Vine Tangles are small patch communities. They may occur in complexes adding up to several acres, but individual patches are generally less than ten meters wide. They may occur in a mosaic, most likely with Stable Dune Barren or Maritime Dry Grassland.

Variation: Little is known of the variation in this community.

Dynamics: Nothing is known of the dynamics of these communities. They mostly likely develop from open communities such as Stable Dune Barren or Maritime Dry Grassland, but given that small vine patches are common in those communities, it is unclear why a few places would become dense tangles while their surroundings stay open. A few dead shrubs are present in some examples, but not enough to suggest the Vine Tangle developed from Maritime Shrub.

Comments: This type is marginal for recognition as distinct, with most patches very small. However, it can be a prominent part of the mosaic of communities in barrier island interiors. It should be used only for the more extremely developed cases. It needs more investigation to determine its abundance and better understand its environmental relationships.

Rare species: No rare species are specifically known to be association with this community.

MARITIME UPLAND FORESTS THEME

Concept: The Maritime Upland Forests theme encompasses dry to mesic forest and shrubland communities on sandy soils within a few miles of the coast, dominated by a characteristic set of species that includes *Quercus virginiana, Juniperus silicicola*, *Ilex vomitoria*, and others that are relatively tolerant of salt and are rarely found inland. Many of the communities occur on barrier islands and coastal spits, where salt spray is an important ecological influence on plant composition and structure. There, canopies often are streamlined and visibly pruned by salt aerosol deposition, though salt spray is less extreme than in many Maritime Grassland communities. Other communities occur on small marsh islands or on broader upland flats a short way inland from the marshes, lacking obvious evidence of salt spray but having similar species composition. A few communities are also influenced by calcareous soil conditions created by concentrations of shells.

Distinguishing Features: Maritime Upland Forests are distinguished from other upland woody communities by occurring on barrier island or coastal spits, or by having vegetation dominated or codominated by species confined to near the coast in North Carolina. These species include *Quercus virginiana*, *Juniperus silicicola*, *Quercus hemisphaerica*, *Sabal palmetto*, *Cartrema americana*, *Prunus caroliniana*, *Ilex vomitoria*, and *Morella cerifera*.

Within the theme, a barrier island setting easily distinguishes Maritime Shrub, Maritime Evergreen Forest, and Maritime Deciduous Forest from other communities, while Coastal Fringe Evergreen Forest and Calcareous Coastal Fringe Forest are distinguished by mainland locations inland of the sounds or marshes. Marsh Hammocks are distinguished by location on small islands embedded in marshes. A few examples of Maritime Shrub or Maritime Evergreen Forest may occur on back-barrier islands in locations where spray of salt or brackish water in the sounds produces similar conditions.

Sites: Most Maritime Upland Forests occur on sand deposits, including stable dunes, former overwash flats that have become sheltered, and low terraces or mounds. A few occur on prehistoric shell middens or in sandy soils with enough shells to produce calcareous conditions. They are always located within a few miles of the coast but are at least somewhat sheltered from wind and salt spray compared to many of the Maritime Grasslands. Sites tend to be sheltered from frequent natural fire, by occurring on small islands or by being surrounded by relatively nonflammable vegetation.

Soils: Soils are generally sandy Entisols or Inceptisols, occasionally Spodosols. They have limited horizon development both because of young age and because of low clay content. Nutrient availability is less limited than in other sandy soils because of ongoing input by aerosols from sea water and because of shell fragments in the soil. Rare communities occur on concentrated shell deposits, either ancient man-made middens or natural accumulations; these soils are calcareous but are still sandy and well drained.

Hydrology: Soils are well drained to excessively drained. Topographic settings suggest a broad range of moisture levels, from xeric to mesic, accompanied with little visible change in vegetation. Sites are above normal flood levels and seasonal high water tables but may occasionally be disturbed by storm flooding. Water comes primarily from rainfall. Saltwater aerosol deposition is both an ongoing stress and a source of nutrients (Boyce 1954).

Vegetation: Vegetation is dominated by woody plants, ranging from shrubland to dense forest. The dominant trees most often include evergreen species, particularly *Quercus virginiana*, *Juniperus silicicola*, *Quercus hemisphaerica*, and *Pinus taeda*, but may also include a few deciduous species such as *Quercus falcata, Carya glabra*, and *Fagus grandifolia*, or calciphilic species such as *Celtis laevigata* and *Tilia americana* var. *caroliniana*. Understory and shrub species include evergreen species such as *Cartrema americana*, *Prunus caroliniana*, *Ilex vomitoria*, and *Morella cerifera*, as well as some more widespread deciduous species such as *Carpinus caroliniana* and *Benthamidia* (*Cornus*) *florida*. Shrublands tend to be dominated by the same shrub species, or by stunted individuals of the same tree species. Overall species richness tends to be low.

Dynamics: Maritime Upland Forests occur in the more stable and sheltered locations within the maritime environment, but the maritime environment is more dynamic than other parts of North Carolina. These communities are subject to extreme natural disturbance by wind, heavy salt spray, or saltwater intrusion during storms, and recovery may take several years. In addition to natural disturbance of vegetation, the environment itself may be drastically altered by natural processes of erosion and deposition. New examples of Maritime Evergreen Forest can develop from Maritime Shrub or various open grasslands by processes of primary succession if an area becomes more protected from salt spray and overwash. This can happen naturally if the coastline accretes seaward or if dunes grow and become stable, and it has happened in areas after dunes were artificially stabilized by planting and sand fencing. Forests potentially can be destroyed by migrating dunes or by erosion associated with migrating inlets, and this may have been more important in the past than at present. Examples can also be destroyed if sheltering dunes are eroded away or are artificially removed or their height reduced. Interior portions of forests may be damaged or altered indirectly by increased salt spray deposition if the seaward side of the patch is cleared.

The recent history and prevailing dynamics on at least the northern Outer Banks are uncertain or controversial. Brown (1959) noted the disagreement and contradictory reports about the amount of maritime forest in earlier history on the Outer Banks. Some believed there had been extensive forest that was destroyed by human activities such as grazing, farming, and burning, to create shifting sand on formerly stable islands. Brown himself suggested that forests were more widespread in the past, noting that the locations of villages likely had been forested. At the same time, he and others (Godfrey and Godfrey 1976; Hosier 1972; Birkemeier et al. 1984) cited extensive efforts by the National Park Service to enhance and stabilize the dunes in the northern half of North Carolina by planting grasses and placing sand fencing. Later authors attributed the development of woody communities to artificial dune stabilization and viewed the prevalence of instability and grassland vegetation as the natural state. Extensive urban development on the barrier islands has obscured the present natural patterns over large areas, but it is possible that both stability and instability prevailed in different places.

It is also possible that both such conditions prevailed at different times in the same places, in response to climatic cycles, and that both have existed at different times despite, rather than because of, human activities. Hurricane paths appear to follow a decadal cycle, producing periods of 10-20 years of greater or lesser activity in North Carolina. Longer term cycles are also likely. It has been 50 or more years since the concerted efforts at dune stabilization on most undeveloped islands, and it is unclear how long the effects would have lasted in such a dynamic environment, if there were not a natural tendency toward stability and dune development. At present, even the least altered barrier islands, such as Core Banks, show a tendency to develop fairly continuous dunes and enough sheltering for Maritime Shrub communities to develop. Though limited in woody vegetation, the recent history of the spit south of Fork Fisher is instructive. The author observed that a relatively continuous line of dunes, enhanced by human actions, was completely destroyed by a hurricane in the 1990s. However, a relatively continuous dune line had again formed, apparently without substantial human intervention, in just a few years. Nevertheless, extensive, well-developed examples of Maritime Upland Forests are largely confined to cape complexes, complex barrier islands with wide older portions, and a few south-facing islands with higher and more extensive dune fields — places that are more conducive to sheltering forests in the longer term.

The climate of the maritime environment is more moderate than in other parts of North Carolina. Winter low temperatures are less extreme, and summer high temperatures too are ameliorated by sea breeze and proximity to the thermal mass of the ocean. This is presumed to be the reason that many of the characteristic species are largely confined to the maritime environment in North Carolina but are more widespread farther south, and it may contribute to the high proportion of evergreen species. Floristically, the maritime forests of North Carolina may be argued to be a northern extension of the evergreen hardwood hammock vegetation that is more widespread farther south.

Salt spray has long been recognized as an important on-going stress in maritime communities (Boyce 1954; Wells 1939; Wells and Shunk 1937). This distinctive environmental factor has been recognized in maritime forests in many different parts of the world (Doutt 1941). Maritime forest canopies often become streamlined by the flow of salt-laden winds. Twigs that grow above the canopy receive much more salt spray and are quickly killed. It is widely recognized that salt spray stress is a filter that is responsible for the small number of species in Maritime Shrub and Maritime Evergreen Forest, and that those present are the most tolerant of salt spray. Given that thick cuticles and tough, thick leaves correlate with the evergreen habit, salt spray alone might be the cause of the evergreen character of the canopy.

Salt spray, despite causing stress, is also a source of nutrients for plants. In mainland locations, salt spray is less of a stress and canopies are not streamlined, but it likely still is an important source of nutrients. The coarse sandy soils are limited in nutrient-holding capacity. Bellis (1995) reviewed literature suggesting nutrient limitation is severe in the sandy soils, that most plant nutrients are contained in the biomass, and that nitrogen fixing and mycorrhizae are both particularly important, while also emphasizing the importance of aerosol inputs. He also noted that the warm, moist climate would enhance decomposition of litter and nutrient cycling, while the evergreen plants would spread litter input through the year. However, the sclerophyllous nature of the litter would slow decomposition rather than enhance it,

The role of fire in Maritime Upland Forests is subject to differing opinions. Studies farther south document frequent occurrence of fire (Huffman et al. 2004; Bratton and Davison 1987), but these were related to European settlement and land use on the larger and more attractive sea islands of that region. Human-caused fires likely occurred in places where settlers kept livestock, but habitation on North Carolina's barrier islands was sparse until recently, both after and before European colonization. Bratton and Davison (1987) indicated evidence of at least some fires of unknown cause before settlement in Buxton Woods, though it is unclear that they were frequent. Bellis (1995) believed fire was important in shaping maritime forests for thousands of years, attributing it to human action, but did not offer compelling evidence. He did, however, note the much lower frequency of dry lightning on the coast of North Carolina compared to Florida and Georgia.

It appears inescapable that, except in areas of intense human land use, fire must necessarily have been rare and less influential on barrier islands than on most of the mainland. Flammable vegetation is patchy on barrier islands, with bare sand, sparse grassland, and tidal channels fragmenting the marshes and shrublands. The major cause of frequent fire in the Coastal Plain, large fire compartments that allow the spread of fires over a large area from a single ignition, is absent there. Any natural fire in a maritime forest would need to be started by a lightning strike within its small area. Given the small size of maritime forest patches and their limited wildlife, one of the most important motivations for human ignition before the arrival of livestock would also have been absent.

Maritime forest vegetation itself is highly variable in flammability. *Quercus virginiana* and *Quercus hemisphaerica* litter is not very flammable. Pine needles are flammable and can drape shrubs and vines to create a thick fuel layer. Where dense shrub layers are dominated by species with waxy leaves, such as *Ilex vomitoria* or *Morella cerifera*, fires might carry readily and be intense. However, shrubs are often sparse under forest canopies. Because shrubs increase following storm disturbance, storms and fire might interact. Some of the characteristic species of maritime forests show adaptations useful in persisting with fire, such as the thick bark of *Quercus virginiana* and *Pinus taeda*, and the sprouting abilities of most of the hardwoods. However, they are mixed with species not well adapted to fire, such as thin-barked *Quercus hemisphaerica, Juniperus silicicola, Fagus grandifolia, Benthamidia* (*Cornus*) *florida*, and *Carpinus caroliniana*. The most fire-adapted species from the mainland, such as *Pinus palustris* and *Quercus laevis*, are scarce or absent in North Carolina's maritime forests.

Fire is a greater possibility in the Maritime Upland Forest communities on the mainland, where fires ignited anywhere over a large area could spread into a given site. Many mainland maritime communities are close to more flammable sandhill and flatwoods vegetation. However, many are interspersed with tidal creeks and swamps, which would inhibit fire spread. Like the barrier island communities, they are dominated by species with litter of limited flammability and contain many species not well adapted to fire. Natural limitations on fire spread may help determine the boundary between Maritime Upland Forests and neighboring longleaf pine communities.

Comments: The Maritime Upland Forest communities of barrier islands have intrigued ecologists from the early decades of the discipline. There is an extensive literature, only part of which is cited here. Wells and Shunk (1931), Wells (1939), Bordeau and Oosting (1959), Brown (1959), and Bellis (1980) made the vegetation and flora, as well as the distinctive structure, familiar to readers. Later synthetic works such as Bellis (1995) summarized the growing literature. However, some other communities within the Maritime Upland Forests theme, especially the coastal fringe communities and Marsh Hammock, have had only limited study. Maritime forests were the first target of CVS sampling in 1988, and the first data to be analyzed (Wentworth et. al. 1990), while more recent analysis of CVS data (Medford 2018) has examined vegetation patterns in more detail.

KEY TO MARITIME UPLAND FORESTS

1. Community a shrubland, with an upper canopy persistently less than five meters high; canopy may be dominated by shrub species such as *Morella cerifera* or *Ilex vomitoria*, or by stunted individuals of tree species, or by young individuals in sites that have not recently supported forest.

  2. Shrubland canopy dominated by tree species that grow taller in other settings, generally *Quercus virginiana* or *Juniperus silicicola*, less often *Pinus taeda* or *Quercus hemisphaerica*.... ....**Maritime Shrub (Stunted Tree Subtype)**

  2. Shrubland canopy dominated by species that do not grow into trees, generally *Morella cerifera, Morella pensylvanica*, or *Ilex vomitoria*.

    3. Shrubland canopy naturally dominated by *Morella pensylvanica*, sometimes codominant with other species; occurring on the northern Currituck Banks, in the northernmost part of the North Carolina coast. ....**Maritime Shrub (Bayberry Subtype)**

    3. Shrubland canopy dominated by other species, generally *Morella cerifera* or, less often, *Ilex vomitoria*. .... **Maritime Shrub (Wax Myrtle Subtype)**

1. Community a forest or, occasionally, a more open woodland, dominated by trees five meters or more tall (may be shorter if recently disturbed by storm but then with evidence of having been taller and of likelihood to again grow taller).

  4. Community occurring on a barrier island or coastal spit exposed to the open ocean, always within 3 miles of the ocean beach and usually within 1.5 miles; canopy stunted and streamlined due to pruning of emerging twigs by salt spray; generally only Maritime Shrub or communities of the Maritime Grasslands or Maritime Wetlands theme occurring between it and the beach (occasional fingers of Estuarine Communities may also intrude).

    5. Canopy dominated by some combination of *Quercus virginiana, Quercus hemisphaerica*, and *Juniperus virginiana*, along with *Pinus taeda*; generally almost no other tree species present (occasionally with a few *Prunus serotina*, *Diospyros virginiana*, or *Carya glabra* present).

      6. Canopy containing *Sabal palmetto* or occurring on islands where it is naturally present; rare community in North Carolina though more common southward, limited in North Carolina to the Smith Island complex, including Bald Head Island, and southward. .... **Maritime Evergreen Forest (South Atlantic Subtype)**

      6. *Sabal palmetto* not naturally present; community occurring elsewhere on the coast (including the south-facing Brunswick County coast) …………………………………….. .... **Maritime Evergreen Forest (Mid Atlantic Subtype)**

    5. Canopy generally dominated by *Fagus grandifolia* and *Quercus falcata*, in combination with *Pinus taeda*, occasionally with *Quercus nigra codominant*..**Maritime Deciduous Forest**

  4. Community occurring on a back-barrier island or mainland site within 10 miles of the coast, occasionally within two miles; canopy not pruned by salt spray; inland communities or large expanses of Estuarine Communities or Freshwater Tidal Wetlands occurring between it and the ocean beach.

    7. Community showing strong calcareous influence on the flora; soil containing abundant shell material, which may be from ancient anthropogenic shell middens or natural estuarine deposits; containing multiple calciphilic species and species unusual in maritime settings, potentially including *Sageretia minutiflora, Parietaria praetermissa, Parietaria floridana, Swida*(*Cornus*) *asperifolia, Celtis laevigata, Tilia americana* var. *caroliniana, Magnolia*

grandiflora, Ulmus rubra, *Aesculus pavia,* and *Aquilegia canadensis*, though the dominant species are generally more typical of Maritime Upland Forests.

8. Community persistently an open woodland, even in the absence of recent disturbance; substrate consisting primarily of shell, leading to excessively drained or unstable conditions; community extremely rare, with the only examples occurring on back-barrier islands embedded in Salt Marshes or lagoons. .... **Coastal Fringe Shell Woodland**

8. Community a forest, with a nearly closed canopy of tall trees when not recently disturbed; substrate with abundant shells with a sandy matrix, less excessively drained and generally stable; community very rare, with the handful of examples occurring on the mainland or on back-barrier islands.

9. Forest in the southernmost part of North Carolina (also in states to the south); containing *Magnolia grandiflora* and other species of more southern affinities. ....**Calcareous Coastal Fringe Forest (Southern Subtype)**

9. Forest farther north, with known examples from Onslow County to Currituck County; southern species such as *Magnolia grandiflora* absent. ....**Calcareous Coastal Fringe Forest (Northern Subtype)**

7. Community not showing strong calcareous influence; soil containing limited shell material; species listed above generally absent or only one or two species present in small numbers.

10. Very rare community occurring on relatively recently deposited sand spits along an estuarine river; canopy generally an open woodland; shrub and herbaceous flora a mix of maritime, estuarine, sandhill, and weedy species, including *Spartina patens*, *Panicum amarum* var. *amarum*, *Eustachys petraea*, *Carex arenaria, Elymus virginicus*, *Scleria flaccida*, and *Cyperus* spp.; presently known on in a few sites along the lower Cape Fear River ....**Coastal Fringe Evergreen Forest (Sand Spit Woodland Subtype)**

10. Community not on a sand spit along an estuarine river, or if so, lacking the above combinations of species.

11. Community in small patches embedded within a patch of Salt Marsh, Brackish Marsh, or potentially Tidal Freshwater Marsh, or at its edge along a tidal channel; canopy open or closed, trees often stunted or small; canopy of limited diversity, generally consisting of *Quercus virginiana* or *Juniperus silicicola*, though occasionally containing *Pinus taeda*; lower strata containing species shared with the adjacent marsh, such as *Juncus roemerianus* or *Spartina patens*. (If rarely dominated by *Pinus taeda*, the community is distinctly elevated above the marsh, is higher and drier than Estuarine Fringe Pine Forest, with sandy rather than mucky soil). .... **Marsh Hammock**

11. Community in large to small patches, occurring on the mainland, associated with some communities in addition to tidal marshes, though tidal marshes may also be adjacent; canopy of tall trees, generally closed if not recently disturbed, canopy potentially of slightly higher diversity, containing *Quercus hemisphaerica, Pinus taeda, Quercus virginiana*, less often *Juniperus silicicola*, and potentially also *Carya glabra, Quercus nigra, Quercus falcata*, and other species. (Note that overgrown Pine/Scrub Oak Sandhill (Coastal Fringe Subtype) communities may come to resemble this community, but they will be drier and may show evidence of *Pinus palustris* having been present. Note also that Swamp Island Evergreen Forest has similar canopy composition but has less of a maritime species component; it lacks *Ilex vomitoria* and is less likely to have abundant *Quercus virginiana*, and it occurs farther inland on upland islands surrounded by riverine or nonriverine swamps). .... **Coastal Fringe Evergreen Forest (Typic Subtype)**

MARITIME SHRUB (STUNTED TREE SUBTYPE)

Concept: Maritime Shrub communities are naturally short woody vegetation (less than 5 meters tall) of barrier island uplands and swales, where salt spray is a major influence on plant composition and stature. The Stunted Tree Subtype is dominated or codominated by *Quercus virginiana*, *Juniperus virginiana* var. *silicicola*, *Persea palustris*, or other tree species kept short by salt spray.

Distinguishing Features: Maritime Shrub communities are distinguished from Maritime Evergreen Forests and other forests by the stature of the canopy, which is persistently less than 5 meters tall. Usually, the canopy is streamlined and visibly pruned by salt spray. It may grade smoothly into Maritime Evergreen Forest with increasing canopy height as salt spray diminishes with distance from the ocean or as the ground drops behind dunes. Maritime Shrub is distinguished from Salt Shrub by species composition, with *Morella cerifera, Ilex vomitoria*, or other upland species dominant and with wetland species such as *Baccharis halimifolia* and *Iva frutescens* only a minor component if present. Some Maritime Shrub communities are transitional to Maritime Grasslands, having an open canopy. This boundary may depend on the spatial scale of focus, but in general is determined by the preponderance of shrub cover over herbaceous cover.

The flora of the Stunted Tree Subtype may be very similar to that of Maritime Evergreen Forest, with only the vegetation height distinguishing them, but often it has fewer species and is more likely to be dominated by *Juniperus silicicola* or *Quercus virginiana* rather than *Quercus hemisphaerica* or *Pinus taeda*. The Stunted Tree Subtype is distinguished from other subtypes by the dominance or codominance of species capable of becoming larger trees, rather than solely by *Morella cerifera*, *Ilex vomitoria*, or other shrubs.

Crosswalks: *Quercus virginiana - (Ilex vomitoria)* Shrubland (CEGL003833).
G494 South Atlantic & Gulf Coastal Dune Grassland Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Maritime Shrub occurs on barrier islands and coastal spits, in dune swales, on sand flats sheltered from overwash, and sometimes higher on the leeward slopes of dunes.

Soils: Most examples are mapped as Newhan (Typic Quartzipsamments) or Corolla (Aquic Quartzipsamment), a few as Duckston (Typic Psammaquent) or other sandy Entisols.

Hydrology: Hydrology is typical of the theme as a whole, ranging from apparently xeric to mesic. Salt spray is generally less than in Dune Grass but is substantial, enough to exclude even some species of Maritime Evergreen Forest and to limit the height of the canopy. Saltwater intrusion rarely if ever occurs and is a major disturbance if it does.

Vegetation: The vegetation is a thicket of shrubs and stunted trees less than 5 meters tall. In shorter examples, the tree crowns effectively extend to the ground. In taller examples, there may be open space beneath the canopy, but there are not distinguishable understory and shrub layers. The canopy typically is dense but may be open or may have small breaks in some cases. *Quercus* *virginiana* or *Juniperus silicicola* generally dominate the canopy, alone, together, or in combination with *Ilex vomitoria*. Infrequently, *Persea palustris*, *Prunus caroliniana*, *Prunus serotina*, or some other tree species may be abundant or even dominant in the canopy. CVS plot data also show high constancy and often high cover for *Morella cerifera*, *Smilax auriculata*, *Smilax bona-nox, Muscadinia rotundifolia, Parthenocissus quinquefolia*, and only slightly less for *Toxicodendron radicans*. Herbs have low cover beneath the canopy but may be locally more abundant in small openings. No herbaceous species are as constant as the woody dominants. The most frequent species are *Uniola paniculata, Solidago mexicana* (*sempervirens*)*, Galium bermudense, Opuntia drummondii*, *Spartina patens, Heterotheca subaxillaris*, and *Oenothera humifusa*. A wide variety of species of various Maritime Grassland communities may be present occasionally.

Range and Abundance: Ranked G3. The related association ranges from Virginia to Georgia. The Stunted Tree Subtype is scattered along the entire coast of North Carolina, but more sparsely than the Wax Myrtle Subtype. Most examples are on wider or more stable barrier islands, where they are associated with forests. However, new vegetation resembling this subtype is developing in sand flats where the dunes have become continuous and stable, either artificially or by apparently natural processes. This vegetation is depauperate compared to long-standing examples, but may become more like them over time.

Associations and Patterns: Maritime Shrub (Stunted Tree Subtype) most often occurs at the seaward edge of patches of Maritime Evergreen Forest, where salt spray becomes more extreme. Seaward, it gives way abruptly to Dune Grass, Maritime Wet Grassland, or Maritime Dry Grassland. Though the Stunted Tree Subtype usually occurs in association with Maritime Evergreen Forest, it can also occur as small isolated patches that "crouch" behind high dunes in a matrix of Dune Grass. Occasional examples may grade to marshes at the back of the island.

Variation: No variants are recognized at present, but they may be warranted. This community covers a broad geographic range, and biogeographic variation comparable to that in Maritime Evergreen Forest may exist. However, the more extreme environment and more depauperate flora may limit such variation. There also may be a worthwhile distinction between long-standing examples on the extremely streamlined leading edge of forest patches, and earlier primary successional examples I n places where shelter from salt spray has increased. The latter occur naturally in places where the coast has accreted or where growing dunes have increased shelter. A similar situation occurs where dunes have been artificially stabilized on narrower barrier islands. It can be difficult to distinguish these situations.

Dynamics: The dynamics of Maritime Shrub and Maritime Evergreen Forest have been the subject of intense scientific interest, as discussed in the Maritime Upland Forests theme description. As with other barrier island communities, Maritime Shrub communities occur in a dynamic environment. They may be temporarily disturbed or permanently converted to other community types by sand dune migration, loss of protection from salt spray, or erosion in severe storms. However, some examples, especially of this subtype, are old and have long been stable.

Examples may develop by primary succession if protection from salt spray and overwash increases. This appears to be happening naturally in places where the coastline has accreted, such as in some areas near Cape Hatteras. An artificially caused analogue develops in places where sand dunes have been increased by sand fencing and planting. The shrublands in these places may come to resemble more natural examples over time but appear to remain depauperate and not well developed decades after the dunes were stabilized.

The vegetation height that marks the conceptual threshold between Maritime Shrub and Maritime Evergreen Forest is very sensitive to changes in sheltering from salt spray, because the gradient in salt spray influence is steep. Where Maritime Shrub has been cleared at the seaward edge of a forest patch, the nearby forest canopy often dies back and is reduced in stature, developing a new shrub-height leading edge.

Comments: Because this subtype can be so floristically similar to Maritime Evergreen Forest, Medford's (2018) analysis did not distinguish it readily. Some CVS plots clustered together in a group that was recognized as such, but more plots were in forest clusters. Plot data cannot always be distinguished readily by cover data alone, and canopy height may be needed for accurate identification of this community. Maritime Evergreen Forest plots that have been recently disturbed and are dominated by understory and shrub species may conversely be difficult to recognize in plot data, but generally are apparent in the field by their location and the presence of dead trees.

Rare species:
Vascular plants – *Crocanthemum georgianum*, *Sabal palmetto*, *Solanum pseudogracile,* and *Solidago villosicarpa*.

Vertebrate animals – *Lampropeltis getula sticticeps* and *Passerina ciris*.

Invertebrate animals – *Heraclides cresphontes*.

MARITIME SHRUB (WAX-MYRTLE SUBTYPE)

Concept: Maritime Shrub communities are naturally short woody vegetation (persistently less than 5 meters tall) of barrier island uplands and swales, where salt spray is a major influence on plant composition and stature. The Wax-Myrtle Subtype covers examples dominated by shrub species, generally *Morella cerifera* alone or with *Ilex vomitoria*, without appreciable numbers of species capable of becoming larger trees.

Distinguishing Features: The Maritime Shrub type is distinguished from Maritime Evergreen Forest and other forests by the stature of the canopy, which is persistently less than 5 meters tall. Some Maritime Shrub communities are transitional to Maritime Dry Grassland or Maritime Wet Grassland, having an open canopy and a substantial presence of herbs. This boundary is determined by the preponderance of shrub cover and the amount of the area where herb cover is suppressed by shrubs.

The Wax Myrtle Subtype may be wetter than the Stunted Tree Subtype, extending into marginal wetland conditions, but similar vegetation occurs in areas that do not appear wet. It may be difficult to distinguished from Salt Shrub, which can also have substantial *Morella cerifera*, but it has only limited amounts of *Iva frutescens, Baccharis halimifolia*, *Borrichia frutescens*, or other more salt-tolerant species.

The Wax Myrtle Subtype is distinguished from other subtypes by the absence or low cover of *Quercus virginiana, Juniperus silicicola*, and other species capable of becoming larger trees, along with the absence of *Morella pensylvanica*.

Crosswalks: *Morella cerifera / Spartina patens* Wet Shrubland (CEGL003839)
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Maritime Shrub occurs on barrier islands and coastal spits, in dune swales, sand flats sheltered from overwash, sometimes higher on the leeward side of dunes. The Wax-Myrtle Subtype can occur in more exposed sites than the Stunted Tree Subtype, in places more prone to flooding by saltwater intrusion, and in wetter swales.

Soils: Examples are most often mapped as Duckston (Typic Psammaquent) and Corolla (Aquic Quartzipsamment) but may occur on other sandy Entisols.

Hydrology: Sites are dry to mesic or moderately wet. Examples in swales may have periodic high water tables, but long-term wetness is difficult to distinguish given the sandy soil and sometimes depauperate flora. As conceived, this community may cross the boundary between upland and marginal wetland, overlapping Maritime Wet Grassland in moisture regime. Salt spray is usually substantial, excluding most plant species and limiting the height of vegetation, but may be less in some swales. Saltwater intrusion is rare but is more likely to occur than in the Stunted Tree Subtype.

Vegetation: The vegetation includes a dense or open canopy of shrubs, with *Morella cerifera* dominant, alone or codominant with *Ilex vomitoria*. *Baccharis halimifolia* or various tree species may be present in small numbers or low cover. Vines may be extensive or absent. *Toxicodendron radicans* is the most frequent species, but *Smilax bona-nox, Smilax auriculata, Nekemias arborea*, or other species may be present. Herbs may be nearly absent in dense examples, or may be diverse and have moderate, even high, cover in open examples. CVS plot data analyzed by (Medford 2018) indicate extreme variability in species present and their cover. *Spartina patens, Hydrocotyle bonariensis, Uniola paniculata*, and *Solidago mexicana* (*sempervirens*) have high constancy in the data, and all but the last sometimes have as much cover as the shrubs. Some of these details may be unreliable, as plots may include edges with open vegetation and there may be a sampling bias toward more open shrublands. There may also be confusion of plots from this community with Salt Shrub and marsh ecotone areas. However, more general observations show that any species of Maritime Dry Grassland or Maritime Wet Grassland may be present in open examples in dune swales. *Juncus roemerianus* may occasionally be extensive, even in swales isolated from salt marshes.

Range and Abundance: Ranked G3G4. This subtype occurs throughout the coast of North Carolina except possibly in the northernmost part. Suitable environments are more abundant than for the Stunted Tree Subtype, and it probably is more abundant, but examples often are not well reported. The equivalent NVC association, as very broadly defined, ranges from Maryland and Delaware to Florida. The high uncertainty in the global rank probably reflects confusion over how the synonymized association is defined.

Associations and Patterns: This community occurs as small to large patches and tends to be present in all but the lowest and most frequently overwashed parts of barrier islands. It can occur in small, sheltered microenvironments within Dune Grass communities. It can also occur in deeper dune swales, where it grades to Maritime Wet Grassland or Maritime Dry Grassland. It may occur as a "leading edge" to a forest patch, but less often than the Stunted Tree Subtype. Patches may also occur on the sound side of barrier islands, where they can be difficult to distinguish from Salt Shrub.

Variation: Examples vary over a wide range of shrub density, herb density, and composition of the herb component, as well as a wide range of wetness and exposure to disturbance. Three variants are recognized:

1. Closed Variant encompasses examples with dense shrubs and few openings. They have little herb cover and few species.

2. Dry Open Variant includes examples with less dense shrub layers, occurring on dunes and elevated sand flats. They have a low to moderate density of herbs such as *Uniola paniculata, Hydrocotyle bonariensis, Oenothera humifusa, Erigeron pusillus* (*Conyza canadensis*)*, Strophostyles helvola, Panicum amarum*, *Physalis walteri*, and other species shared with Dune Grass.

3. Wet Open Variant includes examples with less dense shrub layers, occurring in dune swales and on low flats. They have a low to high cover of herbs shared with Maritime Wet Grassland,

especially *Spartina patens*, but including *Hydrocotyle bonariensis, Juncus megacephalus, Juncus scirpoides, Centella erecta, Setaria parviflora*, *Hydrocotyle verticillata*, and many others. This variant may be the most distinct; given that it appears to be a true wetland, it perhaps should be distinguished as a separate community type.

Dynamics: As with other barrier island communities, Maritime Shrub communities occur in a dynamic environment, and the Wax Myrtle Subtype may be especially dynamic. Some patches occur just behind the foredunes, in areas only marginally suitable for woody vegetation because of high salt spray. Others occur in dune swales that occasionally receive saltwater flooding during storms, so that the vegetation is killed and plants must establish anew. Other examples occur in stabilized sheltered swales, which may be subject to the stress of high water tables in wet years. Some examples are stable over long periods, maintained by salt spray, while others may be a stage in primary succession that will give way to a forest.

Morella cerifera supports symbiotic bacteria that fix atmospheric nitrogen. This may potentially make this community particularly fertile, but given the environmental stresses it endures, it is unclear if this potential is realized.

Comments: This subtype is somewhat problematic in its hierarchical placement and synonymy. *Morella cerifera* shrublands with limited wetland vegetation range from sites in low swales to drier overwash flats to higher on dune slopes. They may be closely associated with Maritime Wet Grassland, Maritime Dry Grassland, or Dune Grass. It appears unwise to divide them into separate types for wet and dry sites when their vegetation is similar and no other differences are obvious. Their placement in Maritime Upland Forests rather than in Maritime Wetlands is therefore somewhat arbitrary. The NVC association is specifically described as a wet community, but no similar dry association exists. The NVC association is very broadly defined, including northern wetland swales containing *Vaccinium macrocarpon* and other species suggestive of a very different community. It presumably will be divided when it receives further attention. While NVC sets a shrub cover threshold of 25% for recognizing this association, a somewhat higher cover threshold is desirable. Vegetation with 25% shrub cover can have a dense and diverse herb layer indistinguishable from a shrubless maritime grassland community.

This community was called the Shrub Subtype in earlier editions of the 4th approximation guide, and the Bayberry Subtype was called the Northern Subtype. After changes in the NVC, the association equivalent of the Wax Myrtle Subtype ranges well to the north of North Carolina, and the names were changed to reduce confusion.

Rare species:
Vascular plants – *Elymus halophilus* and *Solanum pseudogracile.*

Vertebrate animals – *Lampropeltis getula sticticeps* and *Passerina ciris.*

Invertebrate animals – *Heraclides cresphontes.*

MARITIME SHRUB (BAYBERRY SUBTYPE)

Concept: Maritime Shrub communities are naturally short woody vegetation (persistently less than 5 meters tall) of barrier island uplands and swales, where salt spray is a major influence on plant composition and stature. The Bayberry Subtype covers rare examples in the northernmost part of the state which have *Morella pensylvanica* dominant or codominant in them. Stunted trees may be present at low density.

Distinguishing Features: The Maritime Shrub type is distinguished from Maritime Evergreen Forest and other forests by the stature of the canopy, which is persistently less than 5 meters tall. The Bayberry Subtype is distinguished by the dominance or codominance of *Morella pensylvanica*. A few small trees may be present, either as stunted individuals or as initial colonization of the shrubland by trees as part of primary succession. However, areas dominated by small trees should be treated as the Stunted Tree Subtype. Areas that show evidence of having had larger trees in the recent past and that appear likely to recover to forest should be treated as a disturbed Maritime Evergreen Forest.

Crosswalks: *Morella pensylvanica / Diodia teres* Shrubland (CEGL003881).
G493 North Atlantic Coastal Dune & Grassland Group.
Northern Atlantic Coastal Plain Dune and Swale Ecological Systems (CES203.264).

Sites: The Bayberry Subtype occurs exclusively on the Currituck Banks, the northernmost coast in North Carolina. Examples occur immediately behind the foredunes. No overwash flats are known on this part of the coast, but if they occurred, this community might develop on them.

Soils: The Bayberry Subtype may occur on any of the sandy Entisols characteristic of the barrier islands.

Hydrology: Sites are dry to mesic or moderately wet. Salt spray is generally less than in Dune Grass but is substantial, enough to exclude even some species of Maritime Evergreen Forest and to limit the height of the canopy. Saltwater intrusion rarely if ever occurs, and is a major disturbance if it does.

Vegetation: The vegetation includes a dense or open canopy of shrubs, with *Morella pensylvanica* dominant or codominant. Small trees as well as shrubs may be present in lesser amounts. Limited plot data from North Carolina and Virginia show additional frequent woody species as *Baccharis halimifolia, Prunus serotina*, *Diospyros virginiana, Toxicodendron radicans*, *Muscadinia rotundifolia*, and *Salix caroliniana*. *Spartina patens* is present in almost all examples and can have moderate cover. Other herbs vary widely, and include many species shared with Dune Grass, Maritime Dry Grassland, and Maritime Wet Grassland. A few include *Uniola paniculata, Panicum/Coleataenia* sp., *Andropogon virginicus, Cenchrus tribuloides, Erigeron pusillus* (*Conyza canadensis*)*, Hexasepalum (Diodia) teres*, and *Eupatorium* sp.

Range and Abundance: Ranked G2. This subtype is present in North Carolina only on the Currituck Banks, the southernmost native range extent for *Morella pensylvanica*. Its abundance there is poorly known but it appears to be very rare even there. It was first defined in Virginia, and ranges northward to Delaware.

Associations and Patterns: The Bayberry Subtype occurs as small patches, at least in North Carolina. It may be associated with Dune Grass or Maritime Wet Grassland, potentially with Maritime Dry Grassland or Maritime Evergreen Forest. It appears that the Wax Myrtle Subtype may also occur on the Currituck Banks, and the relationship between the two subtypes there is not known.

Variation: Little is known about the variation in North Carolina. Examples appear to vary in ways similar to the Open Dry and Open Wet variants of the Wax Myrtle Subtype, ranging from wet to dry and sharing species with the grassland communities of those environments.

Dynamics: Little is known specifically about the dynamics of this community in North Carolina. The natural range of possible dynamics probably resembles that of the Wax Myrtle Subtype. All North Carolina examples occur on the northern Currituck Banks, an area that is particularly poorly studied. Grass planting and artificial dune stabilization are believed to have been extensive in this area, but as discussed in the theme description, there is general uncertainty about the persistence of their impact. In any case, it is clear that at some time in the past, if not recently, the Currituck Banks has experienced the same range of stability and instability as other parts of the Outer Banks and that the Bayberry Subtype coexisted with it.

Comments: The Bayberry Subtype is poorly studied, but some CVS plots exist for it. Its relationship to other communities in the area is not well known. It appears that the Wax Myrtle Subtype co-occurs with it on the Currituck Banks.

Rare species: No rare species are known to be specifically associated with this community.

MARITIME EVERGREEN FOREST (MID-ATLANTIC SUBTYPE)

Concept: Maritime Evergreen Forests are evergreen hardwood-pine forests of barrier islands and coastal spits. Salt spray is a major environmental factor in these communities, and its influence generally is indicated by a distinctively streamlined canopy form. The vegetation is dominated by some combination of *Quercus virginiana, Quercus hemisphaerica*, *Pinus taeda*, and *Juniperus silicicola*. The Mid-Atlantic Subtype covers most of the maritime forests in North Carolina, where deciduous canopy trees are largely absent and where more southerly species, particularly *Sabal palmetto*, are absent.

Distinguishing Features: The Maritime Evergreen Forest type is distinguished from all other communities by the combination of evergreen forest vegetation with a canopy greater than 5 meters tall and location on a barrier island or comparable coastal spit. Examples usually have a compact, streamlined, salt-pruned canopy, though those dominated by *Juniperus* may not. Deciduous trees are largely absent, and the characteristic evergreen trees listed above make up most of the canopy in varying abundance. Maritime Evergreen Forest is distinguished from Marsh Hammock by having a broader set of the characteristic species, by generally having a streamlined canopy, and by the general absence of marsh and shade-intolerant herbs. It also occurs in a different setting, on barrier island interiors rather than on small raised patches within salt marshes.

These communities are periodically subject to heavy disturbance by hurricanes. Hard-hit examples may take some years to recover a closed canopy, but they should be classified as Maritime Evergreen Forest unless major erosion has changed the environment so that forest cannot recover.

The South-Atlantic Subtype is distinguished from the Mid-Atlantic Subtype in North Carolina by the presence of *Sabal palmetto*, though that species may have limited cover.

Crosswalks: *Quercus virginiana - Quercus hemisphaerica - Pinus taeda / Persea palustris - Ilex vomitoria* Forest (CEGL007027).
G798 Coastal Live Oak - Hickory - Palmetto Forest Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Maritime Evergreen Forests occur on barrier islands and coastal spits, on stabilized dunes and flats protected from saltwater flooding and from the most extreme salt spray. Most examples are limited to wider barrier islands with substantial dune development. A few occur on back-barrier islands in sounds or embedded in marshes near the coast.

Soils: Most examples are mapped as Newhan or Fripp series (Typic Quartzipsamments), some as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent), or a few as other sandy Entisols.

Hydrology: Hydrology is typical of the theme as a whole, ranging from apparently xeric to mesic. Salt spray is significant enough to shape the canopy and to exclude many plant species but is less extreme than that in most Maritime Shrub.

Vegetation: Vegetation is generally a closed forest with a dense canopy, though the canopy may be open in recently disturbed examples and in newly developed examples. The canopy is composed of varying combinations of *Quercus virginiana, Quercus hemisphaerica*, *Pinus taeda*, and *Juniperus silicicola*. All have fairly high constancy, and any may dominate. Usually, no other canopy trees are present, but occasional *Diospyros virginiana, Prunus serotina*, *Carya glabra*, *Zanthoxylum clava-herculis*, or species of the understory may occur. Frequent understory species in CVS plot data and site descriptions are *Persea palustris* and *Cartrema americana*, while *Prunus caroliniana, Ilex opaca, Carpinus caroliniana*, *Benthamidia* (*Cornus*) *florida*, and canopy species are also fairly frequent. The shrub layer ranges from sparse under dense canopy to very dense where the canopy is open. *Ilex vomitoria* is almost always present and usually dominant. Saplings of oaks and of understory species may also be dense, and *Morella cerifera, Baccharis halimifolia,* or *Rhus copallinum* may be abundant in more open or recently developed examples. *Callicarpa americana* and *Hypericum hypericoides* are often present in small numbers. Vines are usually abundant, covering the ground in dense forest but sometimes draping the trees where the canopy has been disturbed. *Muscadinia rotundifolia* var. *rotundifolia, Toxicodendron radicans*, *Smilax bona-nox, Smilax auriculata, Smilax rotundifolia,* and *Parthenocissus quinquefolia* are the most frequent and abundant. *Berchemia scandens* also is frequent in plot data, and *Bignonia capreolata, Gelsemium sempervirens*, and *Nekemias* (*Ampelopsis*) *arborea* are frequently observed. The herb layer is sparse to moderate in density. Plot data shows few herbs. *Galium bermudense, Dichanthelium commutatum,* and various other *Dichanthelium* species are the most frequent. Other species observed to be abundant in some examples or present in many include *Mitchella repens, Piptochaetium avenaceum, Asplenium platyneuron, Chasmanthium laxum, Chasmanthium sessilifolium, Scleria flaccida*, and *Oplismenus setarius*. *Tillandsia usneoides* is sometimes abundant as an epiphyte. In open examples or examples transitional to wetter communities, additional species such as *Spartina patens, Hydrocotyle bonariensis, Uniola paniculata*, or even *Juncus roemerianus* may be present.

Range and Abundance: Ranked G2. North Carolina examples are scattered along the coast from the Virginia line southward to the Carolina Beach area, with a few examples on exposed islands in brackish or saltwater sounds. This subtype ranges into southern Virginia. It is replaced by the South Atlantic Subtype from Bald Head Island southwestward in North Carolina. See the discussion below about areas farther south.

Associations and Patterns: Maritime Evergreen Forest usually grades into Maritime Shrub at more exposed seaward edges. However, it may abruptly border Dune Grass or Maritime Grassland on the seaward edge, and often borders them on other edges. It may grade to Salt Shrub and various other Estuarine Communities or Freshwater Tidal Wetlands communities on the landward side of islands. Maritime Evergreen Forest may also grade to Maritime Swamp Forest, Maritime Shrub Swamp, or Interdune Pond in wet swales.

Variation: Wentworth, et al. (1990), analyzing woody stem data in the early CVS plots, found the most fundamental division to be between forests dominated by *Quercus virginiana* and *Quercus hemisphaerica* and those dominated by *Pinus taeda*. Medford's (2018) analysis of cover data in CVS plots recognized a different configuration of three major divisions within the range of Maritime Evergreen Forest vegetation, though not all were called by that name. One consists of plots dominated by *Quercus virginiana* or *Juniperus silicicola*, another by *Quercus hemisphaerica* or *Pinus taeda*. The third major group consisted of plots dominated by *Quercus virginiana* and *Pinus taeda* with more limited species richness, all from the Currituck Banks. Subdivisions within the first two groups also show a strong geographic signal, with most of the plots from one location (Bogue Banks, Buxton Woods) clustering together. Other subdivisions reflected plots transitional to Maritime Shrub or Maritime Wet Grassland.

Because the distribution of maritime forests is discontinuous, and because natural and human disturbance history is confounded with geographic location, it is unclear how many of these differences are useful for classification of natural conditions. Dominance by pines is problematic for differentiating subtypes because, though relatively less tolerant of salt spray, their abundance can change drastically and persistently in response to single disturbances. Nevertheless, a division based on apparent primary successional age may be useful, and recognition of the most striking geographic break seems warranted. Based on this, three variants are recognized:

1. Northern Variant includes the examples on Currituck Banks. They have more *Diospyros virginiana* and *Prunus serotina*, in common with maritime forests farther north, while lacking some of the southern species such as *Prunus caroliniana*.

2. Live Oak–Red Cedar Variant includes forests south of the Currituck Banks that are heavily dominated by *Quercus virginiana* or *Juniperus silicicola*, generally lacking pines and *Quercus hemisphaerica*. They tend to occur in more exposed or successionally younger areas.

3. Laurel Oak—Pine Variant includes forests south of Currituck Banks with substantial *Quercus hemisphaerica* or *Pinus taeda*. *Quercus virginiana* may also be abundant, but only rarely is *Juniperus silicicola* important. This variant occurs in areas that are both more sheltered or farther from the ocean and are generally later in primary succession.

Dynamics: The dynamics of this subtype are similar to the theme as a whole, especially the barrier island portion of it. Salt spray is an important factor in excluding many species, as well as in shaping the canopy.

Storm disturbance can create long-lasting changes in composition, as can historical land use. This is exemplified by Buxton Woods. Brown (1959) described it as being dominated by *Quercus virginiana* and *Pinus taeda*, but selective logging of *Quercus virginiana* as early as the 1700s (Bratton and Davison 1987) had reduced the abundance of that species and increased the pine. Brown (1959) noted that the forest was being logged as he studied it. C.W. Brown's (1983) palynological record dating back 895 years found relatively stable vegetation with 51% oak and 30% pine pollen and a small amount of hickory, until 1700. In the most recent record, oak pollen constituted 6% and pine 80%. When sampled by CVS in 1988, the forest was strongly dominated by *Pinus taeda*, with an understory dominated by *Quercus hemisphaerica*. A hurricane later killed most of the pines through breakage and salt spray, leaving a shorter canopy dominated by *Quercus hemisphaerica*. Despite its greater tolerance to the salt spray that apparently killed most of the pines, *Quercus virginiana* remained a small component. Accretion of the island and concomitant increasing shelter from chronic salt spray may have changed the environment enough that it is now more favorable to *Quercus hemisphaerica*. The dramatic changes documented at Bull Island in South Carolina (Helm, et al. 1991, Conner et al. 2005), with a shift from pine dominance to oak in response to a hurricane but perhaps also in response to ongoing beach erosion, also illustrate the potential dynamics of maritime forests, though that site is the South Atlantic Subtype rather than the Mid-Atlantic Subtype. More general observations suggest that effects of storm disturbance can vary, sometimes increasing pines, sometimes decreasing them. Storms can also leave forests with broken canopies and dominance by understory species for many years. Human disturbance such as logging or clearing usually leads to pine dominance, often initially with little understory and with dense tangles of vines.

Maritime Evergreen Forests can potentially develop quickly from Maritime Shrub if an area becomes more sheltered, with stunted trees growing to forest stature. More often, it seems to occur gradually through a process of scattered trees coalescing into more continuous canopy. It may be that common processes of primary succession, such as accumulation of nutrients and soil organic matter, amelioration of the environment by vegetation, are needed to facilitate forest development. It may also be that in environments that are only marginally suitable for this community, tree establishment is a rare event, leaving the closure of the canopy to occur through vegetative spread rather than extensive establishment from seed. The first trees to establish seem to be *Juniperus silicicola* or *Quercus virginiana*, the most salt-tolerant trees, with *Pinus taeda* and *Quercus hemisphaerica* appearing later.

Maritime Evergreen Forests are very susceptible to alterations in wind flow patterns, because of the effect on salt spray deposition. Breaks in the canopy can potentially create eddies that concentrate salt spray deposition and lead to death of trees around the opening. Loss of the Maritime Shrub community on the seaward edge of the forest can lead to canopy death or severe salt-pruning, effectively turning part of the forest into a new Maritime Shrub edge. This was documented by Lopazanski (1987) on Bogue Banks, and can be observed in other developed areas.

Comments: This subtype is what most people think of as the typical maritime forest in North Carolina. It was the primary focus of the early ecological studies such as Wells and Shunk (1931), Wells (1939), Bordeau and Oosting (1959), and Brown (1959), as well as the primary focus of most of the later studies.

With their restriction to the most stable, sheltered parts of barrier islands, these communities have always been very limited in extent. This sheltered environment has long been the focus of habitation and other human activities on the islands, and the destruction of maritime forests by development accelerated in the late 1900s. While some developments were created with efforts to minimize clearing and to retain the forest canopy, the creation of numerous small clearings for houses presumably has had far-reaching effects on the dynamics of the forests.

The range and ecology of this subtype south of North Carolina is somewhat unclear. In North Carolina, it is distinguished by the absence of more southern species such as *Sabal palmetto* and represents a latitudinal shift in communities. However, the corresponding NVC association is attributed to South Carolina and questionably to Georgia, within the range of these southern species. Some South Carolina plots were clustered with the North Carolina plots for this subtype in the Medford (2018) analysis. The low cover of the indicator species may make recognition in plot data difficult; however, some barrier islands in South Carolina apparently have maritime forests resembling this subtype, lacking *Sabal palmetto, Pinus elliottii*, and other southern species. The distinction between subtypes may thus be ecological as well as biogeographic.

Pinus taeda / *Hudsonia tomentosa* Woodland (CEGL006052) is an open maritime forest described from southeasternmost Virginia. Comparable vegetation may occur on the Currituck Banks, but none is known. Maritime Forests on the Currituck Banks tend to be more open than farther south, and have openings containing *Hudsonia tomentosa*, but have more *Quercus virginiana*. These are considered part of this Maritime Evergreen Forest community. However, interpretation is confused by the tendency of pines to increase in examples that have been artificially cleared in the past.

Pinus taeda - Quercus (falcata, nigra) / Morella cerifera / Vitis rotundifolia Forest (CEGL006040) is another pine-dominated open forest that occurs in maritime areas of Virginia. No natural vegetation of this kind is believed to exist in North Carolina, though it appears more closely related to Maritime Deciduous Forest than Maritime Evergreen Forest.

Rare species:
Vascular plants – *Carex calcifugens, Clematis catesbyana, Corallorhiza maculata* var. *maculata, Crocanthemum georgianum, Cyperus tetragonus, Dichanthelium bicknellii, Erythrina herbacea, Oplismenus setarius, Parietaria praetermissa, Sageretia minutiflora, Sideroxylon tenax,* and *Tridens chapmanii*.

Nonvascular plants – *Cheilolejeunea rigidula, Microlejeunea epiphylla, Plagiochila miradorensis* var. *miradorensis, Syrrhopodon incompletus,* and *Teloschistes flavicans*.

Vertebrate animals – *Lampropeltis getula sticticeps, Micrurus fulvius fulvius, Passerina ciris,* and *Peromyscus leucopus buxtoni*.

Invertebrate animals – *Heraclides cresphontes, Satyrium favonius favonius,* and *Zale declarans.*

MARITIME EVERGREEN FOREST (SOUTH-ATLANTIC SUBTYPE)

Concept: Maritime Evergreen Forests are evergreen hardwood-pine forests of barrier islands and coastal spits. Salt spray is a major environmental influence on these communities, and its influence generally is indicated by a distinctively streamlined canopy form. The South-Atlantic Subtype encompasses the forests from southeastern North Carolina southward, where *Sabal palmetto* mixes with the dominant combinations of *Quercus virginiana, Quercus hemisphaerica*, *Pinus taeda*, and *Juniperus silicicola*.

Distinguishing Features: The Maritime Evergreen Forest type is distinguished from all other communities by the combination of evergreen forest vegetation with a canopy greater than 5 meters tall when not recently disturbed, along with location on a barrier island or comparable coastal spit. The South Atlantic Subtype is distinguished by the native presence of *Sabal palmetto* in the stand. *Sabal palmetto* may be a small component or may codominate; it generally is well distributed in the community but may be absent from individual plots. South of North Carolina, *Pinus elliottii* also distinguishes this subtype.

Crosswalks: *Quercus virginiana - (Pinus elliottii, Sabal palmetto) / Persea borbonia - Callicarpa americana* Forest (CEGL007032).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: The South Atlantic Subtype occurs on barrier islands, on stable dunes, swales, and flats protected from saltwater flooding and from the most extreme salt spray.

Soils: Examples are mapped as Newhan or Fripp (Typic Quartzipsamments), but could potentially occur on other sandy Entisols.

Hydrology: Hydrology is typical of the theme as a whole, ranging from apparently xeric to mesic. Salt spray is significant enough to shape the canopy and to exclude many plant species but is less extreme than that in Maritime Shrub.

Vegetation: Maritime Evergreen Forest vegetation is generally a closed forest with a dense canopy, though the canopy may be open or may be dominated by understory species in recently disturbed areas. The South-Atlantic Subtype canopy is composed of varying combinations of *Quercus virginiana, Quercus hemisphaerica*, *Pinus taeda*, and *Juniperus silicicola*, with small to large numbers of *Sabal palmetto*. In CVS plot data for Bald Head Island, the hardwoods dominate and are constant while *Pinus* and *Sabal* have somewhat lower constancy and cover, but field observations show both widely distributed in the community as a whole. Understory species with high constancy and cover are *Prunus caroliniana, Cartrema americana*, and *Persea borbonia*. Also frequent and abundant are *Benthamidia* (*Cornus*) *florida, Ilex opaca*, and *Carpinus caroliniana*. The shrub layer ranges from sparse under dense canopy to dense where the canopy is broken. *Ilex vomitoria* dominates the shrub layer in our examples, but *Sabal minor* is frequent and often very abundant. *Callicarpa americana* is also frequent. Vines are abundant, with *Toxicodendron radicans, Muscadinia rotundifolia*, and *Smilax bona-nox* always present with high cover in plot data, and *Gelsemium sempervirens, Smilax auriculata*, and *Berchemia scandens* also frequent and abundant. The herb layer is generally moderate to sparse. *Mitchella repens* is constant and most extensive in this layer. Other frequent species include *Asplenium platyneuron, Galium bermudense, Carex* sp., *Dichanthelium commutatum, Sanicula canadensis* var. *canadensis*, *Chasmanthium laxum*, and *Oplismenus setarius*. *Pleopeltis michauxiana* (*Polypodium polypodioides*) and *Tillandsia usneoides* are frequent as epiphytes.

Range and Abundance: Ranked G2. In North Carolina, the South Atlantic Subtype occurs only in the Smith Island (Bald Head Island) complex and along the southern Brunswick County coast. The association extends southward to Florida and westward to Alabama and possibly Mississippi.

Associations and Patterns: Maritime Evergreen Forest may grade into Maritime Shrub on the seaward side in places. In other places the border may be a steep dunes supporting Dune Grass communities. On the inland side, Maritime Evergreen Forest grades to Salt Marsh or to various marsh edge communities.

Variation: Because of its limited range in the state, this community has little recognized variation. As with the Mid Atlantic Subtype, within its few occurrences, it ranges across microsites that appear xeric to mesic or intermittently wet without visible change in vegetation. Some plots from Bald Head Island consistently are distinguished in analysis because they are dominated by understory species left after storm-caused canopy mortality. Farther south, within its range, *Pinus elliotii* replaces *Pinus taeda* as the predominant pine, and *Sabal palmetto* becomes more abundant.

Dynamics: The dynamics of this community are generally similar to those of the Mid-Atlantic Subtype. Because all examples in North Carolina are on islands that have long been stable, there are no known areas in early primary succession and no areas with composition known to be altered by past logging. Some areas have been heavily disturbed by storms, leading to shrubby open forest that can persist for years. The changes documented at Bull Island in South Carolina, an example of this subtype, illustrate the kind of dramatic changes that are possible. Bull Island initially had a large area dominated by *Pinus taeda*, noted for its age (Helm, et al. 1991). Hurricane Hugo killed almost all the pines, while *Sabal palmetto* doubled in density and basal area in the aftermath. Pines regenerated in subsequent years. *Quercus virginiana* was moderately reduced by the storm. At the same time, oak regeneration failed in some areas, apparently due to rising water tables in wetter areas and to increased salt spray where the island was eroding (Conner, et al. 2005).

These forests are very susceptible to alterations in wind flow patterns, because of the effect on salt spray deposition. Breaks in the canopy can potentially create eddies that concentrate salt spray deposition and lead to death of trees around the opening.

Comments: The analysis of CVS data by Medford (2018) did not recognize the clear distinctness of this community. The 8 plots representing this subtype were lumped with plots of Coastal Fringe Evergreen Forest, perhaps because a coincidental high cover of deciduous understory species influenced the clustering algorithm more than the smaller cover of the more distinctive *Sabal palmetto*.

Sabal palmetto - Quercus virginiana Saturated Forest (CEGL007040), a hydric hammock community of central and southern Florida has been attributed to North Carolina, reportedly from the Bald Head Island complex. While the South Atlantic Subtype occurrence contains a few marginally wet swales dominated by these species, patches are very small and not distinct from the surrounding forest. It does not seem constructive to equate these small patches with this distant, non-maritime association, which contains many additional southern species.

Rare species:
Vascular plants – *Crocanthemum corymbosum, Cyperus tetragonus, Elymus halophila, Erythrina herbacea, Oplismenus setarius, Sabal palmetto, Sideroxylon tenax,* and *Solidago villosicarpa*.

Nonvascular plants – *Cheilolejeunea rigidula, Microlejeunea epiphylla*, *Syrrhopodon incompletus,* and *Teloschistes flavicans*.

Vertebrate animals – *Lampropeltis getula sticticeps,* and *Passerina ciris*.

Invertebrate animals – *Heraclides cresphontes, Satyrium favonius favonius,* and *Zale declarans*.

MARITIME DECIDUOUS FOREST

Concept: Maritime Deciduous Forests are barrier island upland forests dominated or codominated by deciduous hardwood trees, especially *Quercus falcata, Fagus grandifolia*, and *Quercus nigra* along with *Pinus taeda*. This community needs more shelter from salt spray than Maritime Evergreen Forest. It has distinctive species combinations not found in mainland forests.

Distinguishing Features: Maritime Deciduous Forest is readily distinguished from all other barrier island upland forests by the dominance or codominance of deciduous hardwoods. Maritime Swamp Forest differs in its dominance by wetland tree species. In the few cases of forests dominated by species that could belong to either, such as *Acer rubrum* or *Liquidambar styraciflua*, the lower strata should distinguish upland and wetland communities. Maritime Deciduous Forests may resemble some Mesic Mixed Hardwood Forest (Coastal Plain Subtype) communities of the mainland, but they have lower species richness while at the same time having species suggestive of a greater range of moisture tolerance. In addition, maritime species such as *Quercus hemisphaerica* and *Quercus virginiana* are often present in Maritime Deciduous Forest.

Crosswalks: *Quercus falcata - Pinus taeda - (Fagus grandifolia, Quercus nigra) / Persea palustris* Maritime Forest (CEGL007540).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Maritime Deciduous Forests occur only on the more sheltered parts of unusually wide stable barrier islands. They are farther from the ocean and have more shelter from salt spray than even most Maritime Evergreen Forest occurrences.

Soils: Most areas are mapped as Fripp (Typic Quartzipsamment). A few parts are mapped as Ousley (Aquic Quartzipsamment) and Duckston (Typic Psammaquent).

Hydrology: Hydrology is typical of the theme as a whole, ranging from apparently xeric to mesic. Salt spray is significant enough to exclude many plant species but is less extreme than in other maritime communities.

Vegetation: Vegetation is a closed canopy forest where not disturbed, with a well-developed understory. In Medford's (2018) analysis of CVS data, this community was one of the most distinct clusters among maritime forests. The canopy is dominated by a varying mixture, with *Pinus taeda, Quercus falcata*, and *Carya glabra* most frequently codominant. *Fagus grandifolia* and *Quercus virginiana* are fairly frequent (43%) and often codominant when present. *Liquidambar styraciflua, Quercus hemisphaerica, Quercus phellos*, *Juniperus silicicola*, and *Quercus alba* are at least fairly frequent but seldom as abundant. A few other species, including *Carya pallida, Quercus nigra*, and *Quercus michauxii* may codominate in one or two plots. Brown (1959) also noted the presence of old *Pinus echinata*, while surprising species such as *Quercus alba* or *Pinus palustris* are found in some site-specific descriptions and in a few CVS plots. The understory usually is dominated by *Benthamidia* (*Cornus*) *florida, Ostrya virginiana, Carpinus caroliniana*, or *Persea palustris. Ilex opaca*, *Sassafras albidum*, and *Nyssa sylvatica* have high constancy but are seldom dominant. Other species include *Acer rubrum, Diospyros virginiana*, and occasionally *Oxydendrum* *arboreum*. The shrub layer varies in density. *Arundinaria tecta*, *Gaylussacia frondosa*, or *Vaccinium pallidum* may dominate patches. *Callicarpa americana, Amelanchier canadensis*, *Morella cerifera,* and *Vaccinium arboreum* are frequent, while *Castanea pumila* and *Euonymus americanus* are fairly frequent. Vines can be extensive in the canopy or ground cover. Frequent species are *Muscadinia rotundifolia*, *Toxicodendron radicans*, *Smilax rotundifolia*, *Smilax bona-nox*, *Vitis aestivalis, Gelsemium sempervirens*, *Parthenocissus quinquefolia*, and *Bignonia capreolata*. The herb layer generally is sparse to moderately dense. *Mitchella repens*, *Pteridium pseudocaudatum,* or *Piptochaetium avenaceum* may dominate patches. *Hieracium gronovii, Nabalus autumnalis,* and *Asplenium platyneuron* occur in more than half the plots, and *Cnidoscolus stimulosus* and *Danthonia sericea* are almost as frequent. *Tillandsia usneoides* and *Pleopeltis michauxiana* (*Polypodium polypodioides*) are often present as epiphytes. A few wetland herbs are present, especially *Osmunda spectabilis* and *Lorinseria areolata*.

Range and Abundance: Ranked G1. The only examples remaining in North Carolina are in northern Dare County, primarily at Nags Head Woods and Kitty Hawk Woods. One or a few examples occur in southern Virginia.

Associations and Patterns: Maritime Deciduous Forest occurs in large patches, with embedded Maritime Swamp Forest, Maritime Shrub Swamp, and Interdune Ponds in wet swales. It may grade to Maritime Evergreen Forest or open dune and grassland communities seaward, but the natural context has been lost in the known examples.

Variation: Some differentiation along a moisture gradient may be recognized, with more xerophytic species increasing on the higher hills and mesophytic species in swales. The driest plots contain a few species of sandhills and dry inland forests, including *Cnidoscolus stimulosus, Vaccinium pallidum*, and even some *Pinus palustris*. These examples may warrant recognition as a xeric variant in the future. However, it is a notable characteristic of this community type that species with typically very different moisture tolerances are mixed together.

Dynamics: These communities are the most sheltered of any barrier island community from the stresses of the maritime environment. The high dune ridges and distance from the beach protect them from most salt spray and storm waves. They are, however, still subject to high winds and salt spray during storms, and disturbance is more frequent than in inland communities. Such disturbance may kill parts, but generally not all, of the canopy, producing a multi-aged population of trees.

As in other maritime forests, it is unlikely that natural fire was frequent in this community. It is notable that *Pinus palustris* and some other species associated with sandhill communities are present occasionally, but the more frequent species include *Fagus grandifolia, Carpinus caroliniana*, *Ostrya virginiana*, and others that are not tolerant of fire. The large patches might occasionally be hit by lightning and ignited, but the surrounding areas are not flammable, and fires would not spread from ignitions elsewhere. The rugged topography and interspersion of the forest with wetlands also would inhibit fire spread. While *Fagus grandifolia* and other mesophytic species can spread into mainland fire-prone sites after a long time without burning, the isolation of the Maritime Deciduous Forest sites from other populations makes it implausible that they are recent invaders in them.

Comments: This community more resembles common inland mesic communities than other maritime forests do. It is more diverse and contains species less tolerant of salt. However, the unusual combinations of species, along with a distinctive environment, justifies its recognition as distinct. More frequent natural disturbance, the sandy soil containing shell fragments, the continuous input of nutrients by salt spray, or the more moderate temperatures may be the cause of the unusual combinations of species.

Medford (2018) found several plots from mainland bluff sites that resembled the Maritime Deciduous Forest plots. While not similar enough to be regarded as representing this community, these sites warrant further investigation. *Quercus hemisphaerica* is present in some, though other maritime species are not. They could prove to be a mainland analogue – a kind of coastal fringe maritime deciduous forest. Other than these bluff sites, the Maritime Deciduous Forest plots cluster very distinctly in Medford's (2018) analysis. Wentworth, et al. (1990), analyzing only woody stem data from early CVS plots, found that pine-dominated Maritime Evergreen Forest plots clustered with pine-dominated Maritime Deciduous Forest plots, though they separated cleanly at a lower level of clustering.

While Maritime Deciduous Forest has not received the intensive research focus that Maritime Evergreen Forest has, the distinctive vegetation was described by Brown (1959) and in a number of site-specific descriptive reports.

Rare species:
Vascular plants – *Carex calcifugens, Crocanthemum carolinianum, Psilotum nudum,* and *Tridens chapmanii*.

Invertebrate Animals – *Catocala messalina*.

COASTAL FRINGE EVERGREEN FOREST (TYPIC SUBTYPE)

Concept: Coastal Fringe Evergreen Forests are communities that occur on the mainland within a few miles of the coast, not strongly influenced by salt spray, but which contain species typical of Maritime Evergreen Forest and otherwise largely absent on the mainland. This include *Quercus virginiana, Quercus hemisphaerica, Cartrema americana*, and *Ilex vomitoria*. The Typic Subtype covers most examples, which lack the distinctive characteristics of the Sand Spit Woodland Subtype. They are tall forests of mesophytic or broadly tolerant species.

Distinguishing Features: Coastal Fringe Evergreen Forests are distinguished from Maritime Evergreen Forests by occurring on the mainland and well inland of any communities of the coastline (Dune Grass, Maritime Dry Grassland, or Maritime Shrub). Ambiguous cases may occur on back-barrier islands within the sounds, though generally Maritime Evergreen Forest will occur on exposed islands surrounded by salty or brackish water. Coastal Fringe Evergreen Forests may be distinguished by lack of a streamlined canopy produced by salt spray and by differences in species composition. Examples generally contain more deciduous species in all strata, and include some species rarely found in Maritime Evergreen Forest, such as *Quercus nigra, Liquidambar styraciflua, Aesculus pavia, Vaccinium arboreum*, and *Nekemias* (*Ampelopsis*) *arborea*.

Coastal Fringe Evergreen Forests are easily distinguished from Swamp Island Evergreen Forests by their setting on low upland flats near the coast rather than on inland ridges surrounded by swamps. Coastal Fringe Evergreen Forest has a greater diversity and abundance of maritime forest plants. *Ilex vomitoria* is not found in Swamp Island Evergreen Forest, and *Quercus virginiana* is rarer there.

The Typic Subtype is distinguished from the Sand Spit Woodland by having a tall canopy that is closed if not recently disturbed, rather than an open, shorter canopy. The Sand Spit Woodland Subtype contains a number of herbaceous species that are shared with sandhill communities and others that are typical of various open habitats. Such species include *Andropogon ternarius, Aristida condensata, Carex arenaria, Cyperus grayi, Opuntia mesacantha (humifusa*), *Panicum amarum*, and *Scleria flaccida*.

Crosswalks: *Quercus virginiana - Quercus hemisphaerica - Pinus taeda - Quercus falcata / Persea palustris* Forest (CEGL007026).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Coastal Fringe Evergreen Forest (Typic Subtype) occurs in two kinds of settings: low flats and gentle rises just uphill of tidal marshes, and small patches farther inland along brackish estuaries.

Soils: The most frequently mapped soil for examples is Wando (Typic Quartzipsamment), with several mapped as Mandarin (Oxyaquic Alorthod). A wide variety of other sandy Entisols, Spodosols, and even Ultisols are mapped occasionally. It is unclear it this indicates a true diversity of potential soil conditions or if the community occurs on inclusions within a variety of units.

Hydrology: Sites are mesic to dry. The water table may be close enough to the surface that small wetland microsites occur within the community. Sites are not regularly subject to inundation, but some could be susceptible to intrusion by brackish water during rare storm surges.

Vegetation: Vegetation is a dense forest, where not recently disturbed. In site descriptions, *Pinus taeda* is most often dominant, and *Quercus hemisphaerica* is almost always present and often dominant. *Quercus virginiana, Quercus nigra*, and *Carya glabra* are frequent. Several other species not typical of maritime forests are moderately frequent, including *Quercus falcata, Quercus stellata*, and *Carya ovalis*. The understory almost always includes *Persea palustris* and *Ilex opaca*. *Cartrema americana, Benthamidia* (*Cornus*) *florida,* and *Juniperus silicicola* are frequent, *Nyssa sylvatica* somewhat less so. A few southern examples have *Persea borbonia* and *Magnolia grandiflora* which appears to be native. Other species characteristic of Maritime Evergreen Forests are present in small numbers, including *Carpinus caroliniana, Prunus serotina*, and *Prunus caroliniana*. The shrub layer is almost always dominated by *Ilex vomitoria*, and *Morella cerifera* is almost always present and often abundant. Other shrubs that are fairly frequent include *Vaccinium arboreum, Callicarpa americana*, and *Sassafras albidum*. Less frequent are *Arundinaria tecta, Vaccinium fuscatum*, and *Aesculus pavia*. Several other *Vaccinium* species, *Gaylussacia frondosa*, and a variety of other shrubs may occur. Woody vines are abundant and diverse. *Smilax bona-nox*, *Muscadinia rotundifolia*, and *Gelsemium sempervirens* are almost always present. *Smilax rotundifolia, Nekemias arborea*, *Toxicodendron radicans* and *Bignonia capreolata* are frequent. Herbs are scarce in most examples. *Mitchella repens*, the most frequent herb layer species, is still noted only in about half the examples. The next most frequent species are *Chimaphila maculata, Chasmanthium laxum*, *Dichanthelium commutatum*, and less often, *Yucca filamentosa* and *Scleria flaccida*. A couple of examples have a diverse herb layer, often with unusual combinations of species.

Range and Abundance: Ranked G2. In North Carolina, this community is confined to within a few miles of the coast or shores of sounds. It appears to have formed a fairly continuous band from southern Carteret County southward, but to have occurred only in scattered small patches northward. The association is reported to range southward to Georgia.

Associations and Patterns: Coastal Fringe Evergreen Forest once formed large patches along the southern mainland coast, but only small, isolated patches remain. It occurs naturally as small patches in more northern and inland estuary sites. It usually grades to Salt Marsh or Brackish Marsh, occasionally to Tidal Swamp. On the inland side, it may grade to the Coastal Fringe Subtype of Xeric Sandhill Scrub or Pine/Scrub Oak Sandhill. In Kure Beach, where the coastal strand is not on a barrier island, it apparently graded directly into Maritime Evergreen Forest.

Variation: No variants are recognized. The northern and more inland small patch occurrences tend to be lower in species richness.

Dynamics: Little is known about the dynamics of these communities. The stress on the canopy by salt spray, so characteristic of barrier islands, is not obvious in Coastal Fringe Evergreen Forests, which tend to be tall and not obviously pruned. Tolerance to salt is believed to be important in limiting species composition in Maritime Evergreen Forests but the same species dominate in Coastal Fringe Evergreen Forest without it obviously being important.

The location of Coastal Fringe Evergreen Forests in low areas near the coast makes them vulnerable to wind and saltwater flooding caused by hurricanes. Their elevation is often lower than the dune settings of maritime forests on barrier islands. The susceptibility to canopy disturbance may be responsible for the characteristic dominance or codominance by *Pinus taeda*.

The mainland location of Coastal Fringe Evergreen Forests potentially makes them more susceptible to natural fire than barrier islands, as fires may spread from ignitions over a large area. Some examples even occur adjacent to sandhill communities. Exposure to fire is generally reduced from typical mainland fire regimes though, by occurrence adjacent to estuaries and in areas dissected by tidal swamps. The flammability of the vegetation is not well known. Pine needles are abundant, and sometimes can drape vines and shrubs to produce a volatile fuel load. However, the litter of the evergreen oaks is not very flammable and may reduce fire spread and intensity.

Comments: Coastal Fringe Evergreen Forests are intermediate in character between Maritime Evergreen Forest and inland Mesic Mixed Hardwood Forest and Dry-Mesic Oak–Hickory Forest. The dominant vegetation is more similar to the forests of barrier islands, but a substantially larger pool of species is present. Several characteristic evergreen canopy and understory tree species occur in North Carolina almost exclusively in maritime or coastal fringe communities, e.g., *Quercus virginiana, Quercus hemisphaerica, Cartrema americana*, and *Ilex vomitoria*. It is not clear why they are confined to near the coast here. Their evergreen habit suggests that moderation of the climate by the ocean may be important. Most of these species occur farther inland in states to the south, where some are widespread. However, the occurrence of several of these species farther inland in the rare Swamp Island Evergreen Forest communities suggests an alternative hypothesis, such as natural sheltering from fire. The fact that the northernmost Coastal Fringe Evergreen Forest examples occur farther inland also is inconsistent with climate being the primary cause.

This community type is naturally limited in extent, though it probably was once more extensive than Maritime Evergreen Forest. With easy access and extensive coastal development, more of it has been lost than of other maritime forests, leaving it one of the most endangered communities in the state.

Rare species:
Vascular plants – *Aristida condensata, Corallorhiza wisteriana, Erythrina herbacea,* and *Solidago villosicarpa*.

Vertebrate animals – *Micrurus fulvius fulvius.*

COASTAL FRINGE EVERGREEN FOREST (SAND SPIT WOODLAND SUBTYPE)

Concept: Coastal Fringe Evergreen Forests are communities that occur on the mainland within a few miles of the coast, not strongly influenced by salt spray, but which contain species typical of Maritime Evergreen Forest and otherwise largely absent on the mainland. This include *Quercus virginiana, Quercus hemisphaerica, Cartrema americana*, and *Ilex vomitoria*.

The Sand Spit Woodland Subtype is a rare open woodland community that occurs on relatively young sand deposits adjacent to estuarine rivers, sharing species both with maritime forests and with other, more open communities. Though treated as a subtype of Coastal Fringe Evergreen Forest, it is conceptually intermediate between it, Pine/Scrub Oak Sandhill, Marsh Hammock, and Estuarine Beach, with characteristics of each.

Distinguishing Features: Coastal Fringe Evergreen Forest (Sand Spit Woodland Subtype) is distinguished from all other communities by a canopy that contains *Quercus virginiana* or other species characteristic of maritime forests, along with a rich herbaceous flora containing species of both sandhills and open coastal habitats. It should not be confused with areas of the Typic Subtype that are transitional to Pine/Scrub Oak Sandhill, or with examples of Pine/Scrub Oak Sandhill that have seen proliferation of oaks due to fire suppression. The Sand Spit Woodland has a more varied flora in the lower strata, and one that contains marsh and coastal elements such as *Spartina patens*, *Panicum amarum*, and *Eustachys petraea*, in addition to other elements not typically in sandhills, such as *Carex arenaria, Elymus virginicus*, *Scleria flaccida*, and *Cyperus* spp. The setting, on high sand spits adjacent to tidal waters, is distinctive.

Crosswalks: *Quercus virginiana - Quercus hemisphaerica / Ilex vomitoria / Aristida condensata - Panicum amarum* var. *amarum* Forest (CEGL004399).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: The Sand Spit Woodland Subtype occurs on sandy areas adjacent to open estuaries. The configuration of known examples is a narrow ridge of sand with lower marshes behind, suggesting a sand spit deposited across a bay by currents in the river, but one old enough to have allowed full development of marshes behind it. They front open water with a wave-washed sandy beach, and wave deposits may have raised the elevation of the spits.

Soils: The occurrences do not appear to be distinguished in soil mapping. Though mapped as Rimini (Entic Haplohumod), they are probably younger sandy Entisols.

Hydrology: Sites are well drained but may be subject to incursion by waves during storms and to spray by brackish water.

Vegetation: The vegetation is a woodland or open forest of fairly short stature but potentially large tree diameter, but without substantial pruning by salt spray. The canopy is dominated by *Quercus virginiana* or *Quercus hemisphaerica*, with some *Juniperus silicicola, Pinus taeda*, and *Carya glabra*. The open understory includes *Cartrema americana* and *Persea palustris*. The shrub layer is dominated by *Ilex vomitoria*, but also includes abundant *Polygonella polygama* and some

Morella cerifera, Amorpha frutescens, and *Yucca filamentosa*. Vines are prominent, especially *Smilax auriculata, Smilax bona-nox*, and *Muscadinia rotundifolia*, but also including *Smilax smallii* and *Gelsemium sempervirens*. The herb layer is patchy but well developed compared to most maritime forest communities. *Spartina patens, Carex arenaria, Aristida condensata, Panicum amarum, Cladonia* (*Cladina*) *evansii*, and other *Cladonia* species may dominate patches. Other species of note, out of a diversity of species, include *Panicum virgatum* var. *virgatum*, *Andropogon ternarius, Cyperus grayi, Opuntia mesacantha, Opuntia pusilla, Scleria flaccida, Schizachyrium scoparium, Galactia regularis, Elymus virginicus, Bulbostylis ciliatifolia, Cirsium repandum, Eustachys petraea*, and *Erythrina herbacea*.

Range and Abundance: Ranked G1G3 because of uncertainty about the range and abundance. This community is newly recognized, and its full status is not well known. It is currently known at only a handful of sites along the estuarine Cape Fear River in New Hanover County. If none are found in other states, it should be ranked G1.

Associations and Patterns: The known examples are bordered by Brackish Marsh or Tidal Freshwater Marsh communities and open water. They may connect to various sandhill communities or to Coastal Fringe Evergreen Forest (Typic Subtype).

Variation: Little is known about variation in the few examples. Newly found examples may differ from the description here.

Dynamics: Little is known about this community. It occurs on sand deposits that are subject to potential wave action and salt water during storms, as well as being exposed to wind, and may be younger than most coastal fringe soils. It may represent a middle stage of long-term primary succession, or it may last indefinitely in a cyclic succession driven by severe natural disturbance.

Comments: This community is rare and not well known. It was first recognized by Richard LeBlond during the New Hanover County natural areas inventory. It was found in several places along the Cape Fear River, but no plot data represent it. LeBlond called these communities Tidal Saltwater Levee Forest, because they occur along the estuarine river in a position analogous to the natural levees of inland rivers. However, these sand spits do not appear to the author to be remnants of flood-deposited natural levees, but rather to have been created by estuarine tidal currents, wave action, and wind.

The placement of this community in the Maritime Upland Forests theme is uncertain. The dominant species are shared mostly closely with the Typic Subtype of Coastal Fringe Evergreen Forest. The open structure and component of xerophytic herbs are shared with Pine/Scrub Oak Sandhill (Coastal Fringe Subtype). However, it is unlikely to burn and does not have *Aristida stricta* or *Pinus palustris*. Salt-tolerant herbs that are shared with adjacent marsh edges tie it to Marsh Hammock, other species are never found in Marsh Hammocks. The location on an estuary shoreline, apparent periodic disturbance by waves, young substrate, and presence of weedy flora resembles Estuarine Beach. However, the sites are drier, less open, and less weedy.

Rare species:
Vascular plants – *Aristida condensata* and *Erythrina herbacea*.

CALCAREOUS COASTAL FRINGE FOREST (NORTHERN SUBTYPE)

Concept: Calcareous Coastal Fringe Forests are extremely rare deciduous hardwood forests of shell-rich sandy soils of the coastal fringe. Coarse-textured calcareous soil, influence of coastal storms, maritime climate, and possibly mild salt spray likely determine their character, with calcareous soils differentiating them from Coastal Fringe Evergreen Forest. The Northern Subtype covers the more northerly examples, in middle and northern North Carolina, lacking more southerly species such as *Magnolia grandiflora*.

Distinguishing Features: Calcareous Coastal Fringe Forests are distinguished from Coastal Fringe Shell Woodlands by denser vegetation, occurring in more sheltered environments, and having finer textured soils. They are distinguished from all other communities by the co-dominance of maritime forest species such as *Quercus virginiana* and *Ilex vomitoria* along with substantial calciphilic flora and vegetation in a coastal fringe site. Lack of species restricted to more southern regions, especially *Magnolia grandiflora*, distinguishes the Northern Subtype from the Southern Subtype.

Crosswalks: *Quercus virginiana-Celtis laevigata - Tilia americana* var. *caroliniana / Aesculus pavia* - *Ilex vomitoria* Forest (CEGL007282).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Calcareous Coastal Fringe Forests occur on sand ridges, upland flats, or small sound islands with substantial amounts of shell material in the soil. The sites are believed to be ancient Native American shell middens but the shells are well mixed into the soil and don't appear as a mound.

Soils: No soils series is specific to these communities. They are mapped as Pactolus or Ousley (both Aquic Quartzipsamments) but might be mapped as other sandy Entisols. The soils are rich in calcium because of the high shell content but are well drained and may be low in other nutrients.

Hydrology: This community could potentially range from dry to mesic or marginally wet. The known examples appear to be mesic to marginally wet.

Vegetation: Calcareous Coastal Fringe Forest generally has a closed to slightly open canopy when not recently disturbed. In the Northern Subtype, *Quercus virginiana* dominates, or codominates with *Carya glabra*, *Tilia americana* var. *caroliniana*, *Celtis laevigata*, *Pinus taeda*, or *Ulmus rubra*. Other canopy trees include *Quercus hemisphaerica, Fraxinus* sp., and *Liriodendron tulipifera*. The understory is dominated by *Persea palustris* or *Acer floridanum*, and other species may include *Ilex opaca, Carpinus caroliniana, Zanthoxylum clava-herculis*, and *Swida (Cornus) asperifolia*. The shrub layer is dominated by *Ilex vomitoria* and *Sabal minor*. *Aesculus pavia* is also sometimes also abundant. Vines are frequent and can be dense, especially *Toxicodendron radicans, Parthenocissus quinquefolia*, *Berchemia scandens*, and *Smilax* spp. The herb layer is sparse to moderate in density. Abundant species in at least one of the sites include *Chasmanthium laxum, Chasmanthium sessilifolium, Asplenium platyneuron*, *Juncus coriaceus*, and *Rhynchospora miliacea*. Other species include *Verbesina occidentalis, Dichanthelium commutatum, Galium bermudense, Sanicula canadensis* var. *floridana*, *Ruellia carolinensis, Elephantopus carolinianus,* *Phryma leptostachya, Piptochaetium avenaceum, Sideroxylon lycioides, Oplismenus setarius*, and *Mitchella repens*.

Range and Abundance: Ranked G1. Only two examples are known, in Onslow and Currituck counties. No examples are known in other states.

Associations and Patterns: The known examples are small patches that grade to various Tidal Freshwater Marsh and Brackish Marsh communities. No natural connection to upland communities remains, but examples might grade to Coastal Fringe Evergreen Forest or to longleaf pine communities.

Variation: The two known examples are somewhat different in ways that may reflect differences in latitude and moisture status.

Dynamics: Dynamics are probably similar to Coastal Fringe Evergreen Forest, with fire of limited importance but with storm disturbance more important than in most communities. The Corn Landing occurrence was heavily disturbed by two hurricanes in 1996; 20 years later it remained with a broken canopy and dense shrub layer very different from when it was first observed.

Comments: There has been confusion in the application of the NVC associations corresponding to the two subtypes, regarding whether the crucial distinction is one of biogeography or one of environmental differences such as moisture. They are here interpreted to represent biogeographic subtypes, marked by the presence or absence of southern indicator species. Each potentially spans a range of moisture levels and varies somewhat in the amount of evergreen versus deciduous canopy trees, but examples are too rare to see the full range.

A different shell midden community, sharing some species but very different in overall flora, occurs farther north, and is better documented than this community (McAvoy and Harrison 2012). The history of shell middens they document, showing human use of estuarine shellfish as early as 3800 years ago, with most intense use 1000-2000 years ago, may apply to North Carolina as well. This is a rare situation, where use by humans and alteration of the environment occurred long enough ago that a natural community has developed in response to it. The more limited flora in North Carolina's shell midden communities may come from the greater distance to inland calcareous rock substrates of any great extent. However, it may be due solely to the lower density of such sites on the coast of North Carolina.

Rare species:
Vascular plants – *Arenaria lanuginosa* var. *lanuginosa, Clematis catesbyana*, *Ipomoea macrorhiza Oplismenus setarius, Sageretia minutiflora,* and *Swida asperifolia*.

CALCAREOUS COASTAL FRINGE FOREST (SOUTHERN SUBTYPE)

Concept: Calcareous Coastal Fringe Forests are rare deciduous hardwood forests of shell-rich sandy soils of the coastal fringe. Coarse-textured calcareous soil, influence of coastal storms, maritime climate, and possibly mild salt spray likely determine their character, with calcareous soils differentiating them from Coastal Fringe Evergreen Forest. The Southern Subtype covers more southerly examples, containing species more widespread south of North Carolina, such as *Magnolia grandiflora*.

Distinguishing Features: Calcareous Coastal Fringe Forests are distinguished from Coastal Fringe Shell Woodlands by denser vegetation, occurring in more sheltered environments, and having finer textured soils with more material other than shells. They are distinguished from all other communities by the co-dominance of maritime forest species such as *Quercus virginiana* and *Ilex vomitoria* with substantial calciphilic flora and vegetation in a coastal fringe site. The southern subtype is distinguished by species of more southern affinities, especially *Magnolia grandiflora*. In South Carolina, *Sabal palmetto* is also a frequent component. *Quercus hemisphaerica* appears to be the predominant maritime oak in plot samples of this subtype, while it is absent and *Quercus virginiana* dominates in the Northern Subtype, but this may not be true of any other examples that may be found.

Crosswalks: *Quercus falcata - Tilia americana* var. *caroliniana - Magnolia grandiflora / Aesculus pavia - Ilex vomitoria* Forest (CEGL007470).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Southern Atlantic Coastal Plain Maritime Forest Ecological System (CES203.537).

Sites: The Southern Subtype occurs on low upland flats or gentle slopes on the mainland coast, with substantial amounts of shell material in the soil. The sites are believed to be ancient Native American shell middens but the shells are well mixed into the soil and don't appear as a mound.

Soils: No soils series is specific to these communities. Examples are mapped as Pactolus (Aquic Quartzipsamment) or Wando (Typic Quartzipsamment) but might be mapped as other sandy Entisols. The soils are rich in calcium because of the high shell content but are well drained and may be low in other nutrients. The few small remaining North Carolina examples have flora suggesting they are only marginally calcareous.

Hydrology: This community can range from dry to mesic or marginally wet. Local wetter inclusions may be present.

Vegetation: Calcareous Coastal Fringe Forest has a closed to slightly open canopy when not recently disturbed. Our examples of the Southern Subtype are most often dominated by *Quercus hemisphaerica* and *Tilia americana* var. *caroliniana*, with *Quercus virginiana*, *Pinus taeda*, *Magnolia grandiflora, Carya glabra*, or *Ulmus americana/rubra* sometimes codominant. *Celtis laevigata*, *Quercus shumardii*, and *Carya cordiformis* may also be abundant. The understory generally is dominated by *Acer floridanum* or *Carpinus caroliniana*, and *Persea palustris (*or *borbonia*) are constant. Other species include *Ilex opaca, Swida* (*Cornus*) *asperifolia, Juniperus silicicola*, *Benthamidia* (*Cornus*) *florida*, *Cartrema americana*, *Prunus caroliniana*, and *Prunus serotina*. The shrub layer is dominated by *Ilex vomitoria*, with *Morella cerifera, Aesculus pavia,* and *Sabal minor* frequent and locally codominant. A wide variety of vines may be present, including *Vitis labrusca*, *Hydrangea (Decumaria) barbara*, and *Berchemia scandens*, as well as more widespread species such as *Muscadinia rotundifolia* and *Smilax* spp. The herb layer is variable and generally sparse. Species include *Mitchella repens, Polystichum acrostichoides, Arisaema triphyllum, Dichanthelium commutatum, Dichanthelium boscii, Sanicula canadensis, Galium bermudense*, other *Galium* spp., *Endodeca serpentaria*, *Asplenium platyneuron*, and many others in a single site. All of the few plots and species lists include some wetland species, such as *Anchistea virginica, Hypericum walteri,* or *Persicaria* spp.

Range and Abundance: Ranked G2G3. Only two examples have been known in North Carolina, both in Brunswick County. This community is somewhat more widespread in South Carolina but still rare.

Associations and Patterns: This community occurs as small patches that grade to various salt marsh communities. No natural connection to upland communities remains, but examples might grade to Coastal Fringe Evergreen Forest or to longleaf pine communities.

Variation: Too few examples remain to characterize variation in North Carolina. In South Carolina it contains much diversity, and it may warrant splitting into several subtypes there. Examples there vary with the amount of shells in the soil.

Dynamics: Dynamics are probably similar to Coastal Fringe Evergreen Forest, with fire of limited importance but with storm disturbance more important than in most communities because of the coastal location and the coarse soil texture.

Comments: Coastal shell middens appear to be more abundant in the Sea Islands region of South Carolina. At the same time, upland mesic forests containing *Magnolia grandiflora* are also more abundant, perhaps making the identity of this community more difficult to distinguish there.

Rare species:
Vascular plants – *Ipomoea macrorhiza* and *Zephyranthes simpsonii*.

COASTAL FRINGE SHELL WOODLAND

Concept: Coastal Fringe Shell Woodlands are rare open communities of shell deposits that support shrubby or woodland vegetation rather than forest due to the coarse soil or exposure to chronic disturbance. This is a more extremely developed version of the conditions that produce Calcareous Coastal Fringe Forest. The community is typically associated with prehistoric shell middens or other deposits of nearly pure shell with poorly developed soil, on small islands within estuaries or on the mainland coast. While a number of well-developed examples occur in South Carolina, only a few small examples are known in North Carolina.

Distinguishing Features: Coastal Fringe Shell Woodlands are distinguished from all other communities by the occurrence of persistent open woody vegetation on coastal fringe shell deposits. The flora has at least some calciphilic component. The distinction from Calcareous Coastal Fringe Forest may be difficult to determine in the immediate aftermath of hurricanes, but the small stature, sparseness, and growth form of trees should make the persistent vegetation structure clear even at times of heavy mortality.

Crosswalks: *Juniperus virginiana* var. *silicicola - Zanthoxylum clava-herculis - Quercus virginiana - (Sabal palmetto) / Sageretia minutiflora* Woodland (CEGL003525).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Southern Atlantic Coastal Plain Maritime Forest Ecological System (CES203.537).
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Coastal Fringe Shell Woodlands occur on back-barrier islands in the sounds or on the edge of the mainland coast, on deposits that consist largely of shells. Most sites probably originated as prehistoric shell middens, but some have been more recently worked by waves, making their origin unclear. At least one known example is a tombolo, a former island connected to the mainland by a recently deposited spit.

Soils: This community has limited soil development. The substrate is whole or fragmented shells mixed with sand. The coarse substrate is excessively drained and readily disturbed by wave action.

Hydrology: Sites are excessively drained, though occurring near sea level.

Vegetation: The two known North Carolina occurrences share a canopy dominated or codominated by *Quercus virginiana*, with *Juniperus silicicola* codominant in one. *Zanthoxylum clava-herculis, Ilex vomitoria*, and *Sageretia minutiflora* are present in both. Other shrubs include *Morella cerifera, Parietaria floridana, Parietaria praetermissa, Aesculus pavia*, and *Baccharis halimifolia*. Herbs include a mix of calciphilic, general maritime, and weedy species. Species reported in one of the examples include *Aquilegia canadensis, Arenaria lanuginosa, Arenaria serpyllifolia, Ageratina aromatica, Geranium carolinianum, Melica mutica, Piptochaetium avenaceum, Sphenopholis obtusata, Phytolacca americana*, and *Atriplex crispa*. Examples in states to the south also contain *Sideroxylon tenax, Celtis laevigata, Frangula caroliniana*, and *Cartrema americana*, which might be found in North Carolina examples in the future.

Range and Abundance: Ranked G2?. Only two examples are known in North Carolina, both in Onslow County. The community is somewhat more abundant in South Carolina and perhaps farther south.

Associations and Patterns: Coastal Fringe Shell Woodlands are small patch communities. They may occur in connection with Salt Marsh or Brackish Marsh, and possibly with Calcareous Coastal Fringe Forest.

Variation: The two known examples are substantially different, but this may partly be related to recent hurricane disturbance when one of them was surveyed.

Dynamics: Coastal Fringe Shell Woodlands appear to be dynamic communities subject to periodic severe natural disturbance. They are exposed to salt spray, storm winds, storm surge, and potential reworking of the underlying sediment. One of the known examples underwent severe disturbance in the hurricanes of 1996, resulting in nearly total canopy mortality. Nevertheless, the presence of specialized plant species that are not in the surrounding communities suggests they have persisted for a long time.

Comments: This community appears to be more abundant in states to the south. North Carolina's examples appear floristically depauperate. *Sabal palmetto* and *Celtis laevigata* are frequent components in other states.

Rare species:
Vascular plants – *Arenaria lanuginosa* var. *lanuginosa, Cyperus tetragonus, Chenopodiastrum* var. *berlandieri, Ipomoea macrorhiza, Parietaria praetermissa,* and *Sageretia minutiflora*.

MARSH HAMMOCK

Concept: Marsh Hammocks are small evergreen forest or woodland patches that occur in a matrix of salt or brackish marshes, on either the sound side of barrier islands or on the mainland. They resemble depauperate Maritime Evergreen Forests but usually contain a number of marsh species, are more subject to edge effects and storm water intrusion, and are less influenced by salt spray. They may occur farther inland than any other maritime communities, though they also overlap their ranges. They may range in structure from forests to woodlands or savannas.

Distinguishing Features: Marsh Hammocks are most easily distinguished from Maritime Evergreen Forest and Coastal Fringe Evergreen Forest by occurring in small patches embedded in marshes or on their edges. The vegetational distinction of these communities can be subtle. Marsh Hammocks may be dominated by any of the same tree species, though *Quercus virginiana, Pinus taeda*, or *Juniperus silicicola* are much more likely than *Quercus hemisphaerica*. The understory and shrub layers of Marsh Hammocks generally have fewer species. Most of the species of the maritime forests may be present, but *Quercus hemisphaerica, Benthamidia* (*Cornus*) *florida*, *Carpinus caroliniana*, and *Prunus caroliniana* are unlikely. Also usually present are some marsh edge species such as *Baccharis halimifolia* and *Borrichia frutescens*, as well as *Morella cerifera*. Herbs may be sparse but usually include some species shared with the adjacent marsh or marsh edge, such as *Juncus roemerianus, Cladium jamaicense, Panicum virgatum,* or *Spartina patens*.

Crosswalks: *Juniperus virginiana var. silicicola - (Quercus virginiana, Sabal palmetto)* Forest (CEGL007813).
G798 Coastal Live Oak - Hickory - Palmetto Forest.
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).

Sites: Marsh Hammocks occur on small, elevated areas within or on the edges of tidal marshes. Most examples are associated with mainland marshes or islands in the sounds, but they could occur on larger barrier islands. Elevations are generally only a few feet above the marsh.

Soils: Soils often are sandy Entisols, but there is little consistency in how the soils in Marsh Hammocks are treated in soil mapping, when patches are large enough to be distinguished at all. Examples on barrier islands may be mapped as Duckston, Newhan, or Fripp (Typic Quartzipsamments), or Corolla (Aquic Quartzipsamment). Mainland examples are mapped as a wide variety of soils, including Humaquepts and even Ultisols.

Hydrology: Sites appear to range from well drained to marginally wet. The small mounds and ridges usually occupied by these communities produce strong gradients in wetness from the edges to the center. The water table is seldom far below the surface, but the water may be brackish; the patches probably are too small to form a lens of fresh groundwater. Mass effects and vegetative spread allow marsh plants to occur even in drier portions, making it difficult to tell how wet or salty an area is, though the presence of less salt-tolerant plants makes it clear that the environment is different from that of the adjacent marsh. Marsh Hammocks are subject to brief flooding by salt or brackish water during major storms but are not flooded or saturated by normal tides.

Vegetation: Marsh Hammocks can range in structure from closed forest canopy to open woodland or even savanna. The canopy may be tall but usually is short. As in all woody maritime communities, the structure may depend on recent history of natural disturbances. Both the limited CVS plot data and qualitative descriptions indicate substantial variation in vegetation. *Quercus virginiana* is constant, usually dominating or codominating the canopy, though occasionally occurring as an understory beneath *Pinus taeda*. *Juniperus silicicola* codominates some examples. *Quercus hemisphaerica* is only rarely present. CVS plot data included no other understory or canopy species, but other observations have noted a few more inland species, such as *Quercus nigra, Carya glabra,* or *Liquidambar styraciflua*, along with understory species such as *Persea palustris, Ilex opaca, Diospyros virginiana*, *Magnolia virginiana*, and some unexpected species such as *Quercus margaretiae* and *Quercus geminata*. All these species have low constancy. The shrub layer may be sparse or dense throughout, or it may be dense only near the edges. *Ilex vomitoria, Morella cerifera*, *Baccharis halimifolia*, *Iva frutescens,* and *Borrichia frutescens* all have high constancy. Vines may be sparse or dense, though species vary. *Toxicodendron radicans* and several species of *Smilax* are most constant, but a wide variety of species occur with low frequency. The herb layer may be dense or sparse. Species typical of marshes or marsh edges are almost always present in significant amounts. *Spartina patens* is most constant and sometimes dense. *Distichlis spicata, Juncus roemerianus*, and *Fimbristylis castanea* are in at least 50% of both plots and other occurrences. Less frequent species include *Panicum virgatum, Ipomoea sagittata, Solidago mexicana* (*sempervirens*)*, Elymus glabriflorus,* and *Limonium carolinianum*.

Range and Abundance: Ranked G3? Marsh Hammocks range along the entire coast of North Carolina, but recorded examples are few and very widely scattered. A few examples are miles inland along the sounds, but most are within a few miles of the mainland coast. Examples often were not reported in earlier site surveys, and it is likely that this community is more abundant than recorded examples suggest. The equivalent association ranges southward to Georgia.

Associations and Patterns: Marsh Hammocks occur as small patches, from a few acres to less than one acre. Most are completely or largely surrounded by Salt Marsh or Brackish Marsh communities, though they may border open water on some sides. They may potentially border upland communities on one side.

Variation: Examples are extremely variable, but patterns are not well enough known to recognize variants. A potential distinction between northern and southern examples, or between more inland and more coastal examples, needs investigation.

Dynamics: Like other maritime communities, Marsh Hammocks are exposed to natural disturbances more than inland communities. The importance of the same evergreen salt-tolerant tree and shrub species suggests a similar environment of moderate climate but exposure to stresses related to salt. Compared to the similar Maritime Evergreen Forest, they are farther from the beach and from chronic salt spray, but they are subject to storm winds and potentially exposed to salt spray during storms. They also are susceptible to flooding by brackish or salt water during storm surges.

The potential role of fire in Marsh Hammocks is unknown. Marsh vegetation can carry fire, and many examples occur in marshes connected to the mainland, where fires might spread from ignitions anywhere in a large area. However, vegetation includes few species known to be intolerant of fire, suggesting that the community is not shaped by it.

Cleary et al. (1979) described the origin of marsh island landforms in southeastern North Carolina as being connected to inlets in the barrier islands, with storm waves pushing sand from flood tidal deltas over marshes to produce higher land. They suggested that ongoing deposition is needed to maintain the island, and that islands will sink and disappear into the marsh if the inlet migrates away. Different dynamics may prevail in other parts of the coast. Marsh Hammocks along more inland estuaries presumably have a different origin.

Comments: This community needs much more study, as it is less well understood than most. In the 3rd Approximation, examples were regarded as small and depauperate Maritime Evergreen Forest occurrences. A similar assumption may have led to them being overlooked in many site-specific descriptions. Differences in vegetation alone are relatively small, since ecotonal or successional Maritime Evergreen Forests can share some of the features otherwise distinguishing Marsh Hammocks. Present interpretation is that the distinctive dynamics and landscape relations indicate a community different enough to be of scientific and conservation interest.

The fit of North Carolina's Marsh Hammocks to the synonymized NVC association is imperfect. The association was described from farther south, and the more southerly examples often have *Sabal palmetto* and other species not shared in North Carolina. The NVC description emphasizes dominance by *Juniperus silicicola*, which is present but rarely dominant in North Carolina's examples. In addition, communities that are not marsh hammocks, such as vegetation along Florida spring run creeks, have also been attributed to the association. The dynamics of such a community would be quite different, and further study is likely to document floristic differences.

Sabal palmetto - (*Juniperus virginiana* var. *silicicola*) Woodland (CEGL003526) is another marsh hammock association defined for South Carolina to Florida; it has been suggested to occur in North Carolina but has not been found. It is classified as a woodland rather than a forest. However, given the natural variability and heterogeneity in vegetation structure in this frequently disturbed community, it does not appear that such a distinction based on narrow differences in structure is appropriate.

Rare species:
Vascular plants – *Parietaria praetermissa*.

DRY LONGLEAF PINE COMMUNITIES THEME

Concept: Dry Longleaf Pine Communities occur in mesic to xeric sites in the Coastal Plain and lower Piedmont, where natural frequent fire promoted open woodland or savanna vegetation structure dominated or codominated by *Pinus palustris*. Drier communities (sandhills) have a distinctive layer of scrub oaks, which moister communities (savannas) lack. In natural condition, all have limited midstory and shrub layers, with the oaks of sandhills confined to scattered groves and shrub-size sprouts, and all but the most xeric communities have dense grass-dominated herb layers.

Distinguishing Features: Dry Longleaf Pine Communities are distinguished by present or past dominance by *Pinus palustris*. It was usually exclusively or strongly dominant under natural fire regimes, but likely was mixed with *Pinus echinata* and a few other species in the Piedmont and in northern areas. In current conditions of inadequate fire, *Pinus palustris* may remain dominant but without reproduction. If it was removed by logging, evidence of past dominance may remain in the form of boundary trees, stumps boxed for sap collection, or associated species. *Aristida stricta* naturally dominated most communities. It is an extremely conservative species that occurred in no other communities, and its presence even as sparse remnant clumps indicates past presence of a longleaf pine community.

Within the theme, communities are distinguished by environmental gradients of moisture and soil texture, as well as by biogeography. Loamy or silty soils support a larger number of different communities than coarse sandy soils. Communities are broadly divided into sand barrens, sandhills, and mesic pine savannas. Sand barrens are the most extreme excessively drained coarse sands and are distinguished by a naturally sparse herb layer, a sparse pine canopy, and a midstory of *Quercus laevis*. Sandhills are dry to dry-mesic, on a variety of soil textures, with a dense grassy herb layer, and are characterized by a layer of scrub oaks and other small hardwoods, which may form a midstory or may exist mainly as shrub-size sprouts and scattered groves, depending on fire history. Mesic pine savannas occur only on finer-textured soils in mesic sites and largely lack a scrub oak layer. They resemble the wetter pine savannas in structure but contain upland species. They often have extremely high species richness.

Within the three drier community types, Coastal Fringe Subtypes are distinguished. All are marked by the presence of a suite of plants that, in North Carolina, are generally confined to within a few miles of the coast.

Dry Piedmont Longleaf Pine Forest occurs in the Piedmont, on very different soils. It lacks *Aristida stricta* and has a mixed grassy herb layer.

Sites: Dry Longleaf Pine communities occurred naturally on most upland sites in the Coastal Plain, with the exception of bluffs, swamp islands, maritime areas, and other places naturally sheltered from frequent fire. They now are most extensive in the relict dunes and dissected uplands of the Sandhills Region. Examples elsewhere in the Coastal Plain remain on well-drained upland flats, as well as on relict dune fields, Carolina bay rims, relict floodplain terraces now above flood levels, and low rises in wetter flats. In the Piedmont, they occurred near the Fall Zone in the southern part of the state, primarily in distinctive settings with sandy soil, silt/clay hardpans derived from meta-sedimentary rock, or dry slopes in the Uwharrie Mountains.

Soils: Examples may occur on virtually any kind of non-hydric upland soil, including Entisols, a few Spodosols, and a wide variety of Ultisols.

Hydrology: This theme encompasses the full range of non-wetland hydrology, from the most xeric excessively drained conditions to the transition to wetlands. Seasonal high water tables may be present in the marginal examples.

Vegetation: Dry Longleaf Pine Communities characteristically have an open canopy with a woodland or savanna structure. *Pinus palustris* is virtually the only canopy species present in most examples, but *Pinus echinata* or *Pinus taeda* may be mixed with it in a few of the communities. With long exclusion of fire, the other pines, along with hardwood species, invade most communities. The herb layer characteristically is dense in all but the most xeric communities. *Aristida stricta* dominates in most communities, while *Schizachyrium scoparium* dominates in Piedmont and far northern communities, and a mix of xerophytic species characterizes the most xeric sands. Herbaceous species richness ranges from fairly low to extremely high. Mesic Pine Savannas can have some of the highest values recorded anywhere at small to moderate scales.

The xeric to dry communities have a midstory of small hardwoods, predominantly scrub oaks (*Quercus laevis, Quercus marilandica, Quercus incana,* and *Quercus margaretiae*), which may become dense with exclusion of fire. The mesic communities tend to lack a midstory when frequently burned, but they may be invaded by a variety of other hardwoods, such as *Liquidambar styraciflua* and forest oaks (e.g. *Quercus falcata, Quercus stellata*), in the long absence of fire. A low shrub layer generally consists of sprouts of midstory hardwoods along with patchy or sparse shrubs of a variety of species. With fire exclusion, shrubs may become dense and the midstory becomes dense and taller.

Dynamics: The distinctive dynamics and characteristics of longleaf pine communities, wet and dry, along with the existence of specialized research stations such as Tall Timbers and the Jones Center at Ichauway and widespread conservation and forestry interest throughout the Southeast has led to a tremendous amount of research. While much remains to be learned, the broad picture of community dynamics and some of the finer details are well known. Dynamics appear to be generally similar across the spectrum from wet to dry longleaf pine communities and across the region, so that studies in Georgia and Florida are likely to be relevant in North Carolina.

Fire of low to moderate intensity at frequent return intervals is the crucial ecological driver of longleaf pine communities, which occur over a tremendous range of site and soil conditions but rarely occur in settings not conducive to fire spread. Longleaf pine communities embody the paradox that they are some of the most frequently disturbed communities in the world, yet they are naturally some of the most stable and are dominated by extremely conservative, stress-tolerating plants rather than ruderal species. Though fire was generally regarded as harmful to forests in the early 1900s and most fire was suppressed, there was some early recognition (e.g., Wells 1942, Garren 1943) of its importance for longleaf pine communities. Though fire is generally described as a disturbance, in these communities it was historically predictable enough that it might better be considered merely a part of the environment. It is in some ways comparable to the winter freezes that cause regular loss of biomass in our climate. As noted by Fill et al. (2015), the view of fire dynamics through a conceptual model of succession after disturbance may be better replaced by one of vegetation-fire feedbacks and dynamic equilibrium. In that vein, it has been suggested that the pines, by producing particularly pyrogenic fuels, are acting as ecosystem engineers, creating the fire environment that benefits them (Platt et al. 2016). This Louisiana study emphasized pine needles, not grass, as the driver of fire dynamics, but *Aristida stricta* is more flammable than the grasses present at their study site and appears to be a similarly important driver in most North Carolina communities. Fire return intervals have generally been suggested to be around two to three years. Intervals as short as one year have been suggested by some authors to be beneficial to some aspects of communities (Glitzenstein et al. 2011, Frost 2000, Palmquist et al. 2014); however, this frequency appears to be less favorable to some of the characteristic species, including *Pinus palustris.*

All of the characteristic plant species of longleaf pine communities are well adapted to surviving fire, so that a typical fire causes almost no loss of individuals of characteristic species. Fire recycles nutrients, though Christensen's (1977) experiments found that substantial amounts of major nutrients were lost to the air. Nevertheless, burned soils stimulated growth for reasons that were unclear. Frequent fire is the crucial factor that excludes uncharacteristic species from the community and removes litter. Fires kill the above-ground parts of mesophytic trees as well as shrub and herbs. *Pinus palustris* is highly specialized to be able to reproduce and mature in conditions of frequent fire. In the past, when fire was more frequent, shrubs and other trees only rarely and locally escaped fire long enough to grow tall. Most individuals existed as short sprouts, though groves apparently occurred in canopy gaps and in natural fire shelters. Under current conditions, even where prescribed burning occurs, scrub oaks are often denser and include more midstory-size stems. Although scrub oaks were less abundant under more natural conditions, they are well enough adapted to fire to have been a consistent component of sandhill communities. Hannon, et al. (2020) found that, even in a frequently burned site, scrub oak abundance varied not only with slope but with more subtle factors such as proximity to the firebreaks where prescribed fires are ignited (and are therefore less intense). Scrub oaks are important to some of the animal species and ecological functions in longleaf pine communities (Hiers et al. 2014). Scrub oaks, and even less fire tolerant species such as *Crataegus* support distinctive insects, including globally rare species in sandhill communities.

There has been increasing evidence that the season when fires occur is important (Parrot 1967, Schneider 1988, Hiers et al. 2000), though it is clear that burning at any season is better than exclusion of fire. Natural fires presumably followed the seasonal pattern of lightning, though fires, once ignited, could burn for long times and spread long distances across the continuous flammable landscapes dominated by longleaf pine. Fires ignited by people far back into prehistory could have been at any season, but the flora and fauna appear to be best adapted for spring and summer fire. However, Hiers et al. (2000) indicate variation in seasonal effects on different herb species, supporting a general idea that variation in fire season may also be important for maintaining plant diversity. The existence of species adapted to different seasons of burning suggests a history of variable burn seasons that pre-dates the arrival of humans.

Removal of fire from longleaf pine communities drastically alters these communities, increasingly so over time. Understory trees or shrubs increase in cover, and their shade, along with accumulation of litter, suppresses and gradually eliminates the herbaceous species. Hiers et al. (2007) indicate that litter rather than shade itself is primarily responsible for suppressing herbaceous vegetation, at least in xeric sandhills in Florida. However, they acknowledged that shade might be more important in mesic communities where the midstory could become denser. Longleaf pine itself is unable to regenerate in the shade of a dense understory, even if canopy gaps are available. This may be due to litter depth, but its "grass stage" delay in initiation of height growth makes it vulnerable to suppression even by shrubs. The accumulation of oak litter and the loss of grass reduces the effectiveness and likelihood of future fires, while scrub oaks that have grown large are fairly tolerant of fire. It therefore is difficult to restore examples that have gone too long without fire. Even if dense midstory or canopy cover is mechanically reduced and litter burned, most of the diversity of herbaceous species is very slow to recover, while sprouting of shrubs and trees from well-established root systems quickly returns, or even increases, dense woody cover. However, Fill et al. (2017) reported fairly rapid vegetative spread of *Aristida beyrichiana,* and *Aristida stricta* likely has similar ability to fill space where it remains in a community at moderate density.

Most plant species associated with longleaf pine communities have conservative life histories. Though most have not been studied in detail, the characteristic herb species appear to have long life spans, rarely reproduce by seed, don't readily invade open areas, and don't have long term seed banks. Fill et al. (2014) indicated that species endemic to longleaf pine communities in general were more likely to be perennial than those that weren't. The more important question of how long the perennial species live is much more difficult to address, but most, especially the dominants, appear to turn over only slowly. Fill et al. (2014) found no difference in apparent seed dispersal ability for longleaf pine community endemic species, but they noted that dispersal does not necessarily indicate that seedlings can easily establish. Though Fill et al. (2017) found that planted *Aristida beyrichiana* had seeded into nearby disturbed ground, and though seedlings of *Aristida stricta* have been found in a few places in North Carolina, the more common situation is to observe no return of the species to mechanically disturbed areas where it is absent. Even small disturbed areas such as old logging decks remain devoid of wiregrass and most other characteristic species after decades, even when surrounded by healthy stands that are burned regularly. Growing season burns appear to be necessary, but even they rarely lead to new seedlings. Coffey and Kirkman (2006), in Georgia, found no viable seed for *Aristida* in the soil and found only a small minority of experimentally buried seeds remain viable after 4 years. Schneider (1988) also found almost no seed bank for the characteristic dominant species in a savanna, with primarily weedy species in the seed bank. Fire is necessary for many of the species, including *Aristida stricta*, to flower, but additional conditions appear to be necessary for most species to successfully establish even in openings. Species diversity and density of most characteristic species recovers only very slowly from reduction by mechanical disturbance, herbicide use, heavy pine straw raking, and past fire suppression.

Longleaf pine also is a conservative species. It is among the most long-lived trees in the region, capable of exceeding 400 years (Platt et al. 1988). The species has numerous adaptations to help it survive the frequent low-intensity fires characteristic of its habitat, and it also survives strong winds better than most trees. Longleaf pine begins to produce seed at an older age or larger size than most trees, and abundant seed crops occur only every few years. Seeds need bare mineral soil to germinate, so successful seeding requires a seed crop to be preceded by a fire (Boyer and White

1990). The species is generally regarded as being extremely intolerant of shade and having limited seed dispersal, compared to other pines. However, Grace et al. (2004) found that seeds dispersed farther than was believed and that few seeds fell close to the parent tree, at least in her old-growth Georgia study site. The population did not have significant genetic structure, suggesting widespread dispersal within the population. Bhuta et al. (2008) indicated that mature trees can survive many years in dense shaded conditions and can still respond with rapid growth if released. Nevertheless, seedlings and saplings can be observed to be largely confined to canopy gaps, generally ¼ acre or more in size (Boyer and White 1990). Reduced pine litter cover and reduced fire intensity as well as light could be contributing reasons. Though the conditions for successful reproduction of longleaf pine appear highly specialized today, these conditions were prevalent enough that the species dominated most of the Coastal Plain landscape.

Longleaf pine canopies naturally occur as old-growth, multi-aged woodlands or savannas. The natural population structure and dynamics of longleaf pine in North Carolina are believed to be similar to that found by Platt, Evans, and Rathbun (1988) in old growth longleaf pine forest in Georgia. The age structure there was patchy and heterogeneous, reflecting irregularities in both reproduction and mortality of the pines in response to environmental conditions and natural disturbances. Tree regeneration is somewhat episodic. Essentially all ages were represented, up to well beyond 200 years, indicating continuous establishment of long-lived trees. Younger trees tended to establish in small even-aged clumps, in areas with lower density of adult trees. Over time the clumps thinned and became less distinct, so that the old trees were more randomly distributed. This natural patch structure has been lost in most present examples, where past clearcutting has resulted in more uniform even-aged stands. Typical thinning also homogenizes any developing patch structure, but older canopies can be seen to be starting to develop a patchy structure as gaps form.

In addition to an old-growth canopy being characteristic under natural conditions, the herbaceous layer fits the concept of old-growth grasslands as outlined by Veldman et al. (2015), with high species richness; many species that do not occur in more disturbed "second growth" examples; and species with good resprouting ability, but poor colonization ability, and fire tolerance or dependence. Unlike other grasslands they discussed, grazing does not appear to have been an important factor in maintaining them. Grazing was widespread in early European times and may have caused damage that has not been recognized. Foraging by hogs is known to have had a significant effect; by preferentially feeding on the roots of longleaf pine seedlings, they prevented regeneration of the species in logged examples and led to its loss over large areas.

Some characteristic animals, such as *Picoides borealis* (red-cockaded woodpecker) and *Crotalus adamanteus* (eastern diamondback rattlesnakes), have similar conservative life histories, with ability to tolerate fire, long life spans, slow reproduction, and difficulty returning areas if they are extirpated. Others, such as many insects, apparently do not readily escape fire; they depend on metapopulation structures and on rapid reproduction of individuals in unburned patches to repopulate burned areas.

The mechanisms by which soil texture determines differences in communities is not fully understood, though some aspects may be easily surmised. Excessive drainage in coarse, pure sands makes them extremely dry. Though the water table may be close enough that it is reached by the deep roots of established plants, drought stress in the seedling stage likely acts as a filter for species. However, coarse sands also have very low cation exchange capacity and nutrient-holding capacity. Loamy soils are better at retaining and supplying both water and nutrients. The effect of dense clay layers may be more complex. Weaver (1969) demonstrated that *Quercus marilandica* growing on soils with clay layers endured more drought stress than *Quercus laevis* on deep coarse sands uphill from it, apparently due to restricted rooting depth. He concluded that nutrient supply, perhaps manganese, rather than moisture, was what kept *Quercus marilandica* from occupying deep sands. Gilliam et al. (1993) surmised that nutrient availability was the crucial aspect of soil texture in their study site. Thus, either nutrient supply or moisture availability may be the reason for the higher diversity of herbs on loamy soils, and for the much lower diversity and abundance of Fabaceae on sands.

More difficult to understand is the absence of scrub oaks in the Mesic Pine Savannas. As one goes downhill into these communities from Pine/Scrub Oak Sandhill, the density and apparent vigor of all scrub oaks decreases until few or none are present. No other midstory species typically replace them, though oak species more typical of forests, such as *Quercus stellata, Quercus falcata*, *Quercus velutina*, and *Quercus nigra,* eventually invade them after long absence of fire. The high species richness and increased density of the herb layer in Mesic Pine Savannas suggest that these sites are more rather than less favorable to plant growth. Competition with the herb layer, increased fire intensity in the more productive sites, or transient high water tables are possible mechanisms that may need investigation. Fill et al. (2017) observed that dense *Aristida beyrichiana*, even recently planted, inhibited the invasion by trees on a loamy soil in South Carolina.

Comments: While many natural communities remain underappreciated, both longleaf pine as a species and longleaf pine communities have received much attention and celebration in the last several decades. As stated by Landers et al. (1990) in a symposium on management of the species: “Probably no other single tree species in any region has so influenced cultural and natural ecology or advancement of the conservation science.” The more broadly defined longleaf pine ecosystem is widely regarded as among the most endangered, with an extreme decline from its original abundance. The conservative life histories of most of its flora, including the dominant species, makes restoration difficult. However, areas that retain *Aristida* and other characteristic herbs can be restored by planting *Pinus palustris*. Emphasis by conservation organizations and the forestry community and by specialized organizations such as America’s Longleaf Restoration Initiative have sought to reverse the drastic declines in acreage of the tree species and the ecosystems it dominates.

Longleaf pine communities, dry and wet, are the prevailing natural vegetation of the entire Coastal Plain of the Southeastern United States, from southernmost Virginia to eastern Texas. As in North Carolina, they occur over a very broad range of landforms and soil conditions throughout that region. However, analysis of plot data from Virginia to Florida found that the strongest variation in vegetation was with biogeography (Palmquist et al. in prep. a). Plots in North Carolina were more similar to each other than they were to plots with comparable moisture levels in Florida. Species richness increases southward, peaking in the Florida panhandle, but there also is significant species turnover through the range, with several centers of endemism. The dominant grasses also vary. *Aristida stricta* reaches its northern range limit just north of the Neuse River, as well as being absent in the Piedmont. It ranges southward only through the northern third of South

Carolina. *Aristida beyrichiana* dominates from southern South Carolina through much of Florida but becomes more ecologically restricted in the Gulf Coast states. Other grasses dominate in central South Carolina, in some inland areas of the Gulf Coastal Plain, and farther west.

Most of the subtypes in this theme were treated as variants in the 3rd Approximation, after being recognized in natural heritage surveys of longleaf pine communities. Most were confirmed by early analysis of Carolina Vegetation Survey (CVS) data. Recent thorough analysis of CVS plot data (Palmquist et al. in prep. b, c), supplemented by data ranging from Virginia to Florida, confirmed the identity of these units but led to a few changes. Most of the descriptions here are based on that analysis but are supplemented by other observations.

The terms "savanna" and "flatwoods" have been widely used in ecological literature in two different ways, applying to both pine and hardwood-dominated communities. At times, they refer simply to vegetation structure, with savannas being grassy and flatwoods being shrubby. In other usages, particularly in the Southeastern U.S., they refer to moisture regimes, with savannas being wetter and flatwoods somewhat drier. Savannas have also often been taken to refer to places with high species richness, flatwoods low. In the 3rd Approximation, the terms were used to indicate moisture regimes, with Mesic Pine Flatwoods and Wet Pine Flatwoods drier than Pine Savanna, which was always wet. Because this usage caused confusion, leading some users to expect that the flatwoods communities should naturally be shrubby, the usage in names has been shifted in the 4th Approximation. The species-rich mesic longleaf pine communities have been renamed to use the term "savanna." They are not naturally more shrubby than wetter savannas. "Flatwoods" is now reserved for marginally wet sandy communities previously known as Wet Pine Flatwoods, which are low in species richness.

With the exception of the one Piedmont community, the NVC divides the associations of the Dry Longleaf Pine Communities theme into two groups. It does so in a different way than the sand barren, sandhill, and mesic savanna grouping implicitly used in the naming of the 4th Approximation communities. G154 Xeric Longleaf Pine Woodland Group encompasses the sand barrens and driest sandhills on coarse sands. G009 Dry-Mesic Loamy Longleaf Pine Woodland Group encompasses the mesic savannas and the less extreme sandhills. As noted above, this gradient was not as strongly marked in vegetation analysis as was biogeography, but the previous NVC group concepts were retained in Palmquist, et al. (2016) and Palmquist, et al. (in prep. a) rather than disrupt the NVC hierarchy. These studies did move a few associations to the other group, to make the groups more internally consistent, but a couple appear to continue to straddle the border. The group boundary remains inconsistent with the community concepts used in the 4th Approximation. Different subtypes of Pine/Scrub Oak Sandhill are placed in different NVC groups.

KEY TO DRY LONGLEAF PINE COMMUNITIES

1. Community in the Piedmont region; *Aristida stricta* almost always absent............................... ....**Dry Piedmont Longleaf Pine Forest**

1. Community in the Coastal Plain.; *Aristida stricta* present in relatively natural examples, except in Pine/Scrub Oak Sandhill (Northern Subtype).

 2. Community in the northern Coastal Plain, north of the native range of *Aristida stricta* (roughly the Tar River) .... **Pine/Scrub Oak Sandhill (Northern Subtype)**

 2. Community in the southern Coastal Plain, including the Sandhills region; *Aristida stricta* naturally present and almost always dominant in the herb layer in relatively unaltered examples.

  3. Community containing scrub oaks (*Quercus laevis, marilandica, incana, margaretiae, geminata*, etc.) in more than minor numbers, either as a distinct midstory or as sprouts after recent fires (or deliberately removed by herbicide treatment).

   4. Community containing a relatively low density of scrub oaks given its management history, exclusively or primarily *Quercus marilandica*; community also containing species more typical of wetter sites, such as *Vaccinium crassifolium, Pyxidanthera barbulata, Bigelowia nudata, Osmundastrum cinnamomeum, Ctenium aromaticum, Cyrilla racemiflora*, and *Vaccinium elliottii* (also keyed elsewhere)

    5. Community occurring on a substrate of clay or cemented rock on or near a hilltop in the Sandhills region; *Vaccinium crassifolium* or *Pyxidanthera* usually abundant. .... **Pine/Scrub Oak Sandhill (Clay/Rock Hilltop Subtype)**

    5. Community not occurring on a substate of clay or cemented rock; *Vaccinium crassifolium* and *Pyxidanthera* abundant or not.

     6. Community occurring on elevated floodplain terraces along the Little River; community often containing *Vaccinium elliottii*, sometimes containing *Amorpha georgiana* ....**Mesic Pine Savanna (Little River Subtype)**

     6. Community occurring on upland flats in the inner Coastal Plain of Robeson County or adjacent areas. ....**Mesic Pine Savanna (Lumbee Subtype)**

   4. Community containing a higher density of scrub oaks, as either a midstory or as fire sprouts, often dense if there has been a period of fire suppression in the past, but at least widespread in the community if not treated with herbicide; scrub oaks include abundant *Quercus laevis, Quercus incana,* or other species besides *Quercus marilandica*; wetland species absent or, if present, confined to wetter microsites and abundance and diversity of these species low.

    7. Scrub oaks consisting exclusively or almost entirely of *Quercus laevis*; community on dry, excessively drained sands with little or no finer texture material.

     8. Community on uncommon deep, excessively drained, nearly pure coarse sands; herb layer sparse to moderate in density even in natural condition, with abundant *Cladonia* lichens, *Stipulicida setacea*, *Cnidoscolus stimulosus*, *Bryodesma acanthonota* (*Selaginella arenicola*), and other species adapted to extremely sandy environments; *Aristida stricta* with limited density even in unaltered sites; *Pinus palustris* stature and density reduced compared to other longleaf pine communities with similar management.

      9. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus hemisphaerica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladonia evansii*, at least at low density; community generally

within a few miles of the coast, but occasionally in isolated sandy sites inland. ....
....**Sand Barren (Coastal Fringe Subtype)**

9. Community not containing species generally indicative of the coastal fringe zone; community farther inland.. **Sand Barren (Typic Subtype)**

8. Community on common deep sands that are somewhat less excessively drained and may contain some silt; *Aristida stricta* at moderate to high density if not altered, dominating the herb layer; *Cladonia, Stipulicida, Cnidoscolus, Bryodesma*, and other species specialized for sand often present but not the predominant herbs; *Pinus palustris* of typical density and stature for its management history (note that sites with soil disturbance may resemble the more sparsely vegetated Sand Barren communities).

10. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus hemisphaerica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladonia evansii*, at least at low density; community generally within a few miles of the coast, but occasionally in isolated sandy sites inland. ....
....**Xeric Sandhill Scrub (Coastal Fringe Subtype)**

10. Community not containing species generally indicative of the coastal fringe zone; community farther inland............................... **Xeric Sandhill Scrub (Typic Subtype)**

7. Scrub oaks mixed, with *Quercus incana, marilandica*, or *margaretiae* dominant or codominant with *Quercus laevis;* community on fine sands, sands with a clay layer near the surface, or loamy soil.

11. Community containing species generally indicative of the coastal fringe zone, such as *Quercus geminata, Quercus virginiana, Quercus hemisphaerica, Cartrema americana, Rhynchospora megalocarpa*, and *Cladonia evansii*, at least at low density; community generally within a few miles of the coast, but occasionally in isolated sandy sites inland .... **Pine/Scrub Oak Sandhill (Coastal Fringe Subtype)**

11. Community not containing species generally indicative of the coastal fringe zone.

12. Community, if not heavily altered, with a diverse herb layer containing species indicative of mesic conditions or loamy soil, such as *Lespedeza capitata, Lespedeza hirta*, *Sorghastrum nutans, Gymnopogon brevifolius, Muhlenbergia capillaris, Andropogon gerardii, Panicum virgatum*, *Parthenium integrifolium*, *Ceanothus americana*, and a number of additional legumes.

13. Community in the Sandhills region; containing species such as *Coreopsis major, Viola pedata, Baptisia cinerea, Rhynchosia reniformis, Phlox nivalis, Asclepias amplexifolius,* and *Galium pilosum* that are primarily in that region. ....
.........................**Pine/Scrub Oak Sandhill (Sandhills Mesic Transition Subtype)**

13. Community elsewhere in the Coastal Plain; species more typical of the Sandhills region scarce or absent; species typical of the outer Coastal Plain, such as *Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum, Helianthus heterophyllus*, and *Rhynchospora plumosa* present..
................**Pinus/Scrub Oak Sandhill (Coastal Plain Mesic Transition Subtype)**

12. Community with moderate to lower herb diversity, containing few or none of the species indicative of mesic conditions or loamy soil.

14. Community occurring on a substrate of clay or cemented rock at the surface, on or near a hilltop in the Sandhills region; scrub oaks primarily *Quercus marilandica*, with little *Quercus laevis*; scrub oaks reduced in density compared to other sandhill communities with the same management history; *Vaccinium crassifolium* or

Pyxidanthera usually abundant. .... **Pine/Scrub Oak Sandhill (Clay/Rock Hilltop Subtype)**

14. Community not occurring on a substate or clay or cemented rock at the surface; scrub oaks mixed, with *Quercus laevis* or *Quercus incana* abundant; scrub oaks at normal density given management history; *Vaccinium crassifolium* generally absent; *Pyxidanthera* abundant or not.

15. Community occurring on sand with a clay or plinthite layer within roughly 2 meters of the surface; scrub oaks a mix of *Quercus marilandica* and *Quercus laevis*; herb layer moderately diverse; common in the Sandhills region but rare elsewhere. .... **Pine/Scrub Oak Sandhill (Blackjack Subtype)**

15. Community occurring on fine sand or sand with silt, without a clay or plinthite layer; scrub oaks generally lacking *Quercus marilandica*, consisting primarily of *Quercus laevis* and *Quercus incana* or *Quercus margaretiae*; herb diversity somewhat lower; scattered in the Coastal Plain and Sandhills. .... **Pine/Scrub Oak Sandhill (Mixed Oak Subtype)**

3. Community not containing scrub oaks in more than minor numbers, though forest oaks (*Quercus falcata, Quercus stellata, Quercus velutina, Quercus nigra*) may be present in unburned examples; species of mesic or loamy sites abundant.

16. Community in the Sandhills region; containing species typical of that region.

17. Very rare community on high terraces of the Little River; containing a mix of species with a wider range of moisture tolerance than typical; *Quercus marilandica* present in small amounts; *Vaccinium elliottii* often present ...**Mesic Pine Savanna (Little River Subtype)**

17. Uncommon community in swales or on loamy soils in typical Sandhills terrain; species typical of dry to mesic sites with limited wetland flora present; *Vaccinium elliottii* never present ....**Mesic Pine Savanna (Sandhills Subtype)**

16. Community in the Coastal Plain outside of the Sandhills.

18. Rare community in the inner Coastal Plain of Robeson County and adjacent areas; containing a mix of species with a wider range of moisture tolerance than typical; *Quercus marilandica* and wetland species such as *Osmundastrum cinnamomeum* and *Sarracenia flava* generally co-occurring; *Quercus elliottii* often present. ....**Mesic Pine Savanna (Lumbee Subtype)**

18. Uncommon community elsewhere in the Coastal Plain; containing a mix of species typical of mesic to wet areas with limited species of drier areas. ....**Mesic Pine Savanna (Coastal Plain Subtype)**

DRY PIEDMONT LONGLEAF PINE FOREST

Concept: Dry Piedmont Longleaf Pine Forest covers woodlands or forests of the eastern Piedmont (primarily the Uwharries and nearby southern fall zone areas) in which *Pinus palustris* naturally dominates or codominates. *Pinus palustris* may be scarce in examples where past logging and fire suppression have removed it and allowed other pines or hardwoods to dominate.

Distinguishing Features: Dry Piedmont Longleaf Pine Forest is distinguished from all other Piedmont dry communities by having *Pinus palustris* dominant or codominant, or by having evidence that it once dominated. In degraded examples, the canopy may resemble Dry Oak–Hickory Forest or Piedmont Monadnock Forest or may be dominated by *Pinus taeda* and *Pinus echinata*, with evidence of *Pinus palustris* limited to scattered individuals or to stumps. Dry Piedmont Longleaf Pine Forest is distinguished from Wet Piedmont Longleaf Pine Forest by its overall dry to dry-mesic vegetation, lacking any appreciable amount of wetland species. It is distinguished from most longleaf pine communities of the adjacent Coastal Plain by lacking *Aristida stricta, Quercus laevis, Quercus incana*, and *Quercus margaretiae*, as well as by its Piedmont location and soils. The Northern Subtype of Pine/Scrub Oak Sandhill also lacks *Aristida stricta* but contains the Coastal Plain scrub oaks.

Crosswalks: *Pinus palustris - Pinus echinata / Quercus marilandica - (Quercus montana) / Vaccinium pallidum* Woodland (CEGL008437).
G165 Piedmont-Coastal Plain Oak Forest & Woodland Group.
Southeastern Interior Longleaf Pine Woodland Ecological System (CES202.319).

Sites: Dry Piedmont Longleaf Pine Forests may occur on a variety of upland sites in the southeastern Piedmont. Many are in rolling terrain on meta-sedimentary rocks with deep soils that are particularly high in silt. Less frequently they are found in more rugged terrain on steeper rocky slopes that face south to west.

Soils: Soils are Ultisols, some very silty, some more typical loams. Most examples are mapped as Herndon or Georgeville (Typic Kanhapludults), Biscoe or Secrest (Aeric Epiaquults).

Hydrology: Conditions are dry to dry-mesic, possibly locally mesic. Some soils may be poorly drained and have wetter microsites.

Vegetation: In natural condition this community is believed to have an open savanna to woodland canopy with limited understory and shrub layer and a well-developed herb layer, comparable to most longleaf pine communities. The canopy is dominated or codominated by *Pinus palustris*. *Pinus taeda* and *Pinus echinata* may be codominant, and *Quercus stellata, Quercus falcata*, and *Quercus montana* are believed to be present in the canopy in small numbers even under natural conditions. These species, and other forest hardwoods, often become dominant in the absence of fire. The understory/midstory includes these hardwoods and additionally may include *Quercus marilandica, Oxydendrum arboreum, Nyssa sylvatica*, *Sassafras albidum*, *Diospyros virginiana*, and *Benthamidia* (*Cornus*) *florida*. These may be characteristic under natural conditions but at reduced density. Other tree species frequent in CVS plot data include *Acer rubrum, Prunus serotina, Quercus coccinea, Quercus alba, Quercus velutina, Liriodendron tulipifera*, and

Liquidambar styraciflua, which presumably became abundant only as a result of fire exclusion and logging. The most abundant shrub species include *Vaccinium tenellum, Gaylussacia frondosa, Vaccinium pallidum, Gaylussacia dumosa, Lyonia mariana, Rhus copallinum*, and *Vaccinium stamineum*, and many of the hardwood tree species may exist more naturally as shrub-size sprouts. Other characteristic shrub species include *Toxicodendron pubescens, Vaccinium arboreum, Hypericum stragulum, Ceanothus americanus, Castanea pumila*, and *Kalmia latifolia*. *Muscadinia rotundifolia* often is abundant on the ground. *Schizachyrium scoparium* probably dominated the herb layer under more natural fire regimes, but only occasionally does so in existing examples. The herb layer potentially is very diverse. Frequent herbs in plot data that likely are naturally characteristic include *Tephrosia virginiana, Solidago odora, Pteridium latiusculum* or *pseudocaudatum*, *Coreopsis major, Iris verna* var. *verna*, *Sorghastrum nutans, Chrysopsis mariana, Pityopsis graminifolia* var. *latifolia,* and *Danthonia sericea*. Other characteristic herbaceous species include *Andropogon gyrans*, *Symphyotrichum patens, Andropogon gerardii, Coreopsis verticillata, Coreopsis major, Helianthus atrorubens, Helianthus divaricatus, Lespedeza hirta, Desmodium nuttallii, Desmodium lineatum,* other *Desmodium* and *Lespedeza* spp., *Mimosa microphylla, Parthenium integrifolium, Hypoxis hirsuta, Eupatorium pilosum, Eupatorium rotundifolium, Galactia erecta, Euphorbia pubentissima, Dichanthelium* spp., *Helianthus laevigatus, Helianthus schweinitzii, Sericocarpus asteroides, Stylosanthes biflora,* and *Ionactis linariifolia*. A number of weedy species may additionally be present in examples that are being restored, and more shade-tolerant species may be present in examples that remain heavily shaded and fire suppressed.

Range and Abundance: Ranked G2. In North Carolina, the most intact remaining examples of this community are primarily in the Uwharrie area, but examples are recognizable near the fall zone as far north as Wake County. The equivalent association ranges to Alabama, where it is more extensive, though still limited. Known there as mountain longleaf pine, it occurs in the Ridge and Valley and Interior Plateaus regions as well as the Piedmont. At least a few examples remain in Georgia. This community likely once was abundant in a fairly narrow band at the edge of the Piedmont.

Associations and Patterns: Dry Piedmont Longleaf Pine Forests sometimes occur in mosaics with Wet Piedmont Longleaf Pine Forest and are often associated with Piedmont Boggy Streamhead and Hillside Seepage Bog communities in embedded wetlands. Piedmont Headwater Stream Forest or Piedmont Alluvial Forest occurs in larger drainages. Dry Piedmont Longleaf Pine Forest is inherently a large patch to matrix forming community in the most suitable fall zone landscapes, but examples now are reduced to small, rarely large, patches. However, naturally small patches occur in rugged hilly terrain dominated by oak forests in parts of Uwharrie National Forest. Elsewhere, the natural transition from longleaf pine to the prevailing Piedmont oak forest landscape is not known. They probably were locally interspersed as determined by topography and its conduciveness to fire spread.

Variation: Dry Piedmont Longleaf Pine Forest covers a broader range of moisture and topographic positions than Piedmont hardwood forests or most longleaf pine forests. The extreme alteration by past logging and fire suppression have made it difficult to tell natural patterns from patterns of alteration. Recent restoration activities, while improving conditions of the communities in many ways, introduce further variation not related to natural patterns. Additional subtypes may become distinguishable as burning continues and as more information is gathered. For the present, two variants are recognized in North Carolina.

1. Typic Variant represents most of the known remaining examples in the fall zone and the eastern Uwharrie region. They have moderate to gentle topography and once occurred as large patch to matrix communities. This variant may warrant further division into mesic, dry-mesic, and dry variants based on topography, or the examples on extremely silty soils may be distinctive.

2. Mountain Variant includes even rarer examples occurring on steeper slopes in rugged terrain in the Uwharrie region. They occur as small patch communities on dry slope aspects. Known examples are shrubbier than the Typic Variant, but this may be a result of having received less fire in recent years. However, fire likely was naturally less frequent in the dissected landscape where this variant occurs. Herbaceous flora is very limited in the few examples at present, but it is presumed there are natural differences from the Typic Variant in herbaceous flora. There are related communities known as mountain longleaf pine forests in Alabama, where they are more widespread in both Piedmont and Blue Ridge regions. Biogeographic differences distinguish them from the Mountain Variant of North Carolina.

Dynamics: As with other longleaf pine communities, Dry Piedmont Longleaf Pine Forest depends on frequent fire to maintain its ecological character. Without fire, trees and shrubs quickly proliferate, and hardwood trees gradually establish a dense canopy that eliminates the characteristic herbs. However, natural fire likely was somewhat less frequent than in the Coastal Plain because of the dissected terrain of the Piedmont and a lower frequency of thunderstorms inland. The absence of *Aristida stricta* also would also reduce fire spread; no other herbs are as flammable as it, nor able to carry fire in as many conditions. This difference in fire frequency, along with the different substrates, presumably is responsible for the different flora and different character of Dry Piedmont Longleaf Pine Forest. The lower fire frequency may allow other pines and some oaks to coexist with the longleaf pine. However, the abundance of *Pinus palustris* suggests fire at greater frequency than was typical in parts of the Piedmont beyond its native range. The Mountain Variant occurs in more dissected terrain, where fire frequency could be expected to be even lower, and dry microsites are probably more crucial to its occurrence.

Comments: Patterson and Knapp (2016) intensively studied the best remaining example of the Mountain Variant, mapping every longleaf pine tree. Dendrochronological study of this site and of small collections of longleaf pines in the rugged parts of the Uwharrie Mountains has revealed the presence of trees up to at least 270 years old.

Another NVC association, *Pinus palustris - Quercus marilandica - Quercus montana / Symplocos tinctoria* Woodland (CEGL004554), was formerly recognized in the NVC but later merged. It appears equivalent to the Mountain Variant. If further investigation of the Mountain Variant determines it to be distinct, this association might be revived to cover it. In its present condition, it does not appear distinctive enough for recognition.

The relationship between this community and Xeric Piedmont Slope Woodland, a dry community of similar environments in the Uwharrie region but lacking *Pinus palustris* needs to be clarified.

Rare species:
Vascular plants – *Cirsium carolinianum, Helianthus laevigatus,* and *Pseudognaphalium helleri*.

Vertebrate animals – *Dryobates borealis*.

SAND BARREN (TYPIC SUBTYPE)

Concept: Sand Barrens are the driest, most barren naturally occurring nonmaritime sandy communities of the Coastal Plain, as well as the driest longleaf pine communities. They have naturally low vegetation cover in all strata and a prominent suite of sand-tolerant (psammophyte) plants. They typically are on Carolina bay rims or on the younger inland sand dunes. The Typic Subtype covers the typical examples in most parts of the Coastal Plain, which lack the plants characteristic of the Coastal Fringe Subtype.

Distinguishing Features: Sand Barrens are distinguished from Xeric Sandhill Scrub and all other longleaf pine communities by low cover of grasses even in natural condition and by high relative abundance of specialized psammophytes, macrolichens, and bare sand. Characteristic plants include *Polygonella polygama, Stipulicida setacea, Geocarpon* (*Mononeuria, Minuartia) carolinianum, Bryodesma (Selaginella) acanthonota*, and *Cnidoscolus stimulosus*, as well as *Aristida stricta* at low density. All vegetation strata typically have low cover, with the scrub oak midstory often the highest. Distinguishing natural Sand Barrens from disturbed Xeric Sandhill Scrub communities can sometimes be difficult. Old-looking or gnarled-looking (though small) longleaf pines and turkey oaks; presence of wiregrass at least in more mesic microsites; a diversity of psammophytes; and absence of weedy plants such as *Andropogon virginicus, Eupatorium capillifolium*, and *Eupatorium compositifolium* are indicators of natural conditions.

The Typic Subtype is distinguished from the Coastal Fringe Subtype by the absence of plants that are (in North Carolina at least) confined to the coastal zone — *Cladonia evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Quercus geminata*, and to a lesser degree, *Quercus hemisphaerica*. Given the extreme environment in this community, most of these species may be sparse.

Crosswalks: *Pinus palustris / Quercus laevis / Stipulicida setacea - Selaginella acanthonota* Woodland (CEGL003584).
G154 Xeric Longleaf Pine Woodland Group
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Xeric Sandhill Scrub (Sand Barren Variant) (3rd Approximation)

Sites: Sand Barrens occur on the coarsest, purest sands, elevated well above the water table. They occur on the highest parts of Carolina bay rims, on younger dunes associated with Carolina bays, and of relict dune systems on the east sides of rivers.

Soils: Soils are Typic Quartzipsamments, generally mapped as the Kureb or Lakeland series. Most areas mapped as these series support Xeric Sandhill Scrub, and only the most extreme minority supports Sand Barrens. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention.

Hydrology: Sites are excessively drained, with precipitation quickly passing through the coarse soil, leaving surface soils extremely dry most of the time. These settings have been described as "deserts in the rain" (Wells 1932). However, the water table may be within reach of the roots of larger plants; trees are sometimes described as acting as phreatophytes.

Vegetation: Vegetation is sparse in all strata. The canopy is almost exclusively *Pinus palustris*, but consists of widely scattered individuals or small clumps, the trees small in stature. The midstory is open and patchy but may be naturally more extensive than in less extreme sandhill communities. *Quercus laevis* strongly dominates, but sparse individuals of *Quercus margaretiae, Diospyros virginiana*, or *Sassafras albidum* often are present. Individuals of unexpected species, such as *Quercus nigra*, *Pinus taeda*, *Pinus serotina*, or *Ilex opaca* may also be found in sites with long fire exclusion. The shrub layer consists of low-stature species in a patchy distribution. *Polygonella polygama* (probably *P. croomii* farther inland), *Gaylussacia dumosa*, *Vaccinium tenellum*, and *Lyonia mariana* are characteristic, the distinctive dwarf form of *Vaccinium stamineum* may occasionally be seen, and in a few notable sites *Chrysoma pauciflosculosa* is abundant. Species of more moist communities sometimes spread into the edges of Sand Barrens from adjacent communities or occur in moister microsites, especially species that spread vegetatively such as *Gaylussacia frondosa, Clethra alnifolia*, and *Arundinaria tecta*. Vines, especially *Muscadinia rotundifolia* or *Gelsemium sempervirens*, may be prominent in sparse patches, especially in fire-suppressed examples. The herb layer is sparse, with much area of bare sand and often high cover of *Cladonia* spp. lichens. *Aristida stricta* is present as scattered individuals or dominating favorable patches in a minority of the area. *Polygonella polygama* may equal it in cover. Other frequent species in CVS plots (Palmquist et al. in prep. b) include *Stipulicida setacea*, *Bryodesma acanthonota*, *Cnidoscolus stimulosus, Cuthbertia graminea,* and *Sabulina caroliniana*. As with shrubs, species of wetter areas are occasionally present, especially clonal species such as *Pteridium pseudocaudatum*. Species richness is very low, with an average in CVS plots of only 12. The open sand appears to have a cryptogamic crust in many places where undisturbed, including sand cemented by black material or a green layer under 1-2 millimeters of sand.

Range and Abundance: Ranked G2G3 but rarer than this implies. It should be G2, if not G1. The Typic Subtype is widely scattered in the middle and inner Coastal Plain and occasional in the Sandhills region. The largest concentration is in the Bladen Lakes area of Bladen and Cumberland counties. The widespread sand sheets of the Sandhills region appear to be too shallow or have too much fine material to support this community. This subtype ranges into northern South Carolina.

Associations and Patterns: Sand Barrens are small patch or large patch communities. They typically grade to Xeric Sandhill Scrub and Wet Pine Flatwoods on lower parts of the dune systems. Pond Pine Woodland or other peatland communities are often nearby in adjacent Carolina bays and swales.

Variation: Two variants are recognized:

1. Typic Variant includes examples in the Bladen Lakes region and Sandhills, fitting the description above and lacking *Chrysoma pauciflosculosa*.

2. Woody Goldenrod Variant covers the very rare examples on river sand dunes along the Lumber River and likely in similar sites in South Carolina, characterized by *Chrysoma pauciflosculosa*, which may be among the most abundant plants.

Dynamics: Sand Barrens differ from all other Dry Longleaf Pine Communities and Wet Longleaf Pine Communities in not necessarily being dependent on frequent fire. The sparse, patchy vegetation makes fire spread irregular; many parts may escape ignition in any given fire. Examples may persist in the absence of fire, long after surrounding communities have been degraded, though some increase in less xerophytic vegetation does occur. It is possible the slow accumulation of litter may eventually lead to more drastic changes and loss of the distinctive character in the absence of fire.

Because of the extremely dry soil conditions, establishment of *Pinus palustris* and perhaps all component plants is likely even more episodic than in other longleaf pine communities, However, it will depend more on the occurrence of wet years than on fire.

Comments: Tiger beetles (*Cicindella* spp.) can often be seen in these communities and may be a more important animal component here than elsewhere.

Because this community has limited *Aristida stricta* abundance, there has been confusion about how to interpret the crosswalked NVC association. It has sometimes been applied to communities in the "wiregrass gap" of South Carolina. However, the biogeography of its component species is not that different from other longleaf pine communities, as it should be treated as having a similar range to other wiregrass-containing communities.

Rare species:
Vascular plants – *Aristida condensata*, *Carex tenax, Chrysoma pauciflosculosa, Paronychia herniarioides, Stylisma pickeringii,* and *Warea cuneifolia*.

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Pituophis melanoleucus melanoleucus*, and *Sistrurus miliarius miliarius*.

SAND BARREN (COASTAL FRINGE SUBTYPE)

Concept: Sand Barrens are the driest, most barren naturally occurring nonmaritime sandy communities of the Coastal Plain, with low vegetation cover in all strata and a prominent suite of sand-tolerant (psammophyte) plants. The Coastal Fringe Subtype combines this extreme character with a suite of characteristic species that occur in North Carolina only very near the coast.

Distinguishing Features: Sand Barrens are distinguished from Xeric Sandhill Scrub and all other longleaf pine communities in natural condition by low cover of grasses and high cover of specialized psammophytes, macrolichens, and bare sand. Characteristic plants include *Polygonella polygama, Stipulicida setacea, Geocarpon* (*Mononeuria, Minuartia) caroliniana, Bryodesma (Selaginella) acanthonota*, and *Cnidoscolus stimulosus*, as well as *Aristida stricta* at low density. The Coastal Fringe Subtype is distinguished by the presence of characteristic coastal fringe flora, such as *Cladonia evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Quercus geminata*, and to a lesser degree, *Quercus hemisphaerica*. These species are indicators and may be present only in small numbers or concentrated in moist microsites.

Crosswalks: *Pinus palustris / Quercus laevis – Quercus geminata / Rhynchospora megalocarpa* Woodland (CEGL003590).
G154 Xeric Longleaf Pine Woodland Group
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Xeric Sandhill Scrub (Coastal Fringe Variant) (3rd Approximation).

Sites: Sand Barrens occur on the coarsest, purest sands, elevated well above the water table. The Coastal Fringe Subtype occurs on relict coastal dunes and beach ridges. Occurrences are in a zone inland of the barrier islands but within a few miles of the coast.

Soils: Soils are Typic Quartzipsamments, generally mapped as the Kureb series. Most areas mapped as these series support Xeric Sandhill Scrub, and only the most extreme minority supports Sand Barrens. The coarse sand, with almost no fine particles and little organic matter, has extremely low capacity for nutrient storage as well as for water retention.

Hydrology: Sites are excessively drained, with precipitation quickly passing through the coarse soil, leaving surface soils extremely dry most of the time. However, the water table may be within reach of the roots of larger plants; trees are sometimes described as acting as phreatophytes.

Vegetation: Vegetation is sparse in all strata. The canopy is almost exclusively *Pinus palustris*, but consists of widely scattered individuals or small clumps, the trees small in stature. The midstory is open and patchy but may be naturally more extensive than in less extreme sandhill communities. *Quercus laevis* dominates, and *Quercus geminata* and *Quercus hemisphaerica* range from sparse to codominant. Individuals of other species, such as *Pinus taeda*, *Diospyros virginiana*, *Quercus nigra*, or *Ilex opaca* may also be found occasionally. The shrub layer is patchy in distribution. *Polygonella polygama, Gaylussacia dumosa*, *Vaccinium tenellum*, *Lyonia mariana*, and *Opuntia mesacantha* are characteristic; *Ilex vomitoria* or the distinctive dwarf form of *Vaccinium stamineum* may occasionally be seen. Vines, though sparse, may be prominent in patches, especially *Muscadinia rotundifolia*, *Gelsemium sempervirens*, and possibly *Smilax* *auriculata*. The herb layer is sparse, with much area of bare sand and often high cover of *Cladonia evansii* as well as other *Cladonia* spp. lichens. *Aristida stricta* is present as scattered individuals or dominating favorable patches in a minority of the area. *Polygonella polygama* may be equally abundant. Other frequent species in CVS plot data (Palmquist et al. in prep. b) include *Rhynchospora megalocarpa*, *Stipulicida setacea*, *Bryodesma acanthonota*, *Cnidoscolus stimulosus, Euphorbia ipecacuanhae,* and *Sabulina caroliniana*. As with shrubs, species of wetter areas are occasionally present, especially clonal species such as *Pteridium latiusculum*.

Range and Abundance: Ranked G2, but possibly G1. This subtype is extremely rare in North Carolina, with only a handful of examples known in the southern third of the coastal fringe zone. It is also known in northern South Carolina.

Associations and Patterns: Examples typically grade to the Coastal Fringe subtypes of Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill on lower parts of the dune systems. They may also be associated with Coastal Fringe Evergreen Forest, and with a variety of wetland communities.

Variation: No variants are recognized. Examples can be very heterogeneous and vary with the transition to adjacent communities.

Dynamics: Both subtypes of Sand Barrens differ from all other Dry Longleaf Pine Communities and Wet Longleaf Pine Communities in not necessarily being dependent on frequent fire. The sparse, patchy vegetation makes fire spread irregular; many parts may escape ignition in any given fire. Examples may persist in the absence of fire, long after surrounding communities have been degraded, but slow accumulation of litter may eventually lead to changes and loss of the distinctive character in the absence of fire.

The Coastal Fringe Subtype presumably is subject to more severe occasional disturbance by tropical storms; salt spray may be a more important disturbance than wind damage.

Comments: This subtype is not as strongly differentiated as most subtypes. The characteristic coastal fringe flora are only marginal in their tolerance of Sand Barren habitats, and they are a less prominent part of the community than they are in the Coastal Fringe subtypes of Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill. However, the climatic factors that support coastal fringe flora in all these community types are likely to have effects on other organisms in the community (animals, microbes) and on ecosystem processes, even in the extreme environment of Sand Barrens.

Rare species:
Vascular plants – *Crocanthemum nashii* and *Stylisma pickeringii*.

Nonvascular plants – *Campylopus carolinae* and *Cladonia submitis.*

Vertebrate animals – *Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Pituophis melanoleucus melanoleucus*, and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Drasteria graphica*.

XERIC SANDHILL SCRUB (TYPIC SUBTYPE)

Concept: Xeric Sandhill Scrub is the widespread longleaf pine community of dry, coarse, infertile sands which have a low diversity scrub oak layer strongly dominated by *Quercus laevis*, but which have fairly high cover of *Aristida stricta* and other herbs. Though occurring on excessively drained sands, the sites are somewhat less extreme than those of Sand Barren communities. The Typic Subtype covers most examples of the Sandhills and Coastal Plain, where plants characteristic of the coastal fringe are absent.

Distinguishing Features: Xeric Sandhill Scrub is distinguished from most other communities by the presence of a scrub oak layer strongly dominated by *Quercus laevis*. *Quercus marilandica* is absent, but *Quercus margaretiae* and *Quercus incana* may be present in small amounts. The Typic Subtype is distinguished from the Coastal Fringe Subtype by the absence of characteristic coastal fringe flora, such as *Cladonia evansii, Rhynchospora megalocarpa, Cartrema americana, Ilex vomitoria*, and *Quercus geminata*.

Xeric Sandhill Scrub is distinguished from Sand Barren by higher plant cover in the herb layer, especially of *Aristida stricta*. Bare sand patches of any size are absent unless the soil or vegetation has been disturbed. Lichens and specialized psammophytes such as *Stipulicida setacea* and *Geocarpon* (*Minuartia, Arenaria*) *carolinianum* may be present but are minor in abundance in comparison with *Aristida stricta*.

Crosswalks: *Pinus palustris / Quercus laevis / Aristida stricta – Baptisia cinerea* Woodland (CEGL003586).
G154 Xeric Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Xeric Sandhill Scrub (Turkey Oak Variant); Xeric Sandhill Scrub (Coastal Plain Variant) (3rd Approximation).

Sites: Xeric Sandhill Scrub occurs on deep sands throughout the Coastal Plain, including the extensive sand sheets on uplands of the Sandhills region, dunes associated with rivers, rims of Carolina bays, Coastal Plain scarps, and relict beach ridges and dunes.

Soils: Soils characteristically are Typic Quartzipsamments, usually mapped as the Lakeland, Kureb, or Candor series, less often as Alpin or Cainhoy. A minority are mapped as Mandarin (Typic Haplohumod) or Centenary (Entic Haplohumod). Examples occur on a number of other soil map units but probably represent inclusions. The coarse sand with its excessive drainage and low nutrient-holding capacity is clearly the environmental factor that distinguishes Xeric Sandhill Scrub from Pine/Scrub Oak Sandhill. Nevertheless, this factor is less extreme than in the Sand Barrens. CVS soil data show the presence of some silt, averaging over 15%, in plots from Xeric Sandhill Scrub.

Hydrology: Site are excessively drained, but less extremely so than the Sand Barrens. Water passes quickly through the coarse soil, leaving dry conditions soon after rain events. Perhaps more than in the Sand Barrens, roots of larger plants may reach the water table and find a more abundant water supply.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. In the long absence of fire, the midstory becomes dense and shrubs expand, but otherwise they are sparse and very patchy. *Pinus palustris* typically is the only canopy tree. The midstory is dominated by *Quercus laevis*. Small numbers of other small tree species may be present, most frequently *Quercus incana* and *Diospyros virginiana*, and less frequently *Quercus margaretiae, Sassafras albidum*, *Nyssa sylvatica*, and occasionally *Crataegus* sp. and *Carya pallida*. The most frequent and extensive shrubs are *Gaylussacia dumosa* and *Toxicodendron radicans*, and CVS data (Palmquist et al. in prep. b) show a surprising high frequency of *Hypericum hypericoides* (perhaps *H. stragulum*). Other shrubs often noted in site-based species lists include *Vaccinium tenellum, Rhus copallinum*, and *Robinia nana*. The herb layer is dense to moderate, with *Aristida stricta* strongly dominant. Other frequent species in Palmquist et al. (in prep. b), though with low cover, include *Schizachyrium scoparium, Andropogon elliottii, Andropogon gyrans, Carphephorus bellidifolius, Cnidoscolus stimulosus, Euphorbia ipecacuanhae, Pityopsis adenolepis, Galactia volubilis, Solidago odora, Cirsium repandum, Stylisma patens*, and *Stipulicida setacea*. Additional characteristic species frequently noted in the field and in site reports include *Tephrosia virginiana, Baptisia cinerea, Sericocarpus linifolius*, and *Euphorbia curtissii*. *Cladonia* spp. lichens are sometimes present but are not usually extensive.

Range and Abundance: Ranked G3? The Typic Subtype is a matrix community and is one of the most extensive longleaf pine communities remaining in North Carolina. It is abundant in natural areas in the Sandhills Region, where it makes up a large portion of the landscape mosaic. Xeric Sandhill Scrub is less extensive but is common in sandy areas of the middle and outer Coastal Plain, except in the narrow coastal fringe. This community ranges into northern South Carolina, where it is similarly abundant in remnant natural landscapes.

Associations and Patterns: Xeric Sandhill Scrub typically occurs as part of a landscape mosaic with Pine/Scrub Oak Sandhill (Blackjack Subtype) and Streamhead Pocosin in the Sandhills Region. In other Coastal Plain regions, it occurs in a mosaic with Wet Pine Flatwoods, Pond Pine Woodland, and less frequently Pine/Scrub Oak Sandhill (Mixed Oak Subtype), Sandy Pine Savanna, Sand Barren, or various Coastal Plain Depressional Wetlands.

Variation: There are floristic difference between examples in the Sandhills region and those in the rest of the Coastal Plain. These can be recognized as variants:

1. Sandhills Variant occurs in the Sandhills Region, is usually more diverse, contains more legumes, and has *Pityopsis adenolepis* frequent.

2. Coastal Plain Variant occurs elsewhere in the inner to outer Coastal Plain, is usually less diverse, often has no legumes, and lacks *Pityopsis adenolepis*. It often has only half as many herbaceous species as the Sandhills Variant.

Dynamics: Dynamics are typical for longleaf pine/scrub oak communities. In the long absence of fire, scrub oaks become dense enough to inhibit regeneration of longleaf pine and to suppress the herb layer. Once established, *Quercus laevis* persistently resprouts after fire.

Rare species:
Vascular plants – *Astragalus michauxii, Carex tenax, Crataegus munda* var. *munda, Crocanthemum rosmarinifolium, Eriogonum tomentosum, Euphorbia cordifolia, Lupinus villosus, Pyxidanthera barbulata* var. *brevifolia, Stylisma pickeringii,* and *Warea cuneifolia.*

Nonvascular plants – *Campylopus carolinae.*

Vertebrate animals – *Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Bleptina sangamonia, Catocala consors, Catocala grisatra, Catocala jair, Datana robusta, Hesperia meskei, Heterocampa varia, Hypomecis buchholzaria,* and *Pygarctia abdominalis*.

XERIC SANDHILL SCRUB (COASTAL FRINGE SUBTYPE)

Concept: Xeric Sandhill Scrub is the longleaf pine community of dry, coarse, infertile sands, which have a low diversity scrub oak layer strongly dominated by *Quercus laevis*, but which have fairly high cover of *Aristida stricta* and other herbs rather than the sparse vegetation of the Sand Barrens. Though occurring on excessively drained sands, the sites are somewhat less extreme than those of Sand Barren communities. The Coastal Fringe Subtype covers examples near the coast that contain characteristic coastal fringe plant species.

Distinguishing Features: Xeric Sandhill Scrub is distinguished from most other communities by the presence of a scrub oak layer strongly dominated by *Quercus laevis*. *Quercus marilandica* is absent, but *Quercus margaretiae* and *Quercus incana* are often present. The Coastal Fringe Subtype is distinguished from the Typic Subtype by the presence of characteristic coastal fringe flora, such as *Cladonia evansii, Rhynchospora megalocarpa, Ilex vomitoria*, *Cartrema americana*, and *Quercus geminata*, though these species may be sparse. The Coastal Fringe Subtype generally occurs within a few miles of the coast.

Xeric Sandhill Scrub is distinguished from Sand Barren by higher plant cover in the herb layer, especially of *Aristida stricta*. Bare sand patches of any size are absent unless the soil or vegetation has been disturbed. Lichens and specialized psammophytes such as *Stipulicida setacea* and *Geocarpon* (*Mononeuria, Minuartia) carolinianum* are generally present but are minor in abundance in comparison with *Aristida stricta*.

Crosswalks: *Pinus palustris / Quercus laevis - Quercus geminata / Aristida stricta* Woodland (CEGL003589).
G154 Xeric Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).

Sites: Xeric Sandhill Scrub (Coastal Fringe Subtype) occurs on deep sands of relict coastal dunes, beach ridges, river dunes, and Carolina bay rims, in a zone inland of the barrier islands but within a few miles of the coast.

Soils: Soils characteristically are Typic Quartzipsamments, usually mapped as the Kureb series, less frequently mapped as Centenary (Entic Haplohumod) or Mandarin (Typic Haplohumod). Examples occur on a number of other soil map units but probably represent inclusions. The coarse sand with its excessive drainage and low nutrient-holding capacity is clearly the environmental factor that distinguishes Xeric Sandhill Scrub from Pine/Scrub Oak Sandhill. Nevertheless, this factor is less extreme than in the Sand Barrens. CVS soil data show the presence of some silt, averaging over 15%, in plots from Xeric Sandhill Scrub.

Hydrology: Sites are excessively drained, but less extremely so than the Sand Barrens. Water passes quickly through the coarse soil, leaving dry conditions soon after rain events. Perhaps more than in the Sand Barrens, roots of larger plants may reach the water table and find a more abundant water supply.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. In the long absence of fire, the midstory becomes dense and shrubs expand, but otherwise they are sparse and very patchy. *Pinus palustris* typically is the only canopy tree. The midstory is dominated by *Quercus laevis* and *Quercus geminata*. Small numbers of other small tree species may be present, most frequently *Diospyros virginiana*, *Sassafras albidum*, *Quercus incana*, and *Quercus hemisphaerica*. The prevalent shrubs in Palmquist et al. (in prep. b) are *Vaccinium tenellum*, *Vaccinium stamineum* (presumably the dwarf form), and *Morella pumila*. *Lyonia mariana* is also frequent; *Ilex vomitoria, Cartrema americanum*, and several species of wetter habitats may occasionally be present. The herb layer is moderate in density, with *Aristida stricta* dominant. Other prevalent species, though with low cover, include *Schizachyrium scoparium*, *Carphephorus bellidifolius, Euphorbia ipecacuanhae, Pityopsis graminifolia, Rhynchospora megalocarpa, Cnidoscolus stimulosus*, and *Galactia* spp. Lichens, *Cladonia evansii* as well as other *Cladonia* spp., may be abundant.

Range and Abundance: Ranked G2?. This subtype is quite rare, and most likely G2 is appropriate. In North Carolina it is confined to a narrow band near the coast in the southern half of the state. It ranges into northern South Carolina.

Associations and Patterns: Xeric Sandhill Scrub (Coastal Fringe Subtype) occurs in a landscape mosaic with Pine/Scrub Oak Sandhill (Coastal Fringe Subtype), Coastal Fringe Evergreen Forest, and occasionally Sand Barren (Coastal Fringe Subtype). A variety of wetland communities may be associated.

Variation: No variants are recognized. Examples vary with the transition to other communities.

Dynamics: Dynamics generally are typical for longleaf pine/scrub oak communities. However, the evergreen oak litter may affect fire behavior on a fine scale. It has been suggested (Frost 2000) that the evergreen scrub oaks, especially *Quercus geminata*, once established, prevent fire from spreading into their microsites because their curled leaves can hold rain water and stay wet much longer than other leaf litter. Thus, their patches may expand and persist without burning even where fire occurs, and it may be particularly hard to reverse an increase in their abundance with fire suppression.

The reasons for the distinctive flora of the Coastal Fringe subtypes in the area near the coast is not well known, and no published study addresses it. The characteristic coastal fringe species are more widespread inland in states farther south, so the moderation of winter temperatures by the ocean is a likely factor. Input of nutrients by aerosols is also greater near the ocean, and this may affect nutrient dynamics in these communities. Salt spray and wind damage during tropical storms likely causes more disturbance in the coastal fringe than inland. Fire dynamics, too, may be affected by aspects of the coastal environment, including interspersion with estuaries and influence of sea breezes.

Comments: As with other coastal fringe communities, the interpretation of this subtype's distinctive character as tied to the coast may only apply in North Carolina and northern South

Carolina. Many of the species that mark them occur in inland areas in states farther south. This community does not occur in those areas because of other biogeographic differences.

Rare species:
Vascular plants – *Aristida condensata, Aristida tenuispica, Crocanthemum georgianum, Euphorbia cordifolia, Gaylussacia nana, Lechea torreyi* var. *congesta, Lupinus villosus, Polygonella articulata, Stylisma pickeringii,* and *Trichostema setaceum*.

Nonvascular plants – *Campylopus carolinae* and *Cladonia submitis.*

Vertebrate animals – *Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Bleptina sangamonia, Catocala jair,* and *Drasteria graphica*.

PINE/SCRUB OAK SANDHILL (BLACKJACK SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Blackjack Subtype covers communities where *Quercus marilandica* is a significant component, generally mixed with *Quercus laevis*. They are associated with soils having a layer of dense clay below a sandy surface. These are common in the Sandhills region but occur only occasionally in other parts of the Coastal Plain.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. However, *Quercus laevis* may still codominate. Pine/Scrub Oak Sandhills are distinguished from Mesic Pine Savannas and wetter longleaf pine communities by the presence of scrub oaks (other than the occasional presence of *Quercus marilandica*) and by generally lower species richness in the herbaceous layer. In frequently burned sites, most or all scrub oaks may exist as sprouts. In sites where land managers have treated stands with herbicide, scrub oaks may be artificially absent, and this type will have to be distinguished from Mesic Pine Savanna by the lack of the more mesophytic herbaceous and shrub species characteristic of that type. Fire-suppressed Mesic Pine Savannas may contain forest oaks such as *Quercus stellata, Q. falcata, Q. velutina*, and *Q. nigra*, but little or none of the scrub oaks characteristic of this type. Pine/Scrub Oak Sandhill (other than the Northern Subtype) is distinguished from Piedmont Longleaf Pine Forest by the presence of *Aristida stricta;* by the absence of characteristic Piedmont upland forest species such as *Oxydendrum arboreum, Quercus montana*, and *Quercus coccinea*; and, in the most natural examples, by the absence of a substantial component of *Pinus taeda.* Substrate and location readily distinguish these two types in altered examples where *Aristida* may have been lost.

The Blackjack Subtype is distinguished from the Mixed Oak Subtype by the presence of appreciable amounts of *Quercus marilandica*. It is distinguished from the Clay/Rock Hilltop Subtype, which may contain substantial *Quercus marilandica,* by the presence of *Quercus laevis*, the absence of *Vaccinium crassifolium* and other wetland species, and the presence of sand at the soil surface. It is distinguished from the Mesic Transition Subtype, which may contain substantial *Quercus marilandica* but generally has little *Quercus laevis*, by the absence of characteristic more-mesic herbs and shrubs; though the herb layer may be fairly diverse, it is less rich in plant species than the Mesic Transition Subtype. The Blackjack Subtype is distinguished from the Northern Subtype by the presence, at least historically, of *Aristida stricta*.

Crosswalks: *Pinus palustris / Quercus marilandica / Gaylussacia dumosa / Aristida stricta* Woodland (CEGL003595).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).

Sites: The Blackjack Subtype occurs in sites with sandy surface material overlying a clay layer near the surface. Most occurrences are on side slopes in the dissected terrain of the Sandhills

Region, where stream erosion has exposed interbedded sands and clays beneath the aeolian sand layer that covers the flatter uplands. A few examples occur in other parts of the Coastal Plain in similar settings.

Soils: Soils are coarse sands with a clay layer beneath. They are classified as Ultisols, but the clay layer apparently generally is part of the parent material rather than solely a result of translocation of clay material. Plinthite is common. The most common soil map units are Candor (Arenic Paleudult), Blaney (Arenic Hapludult), Vaucluse (Typic Hapludult), Gilead (Aquic Hapludult), and Fuquay (Plinthic Paleudult), less often Dothan (Plinthic Paleudult) and Ailey (Arenic Kanhapludult). Many examples are also mapped as Lakeland, a sandy Entisol, but these likely represent inclusions.

Hydrology: Sites are usually dry to xeric but may have a perched water table for brief periods. Weaver (1969) demonstrated that, during drought, the scrub oaks in this community endured more water stress than those in nearby Xeric Sandhill Scrub, presumably because the clay layer restricted root access to the deeper soil and bound remaining water too tightly for it to be used.

Vegetation: Vegetation structure in the Blackjack Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is usually the only canopy species, but occasional *Pinus echinata* or *Pinus taeda* may be present. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by *Quercus laevis* and *Quercus marilandica*, with a wide range of proportions. Other frequent species in CVS plot data (Palmquist et al. in prep. c), seldom abundant, include *Quercus incana, Quercus margaretiae, Diospyros virginiana, Sassafras albidum, Nyssa sylvatica*, *Carya pallida*, and *Benthamidia* (*Cornus*) *florida*. *Gaylussacia dumosa* and *Toxicodendron pubescens* usually are the most abundant shrubs, and *Vaccinium tenellum* and *Rhus copallinum* var. *copallinum* may be frequent. The herb layer is moderate to dense, and has moderate diversity when in good condition. *Aristida stricta* dominates, and a number of grasses and forbs are frequent but not dominant. Frequent species in CVS plots include *Schizachyrium scoparium*, *Andropogon gyrans*, *Andropogon ternarius*, *Sporobolus junceus*, *Tephrosia virginiana*, *Pityopsis adenolepis, Baptisia cinerea*, *Solidago odora*, *Carphephorus bellidifolius*, *Symphyotrichum walteri*, *Ionactis linariifolia*, *Sericocarpus tortifolius*, *Silphium compositum*, *Coreopsis major, Cirsium repandum*, *Liatris pilosa, Euphorbia curtisii*, *Tragia urens*, *Galactia regularis*, *Stylosanthes biflora*, *Danthonia sericea*, *Scleria nitida, Scleria ciliata*, *Iris verna*, *Vernonia angustifolia*, and *Dichanthelium* spp. In the transition to wetter communities, *Pteridium pseudocaudatum*, *Lyonia mariana*, and *Clethra alnifolia* appear and may be abundant.

Range and Abundance: Ranked G2G3. The Blackjack Subtype is one of the most extensive communities in intact landscapes, with large acreage occurring on Fort Liberty and the Sandhills Game Land. However, good examples are scarce beyond these areas, and the limited range, limited number of good examples, and vulnerability to deterioration in the absence of fire threaten it. It is rare elsewhere in the Coastal Plain, where a few examples are known in Carteret, Craven, and Pamlico Counties. It ranges into northern South Carolina in the Sandhills Region, where it also is abundant in the limited intact landscapes.

Associations and Patterns: In the Sandhills, the Blackjack Subtype is a matrix community. It occurs in a mosaic, occupying most of the side slopes while Xeric Sandhill Scrub (Typic Subtype) covers the deeper sands on the rolling uplands and Streamhead Pocosin fills most of the numerous drainages. This mosaic covers most of the Sandhills landscape, with other communities embedded in it as small patches. Sandhill Seep, Pine/Scrub Oak Sandhill (Mesic Transition Subtype), Mesic Pine Savanna, Sandhill Streamhead Swamp, Streamhead Atlantic White Cedar Forest, Streamhead Canebrake, and Coastal Plain Semipermanent Impoundment are among the communities that may border the Blackjack Subtype. The transition to other longleaf pine communities is often very gradual but the transition to the wetland communities is usually abrupt. It may be more gradual under a natural fire regime, but the shift in soil from a sand to muck surface creates an ecological discontinuity. This edge is sometimes a diverse ecotonal zone that resembles a wetter pine savanna community.

In the other parts of the Coastal Plain, the Blackjack Subtype occurs as a small patch community often associated with Mesic Pine Savanna (Coastal Plain Subtype) and possibly Wet Loamy Pine Savanna.

Variation: Two variants are recognized:

1. Typic Variant is the common community of the Sandhills Region.

2. Coastal Plain Variant covers the rare examples in the middle to outer Coastal Plain. Differences are not well known, but there are floristic differences between the Sandhills and the outer Coastal Plain.

Dynamics: The dynamics of this subtype are typical of longleaf pine communities in general, as described in the Dry Longleaf Pine Communities theme.

Comments: The Blackjack Subtype, in a general sense, fits into a moisture and fertility gradient between Xeric Sandhill Scrub and Mesic Pine Savanna. However, this is complicated by varying conditions in areas with clay layers near the surface. These areas may be moist or even wet at times, but the clay layer may limit rooting depth. Weaver (1969) found that sites with *Quercus marilandica* were drier than those with just *Q. laevis*, and that *Q. marilandica* endured greater moisture stress during droughts. He suggested that lack of nutrients rather than dryness was responsible for excluding *Q. marilandica* from Xeric Sandhill Scrub.

This community is confined to the range of *Aristida stricta* and is replaced by a different "wiregrass gap" community in central South Carolina, and by the Northern Subtype in northern North Carolina.

Rare species:
Vascular plants – *Crocanthemum rosmarinifolium, Orthochilus* (*Eulophia*) *ecristatus, Pyxidanthera barbulata* var. *brevifolia*, *Salvia azurea* var. *azurea, Solidago verna,* and *Trichostema setaceum.*

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus*, and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Acronicta albarufa, Bleptina sangamonia, Catocala consors, Catocala grisatra, Catocala jair, Catocala messalina, Hemeroplanis* sp. 1 nr. *obliqualis, Hesperia attalus, Heterocampa varia, Hypomecis buchholzaria, Lagoa pyxidifera,* and *Melanoplus nubilus*.

PINE/SCRUB OAK SANDHILL (MIXED OAK SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that contain a scrub oak layer but are less xeric than Xeric Sandhill Scrub due to at least some fine-textured material in the sandy soil. The scrub oak layer contains a mix of species rather than being strongly dominated by *Quercus laevis*. The Mixed Oak Subtype covers examples on fine sands or on somewhat silty soils without clay, where *Quercus incana* or less often *Quercus margaretiae* are abundant but *Quercus marilandica* is not a significant component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished by having a mix of scrub oaks or having oaks other than *Quercus laevis* dominant or codominant beneath the *Pinus palustris* canopy. The Mixed Oak Subtype is distinguished from Xeric Sandhill Scrub and other drier communities by having codominant or abundant *Quercus incana* or, less often, *Quercus margaretiae*. *Quercus laevis* is, however, usually codominant.

The Mixed Oak Subtype is distinguished from the Blackjack and Clay/Rock Hilltop subtypes by lacking any significant amount of *Quercus marilandica*. It is distinguished from the Mesic Transition subtypes, which may also have dominant *Quercus incana*, by a lower species richness, limited number of leguminous species, and lack of the diverse suite of mesic species characteristic of that subtype. Species typical of the Mesic Transition Subtype and largely absent in the Mixed Oak Subtype include *Crotalaria purshii, Desmodium lineatum, Rhynchosia reniformis, Tephrosia florida, Panicum virgatum, Gymnopogon brevifolius, Anthenantia villosa, Andropogon gerardii*, and *Sorghastrum nutans*. The Mixed Oak Subtype is distinguished from the Northern Subtype by occurring within the range of *Aristida stricta*, and, at least historically, having it present. It is distinguished from the Coastal Fringe Subtype by lacking plants that, in North Carolina at least, are largely confined to near the coast. These include *Quercus geminata, Quercus virginiana, Cartrema americanus, Ilex vomitoria, Rhynchospora megalocarpa*, and *Cladonia evansii*. *Quercus hemisphaerica* is more often abundant in the Coastal Fringe Subtype but may also occur in the Mixed Oak Subtype.

Crosswalks: *Pinus palustris / Quercus laevis - Quercus incana / Gaylussacia dumosa / Aristida stricta* Woodland (CEGL003591).
G154 Xeric Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).

Sites: The Mixed Oak Subtype occurs on deep sand sites where the sand is fine-textured or contains some silt. In the Sandhills Region, it tends to occur in small swales but may occur in larger expanses on the rolling upland surface. In the rest of the Coastal Plain, it is sometimes found in dissected sandy uplands or on Carolina bay rims.

Soils: Soils are fine sand or sand mixed with some silt but without a clay layer or substantial clay component. No soil series or map unit seems to be specifically associated with this subtype. At least 24 series are mapped for known occurrences. Some of the more common are Centenary

(Grossarenic Alorthod), Baymeade (Arenic Hapludult), Kenansville (Arenic Hapludult), Wakulla (Psammentic Hapludult), and Kureb (Spodic Quartzipsamment).

Hydrology: Moisture conditions are dry and well drained but are not as excessively drained as in Xeric Sandhill Scrub. Sites are above the high water table but may be close enough that wet conditions occur in lower microsites or in ecotones.

Vegetation: The Mixed Oak Subtype has an open canopy strongly dominated by *Pinus palustris*. The scrub oak layer is usually a mix of *Quercus incana* and *Quercus laevis*, sometimes with abundant *Quercus margaretiae*. Other oaks are scarce, but *Diospyros virginiana* or *Sassafras albidum* may also occur. In the Palmquist et al. (in prep. b) detailed analysis of CVS plot data, and similarly in site descriptions, *Gaylussacia dumosa* and *Vaccinium tenellum* are highly constant and often dominate patches. *Morella pumila, Gaylussacia frondosa, Vaccinium stamineum,* and *Ilex glabra* are also highly constant among shrubs, and *Toxicodendron pubescens, Vaccinium arboreum,* and *Rhus copallinum* are frequent. The herb layer is dominated by *Aristida stricta*. Other highly constant species include *Schizachyrium scoparium, Cnidoscolus stimulosus, Pityopsis graminifolia, Sericocarpus tortifolius, Ionactis linariifolia, Liatris* spp., *Tragia urens, Solidago odora, Euphorbia ipecacuanhae,* and *Scleria nitida*. Also frequent are *Galactia* spp., *Andropogon ternarius, Cirsium repandum, Symphyotrichum walteri*, *Scleria ciliata*, and in the outer Coastal Plain, *Trilisa odoratissima*.

Range and Abundance: Ranked G3? The Mixed Oak Subtype is scattered throughout the southern half of both the outer and inner Coastal Plain and occurs less commonly in the Sandhills Region. About 35 occurrences are known, but few are in very good condition. Many occur on small privately owned sites in areas with no other longleaf pine communities nearby, though some are present on larger public lands. The NVC association is questionably attributed to South Carolina, and it is likely this community occurs there.

Associations and Patterns: The Mixed Oak Subtype likely once functioned as a matrix community, making up a frequent part of the Coastal Plain landscape mosaic though not predominating, and this is still true in some larger natural areas. However, most of the occurrences are now isolated remnants that more resemble small patch communities.

Variation: Variation is not well characterized. Given the wide range of this subtype, it is likely that there are biogeographic differences among the regions where it occurs, but this is obscured by the alteration caused by lack of fire in many examples.

Dynamics: Dynamics are similar to other sandhill communities, as described in the Dry Longleaf Pine Communities theme description.

Comments: This subtype is one of the less well studied of longleaf pine communities and perhaps one of the less distinctive. It does, however, have a clear niche in the gradient of moisture and soil texture, though the niche appears to be narrower than for most communities. No plant species are known to have it as their primary habitat. It is defined mainly by the absence of characteristic species and features of other longleaf pine communities.

The NVC places the association equivalent to this community in the G154 Xeric Longleaf Pine Woodland Group, separating it from most of the other subtypes of Pine/Scrub Oak Sandhill. Analysis in Palmquist, et al. (in prep. b) retained this placement. The author believes that the greater mix of scrub oaks allies it more closely with the other Pine/Scrub Oak Sandhill subtypes, while recognizing that it is closer to Xeric Sandhill Scrub than the others.

The inclusion of *Quercus nigra* in the NVC association name is somewhat misleading. This species is characteristic only in examples altered by long lack of fire. However, it does tend to invade this subtype more readily than any other Pine/Scrub Oak Sandhill or Xeric Sandhill Scrub subtype.

Rare species:
Vascular plants – *Asclepias pedicellata, Astragalus michauxii, Crocanthemum carolinianum, Dichanthelium fusiforme,* and *Lechea torreyi* var. *congesta*.

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Coluber flagellum flagellum, Dryobates borealis, Heterodon simus, Peucaea borealis, Pituophis melanoleucus melanoleucus*, and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Acronicta albarufa, Bleptina sangamonia, Datana robusta,* and *Hesperia attalus*.

PINE/SCRUB OAK SANDHILL (SANDHILLS MESIC TRANSITION SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and less infertile than Xeric Sandhill Scrub and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by oak species other than *Quercus laevis*. The Sandhills Mesic Transition Subtype covers those with loamy soil, greater fertility, or possibly closer proximity to the water table that support a very diverse flora that includes mesic herb and shrub species, and that contain the distinctive flora of the Sandhills region. They share many plants with Mesic Pine Savannas but differ in having a significant scrub oak component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Sandhills Mesic Transition Subtype is transitional to Mesic Pine Savanna (Sandhills Subtype) and other subtypes of Mesic Pine Savanna, and it shares substantial flora with them. It can be distinguished by the presence of scrub oaks in significant numbers (these may be reduced in density and present as shrub-size sprouts if the site has been frequently burned). Communities in which oaks have been artificially eradicated may be difficult to distinguish but will lack the small component of wetland species usually found in Mesic Pine Savanna. A few scrub oaks are found in the Little River Subtype and Lumbee Subtype of Mesic Pine Savanna, but these communities have other distinctive aspects of species composition.

The Sandhills Mesic Transition Subtype is distinguished from other subtypes of Pine/Scrub Oak Sandhill by the combination of a suite of mesic species with a suite of species typical of the Sandhills region, coupled with absence or scarcity of a suite characteristic of the outer Coastal Plain. Mesic species include *Anthenantia villosa, Sorghastrum nutans, Andropogon gerardii, Paspalum bifidum, Tridens carolinianus, Lespedeza capitata, Lespedeza hirta*, *Helianthus divaricatus, Sorghastrum elliottii*, *Sporobolus clandestinus*, *Lithospermum (Onosmodium) virginianum*, *Muhlenbergia capillaris*, *Ceanothus americanus*, and several *Desmodium* and other *Lespedeza* species. Fabaceae diversity can be very high. The scrub oaks tend to be less dense in this subtype than in the Blackjack Subtype under the same management regime. Forest oaks such as *Quercus falcata* and *Quercus stellata*, plus *Liquidambar styraciflua,* often proliferate in the absence of fire. Species frequent in the Sandhills Mesic Transition Subtype and not in the Coastal Plain Mesic Transition Subtype include *Toxicodendron pubescens, Ceanothus americanus, Galium pilosum, Coreopsis major, Baptisia cinerea, Viola pedata, Rhynchosia reniformis, Phlox nivalis, Asclepias amplexifolius, Astragalus michauxii, Cuthbertia graminea, Carphephorus bellidifolius, Oenothera fruticosa*, and a number of others. Species typical of the Coastal Plain Mesic Transition Subtype include *Eupatorium rotundifolium, Chasmanthium laxum, Baptisia tinctoria, Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum,* and a number of species shared with wetter communities, such as *Polygala lutea, Gymnopogon ambiguus, Helianthus heterophyllus*, and *Rhynchospora plumosa*.

Crosswalks: *Pinus palustris / Quercus incana / Aristida stricta - Sorghastrum nutans - Anthaenantia villosa* Woodland (CEGL003578).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).

Pine/Scrub Oak Sandhill (Loamy Soil Variant) (3rd Approximation).
"Pea swales" (common usage for this community as well as Mesic Pine Savanna).

Sites: The Sandhills Mesic Transition Subtype occurs where the substrate, though sandy, contains a significant component of finer material. It occurs on lower slopes or in gently sloping swales.

Soils: The Sandhills Mesic Transition Subtype has soils with sandy loam or loam texture. The finer material gives them more nutrient holding capacity as well as ability to retain water even while well drained. They are generally not distinguished well in soil mapping. They are mapped as part of larger units of Blaney (Arenic Hapludult), Gilead (Aquic Hapludult), Candor (Arenic Paleudult), or Vaucluse (Typic Hapludult), sometimes as sandy soils such as Lakeland (Typic Quartzipsamment).

Hydrology: Sandhills Mesic Transition Subtype sites are well-drained but are less dry than most sandhills because of the loamy soil texture.

Vegetation: Vegetation structure in the Sandhills Mesic Transition Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is often the only canopy species, but *Pinus echinata* or *Pinus taeda* may be present and occasionally abundant. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by a mix of *Quercus incana. Quercus marilandica*, *Quercus margaretiae*, and *Quercus laevis*. *Quercus stellata* or *Quercus falcata* may be present, and *Liquidambar styraciflua* may become abundant in unburned sites. *Diospyros virginiana, Sassafras albidum, Nyssa sylvatica, Carya pallida*, and *Benthamidia* (*Cornus*) *florida* are also frequent. The highly constant shrubs in CVS plot data (Palmquist et al. in prep. c) are *Gaylussacia dumosa, Vaccinium tenellum, Toxicodendron pubescens*, and *Rhus copallinum*, but species more distinctive to this community also occur, including *Ceanothus americanus* and *Rhus michauxii*.

The herb layer is dominated by *Aristida stricta* but includes a high diversity of species shared with drier sandhills, a suite of distinctive mesic species that are shared with Mesic Pine Savannas, and limited abundance of species typical of wetter communities. Highly constant herb species in CVS plot data (Palmquist et al. in prep. c) include *Schizachyrium scoparium, Andropogon gyrans, Andropogon ternarius, Ionactis linariifolia, Solidago odora, Pityopsis graminifolia, Stylosanthes biflora, Cirsium repandum, Galium pilosum, Sericocarpus tortifolius, Coreopsis major, Symphyotrichum walteri, Silphium compositum, Eupatorium album, Symphyotrichum concolor, Baptisia cinerea, Liatris* sp., *Rhynchosia reniformis, Viola pedata,* and *Euphorbia curtisii*. A large number of other species are frequent in plot data, some of which are more constant in site reports. There are numerous legumes, including *Lespedeza* (*capitata, hirta, repens, virginica*), *Desmodium* (*lineatum, ciliare, obtusum, strictum*), *Tephrosia* (*virginica, florida, spicata*), *Galactia erecta, Galactia regularis, Clitoria mariana, Rhynchosia reniformis, Pediomelum canescens, Chamaecrista* spp., and *Crotalaria purshii*. Other frequent species include *Tragia urens, Iris verna, Euphorbia curtisii, Euphorbia ipecacuanhae, Dichanthelium* (*ovale, aciculare, oligosanthes* and others), *Hieracium marianum, Stylisma angustifolia/patens, Phlox nivalis, Vernonia angustifolia, Carphephorus bellidifolius, Asclepias amplexicaulis, Cuthbertia graminea, Cnidoscolus stimulosus, Chrysopsis gossypina, Oenothera fruticosa, Sericocarpus asteroides, Symphyotrichum dumosum, Eupatorium pilosum, Hieracium gronovii, Hypoxis hirsuta, Hypoxis* *wrightii, Epigaea repens, Euphorbia exserta, Lithospermum virginianum, Parthenium integrifolium, Sphenopholis filiformis, Sporobolus junceus, Stillingia sylvatica, Gentiana villosa*, and *Rhynchospora grayi*. Species less frequent in plots but characteristic of this community include *Paspalum bifidum, Tridens carolinianus, Orbexilum lupinellus, Dalea pinnata, Anthenantia villosa, Andropogon gerardii, Phaseolus sinuatus*, and several species shared with drier sandhills, such as *Pycnanthemum flexuosum, Angelica venenosa, Hypericum stragulum, Nabalus autumnalis,* and *Physalis heterophylla*. Several more legumes are present at somewhat lower frequency, including *Mimosa microphylla, Lespedeza* (*procumbens, stuevei*), *Desmodium* (*laevigatum, paniculatum, marilandicum*), *Rhynchosia tomentosa,* and *Galactia mollis*.

Range and Abundance: Ranked G2G3 but probably G2. The Grank does not yet reflect the split into Sandhills and Coastal Plain subtypes. This subtype appears to be confined to the Sandhills region but may possibly be found in nearby areas with similar site conditions. Most examples known are within Fort Liberty, but some occur on other lands in the central Sandhills. This community also occurs in the Sandhills in northern South Carolina.

Associations and Patterns: The Sandhills Mesic Transition Subtype usually occurs as a small patch community, in localized areas of unusual soil. Rarely, it occurs as larger patches, where the loamy conditions it needs are more extensive. It generally grades uphill to Pine/Scrub Oak Sandhill (Blackjack Subtype) or Xeric Sandhill Scrub. It may grade downhill to Mesic Pine Savanna (Sandhills Subtype) or may be bordered by Streamhead Pocosin. Sandhill Seeps may possibly occur adjacent to it.

Variation: There is substantial variation among examples, but no variants are recognized. The pronounced floristic differences between Mesic Transition communities in the Sandhills and in the outer Coastal Plain, treated as well-defined variants in earlier drafts of the 4th Approximation, has been shown by Palmquist et al. (in prep. c) to be strong enough to create two associations and two subtypes.

It has been suggested by Bruce Sorrie that there are repeatable differences within the Sandhills Mesic Transition Subtype between examples on lower slopes or large loamy soil areas and those in local swales. This needs further investigation.

Dynamics: The dynamics of the Sandhills Mesic Transition Subtype are similar to those of the Dry Longleaf Pine Forests theme in general. Because their productivity is higher than that of other sandhills, they develop dense midstories even faster in the absence of fire, and they are likely to be invaded by forest oaks and *Liquidambar* as well as scrub oaks. These are species that grow faster and can quickly produce more cover.

The environmental factors that control the shift from mesic transition sandhills to Mesic Pine Savanna are not clear. Scrub oaks generally quickly drop out in the transition, and they appear to be excluded from the Mesic Pine Savanna even in the absence of fire. Even in the Mesic Transition Subtypes, they are reduced in density compared to drier sandhills. It may be that, though the savanna is generally mesic, occasional high water tables make survival of scrub oaks difficult. However, increased fire intensity with the increased productivity of the herb layer may also be involved, and competitiveness of the herbs may be significant.

Comments: The division between the Sandhills Mesic Transition Subtype and the Coastal Plain Mesic Transition Subtype was created in the last stages of preparation of the 4th Approximation book, as a result of analysis of CVS data. Only a single Mesic Transition Subtype was recognized in the earlier draft stages. Numerous species differentiate the new subtypes. Some are species common in other sandhill communities, which are more abundant in the Sandhills region in general, but a number are found primarily in mesic sites and are shared primarily with Mesic Pine Savannas. The Coastal Plain Mesic Transition Subtype, in contrast, usually contains more species of wet sites. This may reflect the greater abundance of wet savannas in the outer Coastal Plain and the greater abundance of drier sandhill communities in the Sandhills landscapes.

Rare species:
Vascular plants – *Asemeia* (*Polygala*) *grandiflora, Astragalus michauxii, Crocanthemum rosmarinifolium, Gaillardia aestivalis, Galactia mollis, Pseudognaphalium helleri, Rhus michauxii, Ruellia ciliosa, Salvia azurea* var. *azurea, Schwalbea americana, Solidago tortifolia,* and *Tridens chapmanii*.

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Dryobates borealis, Heterodon simus, Peucaea aestivalis,* and *Sistrurus miliarius miliarius.*

Invertebrate animals – *Hesperia attalus.*

PINE/SCRUB OAK SANDHILL (COASTAL PLAIN MESIC TRANSITION SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and less infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by oak species other than *Quercus laevis*. The Coastal Plain Mesic Transition Subtype covers the examples of the Sandhills Region which have loamy soil, greater fertility, or possibly closer proximity to the water table. They support a very diverse flora that includes mesic herb and shrub species. They share many plants with Mesic Pine Savannas but differ in having a significant scrub oak component.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Mesic Transition Subtype is transitional to Mesic Pine Savanna. It can be distinguished by the presence of scrub oaks in significant numbers (these may be reduced in density and present as shrub-size sprouts if the site has been frequently burned). Communities in which oaks have been artificially eradicated may be difficult to distinguish but will lack the small component of wetland species usually found in Mesic Pine Savanna.

The Coastal Plain Mesic Transition Subtype is distinguished from other subtypes by a combination of a suite of mesic species with a suite of species typical of the Coastal Plain region, coupled with absence or scarcity of a suite characteristic of Sandhills. Mesic species include *Anthenantia villosa, Sorghastrum nutans, Andropogon gerardii, Lespedeza capitata, Lespedeza hirta*, *Helianthus divaricatus, Sorghastrum elliottii*, *Sporobolus clandestinus*, *Muhlenbergia capillaris*, *Ceanothus americanus*, several *Desmodium* spp., and other *Lespedeza* species. Fabaceae diversity can be high. The scrub oaks may be less dense in this subtype than in the Blackjack Subtype under the same management regime. Forest oaks such as *Quercus falcata* and *Quercus stellata*, plus *Liquidambar styraciflua,* often proliferate in the absence of fire. Species frequent in the Coastal Plain Mesic Transition Subtype include *Eupatorium rotundifolium, Chasmanthium laxum, Baptisia tinctoria, Trilisa odoratissima, Tephrosia hispidula, Pterocaulon pycnostachyum,* and a number of species shared with wetter communities, such as *Polygala lutea, Gymnopogon ambiguus, Helianthus heterophyllus*, and *Rhynchospora plumosa*. Species frequent in the Sandhills Mesic Transition Subtype and not in the Coastal Plain Mesic Transition Subtype include *Ceanothus americanus, Galium pilosum, Coreopsis major, Baptisia cinerea, Viola pedata, Phlox nivalis, Asclepias amplexifolius, astragalus michauxii, Cuthbertia graminea, Carphephorus bellidifolius, Oenothera fruticosa*, and a number of others.

Crosswalks: No NVC equivalent. A new association needs to be created. G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Pine/Scrub Oak Sandhill (Loamy Soil Variant) (3rd Approximation).

Sites: The Coastal Plain Mesic Transition Subtype occurs where the substrate, though sandy, contains a significant component of finer material. It usually occurs on rolling dissected uplands.

Soils: The Mesic Transition Subtype has soils with sandy loam or loam texture. The finer material gives them more nutrient holding capacity as well as ability to retain water even while well drained.

They are generally not distinguished well in soil mapping. They are included in a variety of map units, from Kureb (Spodic Quartzipsamment) to Baymeade (Arenic Hapludult) to Foreston (Aquic Paleudult).

Hydrology: Coastal Plain Mesic Transition Subtype sites are well drained but are less dry than most sandhills because of the loamy soil texture.

Vegetation: Vegetation structure in the Sandhills Mesic Transition Subtype is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a dense grassy herbaceous layer. *Pinus palustris* is often the only canopy species, but *Pinus taeda* may become abundant with lack of fire. The midstory and low shrub layer are sparse and patchy when the community is frequently burned but become increasingly dense with fire exclusion. The midstory is dominated by a mix of *Quercus incana* and *Quercus marilandica*, frequent presence of *Quercus margaretiae, Quercus laevis, Quercus falcata*, *Quercus stellata*, *Diospyros virginiana*, and *Sassafras albidum*. *Liquidambar styraciflua* may become abundant in unburned sites. *Vaccinium tenellum* or *Gaylussacia dumosa* dominate patches of the shrub layer, and *Gaylussacia frondosa, Morella pumila*, and *Ilex glabra* have high constancy. Other frequent shrubs include *Vaccinium fuscatum, Persea palustris*, and *Toxicodendron pubescens*, while *Vaccinium arboreum* also sometimes occurs.

The herb layer is dominated by *Aristida stricta*, and it shares a high diversity of species with drier sandhills as well as a number with wetter communities. Highly constant species in the limited number of CVS plots (Palmquist et al. in prep. c) include *Andropogon* (*ternarius, gyrans*), *Schizachyrium scoparium, Solidago odora, Galactia erecta, Ionactis linariifolia, Pityopsis graminifolia, Sericocarpus tortifolia, Symphyotrichum walteri, Cirsium repandum, Eupatorium rotundifolium, Tragia urens, Trilisa odoratissima, Cnidoscolus stimulosus, Lespedeza capitata, Liatris* sp., *Scleria ciliata, Pteridium pseudocaudatum, Stylosanthes biflora*, and *Euphorbia ipecacuanhae*. Other frequent species in plot data include many legumes: *Lespedeza hirta, Lespedeza angustifolia, Desmodium tenuifolium, Desmodium ciliare, Tephrosia florida, Tephrosia hispidula,* and *Crotalaria purshii*. Additional frequent species include *Scleria nitida, Chrysopsis gossypina, Eupatorium album, Lechea minor, Vaccinium crassifolium, Dichanthelium ovale, Dichanthelium webberianum, Rhynchospora plumosa, Carphephorus tomentosus, Panicum virgatum, Pteridium pseudocaudatum, Symphyotrichum concolor, Xyris caroliniana,* and *Polygala lutea*. Additional species that are less frequent in plots but are characteristic of the community include *Baptisia tinctoria, Carphephorus bellidifolius, Gymnopogon brevifolius, Crocanthemum carolinianum, Hieracium marianum, Danthonia sericea, Lobelia nuttallii, Orbexilum pedunculatum, Sericocarpus linifolius, Silphium compositum*, *Pterocaulon pycnostachyum, Gymnopogon ambiguus, Helianthus heterophyllus*, and several more legumes.

Range and Abundance: The new association is not yet ranked, but it may be G1. Well-developed examples are known only in a handful of sites, primarily within Camp Lejeune. The community could possibly occur in northern South Carolina.

Associations and Patterns: The Coastal Plain Mesic Transition Subtype usually occurs as a small patch community, though it once was likely more extensive. It tends to grade downhill to Mesic Pine Savanna (Coastal Plain Subtype) or Wet Loamy Pine Savanna. It may grade uphill to Pine/Scrub Oak Sandhill (Mixed Oak Subtype).

Variation: Details of variation in this subtype are not known as it is newly described and few examples exist.

Dynamics: The dynamics of the Coastal Plain Mesic Transition Subtype are similar to those of the Dry Longleaf Pine Forests theme in general. Because their productivity is higher than that of other sandhills, they develop dense midstories even faster in the absence of fire, and they are likely to be invaded by forest oaks and *Liquidambar* as well as scrub oaks. They may also be invaded by some of the more aggressive species of wetter communities.

As in the Sandhill Mesic Transition Subtype, the environmental factors that control the shift to Mesic Pine Savanna are not clear. Though it needs more investigation, scrub oaks appear not to drop out as quickly at the boundary in the Coastal Plain Mesic Transition Subtype and they do in the Sandhills. However, though the savanna is generally mesic, occasional high water tables may make survival of scrub oaks difficult. Increased fire intensity with the increased productivity of the herb layer may also be involved, and competitiveness of the herbs may be significant.

Comments: This is one of the most recently recognized communities in the 4th Approximation, distinguished as a result of the analysis of plot data by Palmquist et al. (in prep. c). Floristic differences between the Sandhills and other parts of the Coastal Plain are visible in many longleaf pine communities. It appears that the mesic to wet ones, with a large pool of species, show enough difference to recognize as different subtypes. The differences shown by the drier communities appear somewhat less, perhaps solely because of the smaller species pool.

Part of the floristic difference between the Sandhills Mesic Transition Subtype and Coastal Plain Mesic Transition Subtype is in a greater number of drier site species in the former and a greater number of wetter site species in the latter. This may reflect the greater abundance of wet savannas in the outer Coastal Plain and the greater abundance of drier sandhill communities in the Sandhills landscapes.

This subtype is less well characterized than the Sandhills Mesic Transition Subtype because it is less abundant and because fewer plots have been sampled. The vegetation description here is largely based on five CVS plots.

Rare species:
Vascular plants – *Asemeia* (*Polygala*) *grandiflora, Galactia mollis, Solidago tortifolia, Spiranthes eatonii,* and *Tridens chapmanii*.

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Dryobates borealis, Heterodon simus, Peucaea aestivalis,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Hesperia attalus*.

PINE/SCRUB OAK SANDHILL (CLAY/ROCK HILLTOP SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Clay/Rock Hilltop Subtype covers communities occurring on exposed clay or rock layers in the Sandhills region, where *Quercus marilandica* predominates, *Quercus laevis* is generally absent or scarce, and unusual wetland species are often present.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. The Clay/Rock subtype is distinguished from all other subtypes by occurrence on sandstone or hard clay surfaces rather than sand or loam, by the near absence of *Quercus laevis,* and by the presence of *Vaccinium crassifolium* or *Pyxidanthera barbulata* in a hilltop location that would otherwise be well drained. The Clay/Rock Hilltop sometimes has very limited scrub oak abundance, comparable to that in some subtypes of Mesic Pine Savanna. In this case it may still be distinguished by the distinctive environment and by a distinctive low-diversity flora.

Crosswalks: *Pinus palustris / Quercus marilandica / Vaccinium crassifolium / Aristida stricta* Woodland (CEGL003599).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).

Sites: The Clay/Rock Hilltop Subtype occurs in distinctive sites where dense clay or cemented sandstone forms the surface on a ridge top or upper slope.

Soils: Soils in the Clay/Rock Hilltop Subtype are shallow or have properties that restrict root penetration and that may perch rainwater. Plinthite is common, but cemented beds of underlying Cretaceous or Tertiary formations may also support this community. This subtype occurs in small patches that are not distinguished in soil mapping. Occurrences are mapped as the typical Ultisols of the Sandhills, most as Vaucluse (Typic Hapludult), Gilead (Aquic Hapludult), and Blaney (Arenic Hapludult).

Hydrology: Moisture conditions are driven by a combination of rainfall and limited water penetration. Seepage is not a significant source of moisture because there is not a source of groundwater uphill. The typical presence of wetland plants and perhaps the scarcity of most oak species suggests they perch water long enough to produce wetland conditions at times. Conversely, the scarcity of wetland species, as well as the setting, suggests they become quite dry at other times.

Vegetation: The Clay/Rock Hilltop Subtype has a typical open, patchy canopy of *Pinus palustris*, generally with no other species. The scrub oak layer is sparser than in most sandhills. *Quercus marilandica* is the only abundant species. *Quercus laevis, Quercus incana*, *Quercus margaretiae*, and forest oaks, along with *Diospyros virginiana, Nyssa sylvatica*, *Sassafras albidum*, and *Prunus serotina* may be present but only in small numbers and with limited cover even in unburned examples. The dominant shrubs are usually *Gaylussacia dumosa* and *Vaccinium tenellum*, but *Kalmia latifolia* is fairly frequent and may dominate substantial patches. Other shrubs that are constant or frequent in CVS plot data (Palmquist et al. in prep. c) and field observations are *Lyonia mariana, Clethra alnifolia, Gaylussacia frondosa, Morella pumila, Hypericum hypericoides*, and *Rhus copallinum*. Less frequent but indicative are *Cyrilla racemiflora*, *Ilex glabra*, *Vaccinium arboreum*, and *Symplocos tinctoria*. *Aristida stricta* generally dominates the herb layer, but its overall cover is often less than in most sandhills. *Vaccinium crassifolium* is highly constant and often dominates large patches, and *Pyxidanthera barbulata* may also dominate patches. *Schizachyrium scoparium* and *Andropogon* spp. are frequent. Other species that are frequent in CVS plots include *Carphephorus bellidifolius, Epigaea repens, Sericocarpus asteroides, Tephrosia virginiana, Pteridium pseudocaudatum, Pityopsis graminifolia, Sericocarpus linifolius, Dichanthelium ovale/villosissimum, Dichanthelium commutatum, Seymeria cassioides, Solidago odora, Chamaecrista* spp., *Coreopsis verticillata, Danthonia sericea, Lespedeza virginica, Liatris* sp., *Scleria ciliata, Stylosanthes biflora, Symphyotrichum walteri,* and *Hieracium marianum*. However, many of these species have lower frequency than in most sandhill communities, and the average plot species richness of 30 is lower than in most.

Dynamics: As with other sandhill communities, frequent fire is a natural part of the Clay/Rock Hilltop Subtype. However, the presence of rock outcrops and patches of less flammable plants such as *Pyxidanthera barbulata* may make fires less intense or more patchy. The frequent presence of *Kalmia latifolia*, a species that is not well adapted to frequent fire, suggests some degree of natural fire sheltering. The extreme site appears to be less prone to invasion by woody plants in the absence of fire.

Range and Abundance: Ranked G2?. The Clay/Rock Hilltop Subtype is confined to the fall line Sandhills region. It is very rare in North Carolina. Similar clay/rock hilltops are more abundant in South Carolina, but it is unclear how many represent this community rather than the more southerly "wiregrass gap" analogue of it.

Associations and Patterns: The Clay/Rock Hilltop Subtype is a small patch community. Some occurrences have multiple patches that add up to tens of acres but most patches are small. This subtype is present only in scattered locations and is absent in typical landscapes in the North Carolina Sandhills.

Variation: Little is known of variation. Examples with and without *Kalmia latifolia* may warrant recognition as variants.

Rare species:
Vascular plants – *Pyxidanthera barbulata* var. *brevifolia*.

Nonvascular plants – *Campylopus carolinae*.

Vertebrate animals – *Dryobates borealis*.

PINE/SCRUB OAK SANDHILL (COASTAL FRINGE SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Coastal Fringe Subtype has evergreen scrub oaks as a major component, as well as other coastal fringe indicator species.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub and Sand Barren communities by the codominance or substantial presence of scrub oaks other than *Quercus laevis*. However, *Quercus laevis* may still codominate. In frequently burned sites, most or all scrub oaks may exist as sprouts.

The Coastal Fringe Subtype is distinguished by the presence of plant species that, at least in North Carolina, are confined to areas near the coast. These include *Quercus geminata, Cartrema americana, Ilex vomitoria, Rhynchospora megalocarpa*, and *Cladonia evansii*. *Quercus hemisphaerica* is often abundant in the Coastal Fringe Subtype but may occur in small amounts in other sandhill communities such as the Mixed Oak Subtype.

Among the Coastal Fringe subtypes of the different sandhill types, this community is distinguished by being less dry and having greater overall plant cover and diversity than the Xeric Sandhill Scrub or Sand Barren. *Quercus geminata* often is more abundant than *Quercus laevis*, and *Q. hemisphaerica, Q. incana, Q. margaretiae*, and *Q. virginiana* are generally present. Bare sand is limited in extent and the most specialized psammophytes, though often present, are not abundant.

Crosswalks: *Pinus palustris / Quercus geminata - Quercus hemisphaerica - Osmanthus americanus / Aristida stricta* Woodland (CEGL003577).
G154 Xeric Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Coastal Fringe Sandhill (3rd Approximation).

Sites: The Coastal Fringe Subtype occurs on relict coastal dunes and beach ridges, in a zone inland of the barrier islands but within a few miles of the coast. It occurs on lower dunes and lower parts of dunes, downhill of Xeric Sandhill Scrub.

Soils: Soils are deep sandy Entisols or dry Spodosols. Most are mapped as Kureb (Typic Quartzipsamment) or Mandarin (Typic Haplohumod), a few as Echaw (Entic Haplohumod), Wando (Typic Udipsamment), Pactolus (Aquic Quartzipsamment), or Leon (Aeric Haplohumod). A few examples may occur on sandy Ultisols. The coarse sand has limited capacity for retaining water or nutrients, but conditions are less dry than in Xeric Sandhill Scrub or Sand Barren due to some fine-texture material or to a water table that is more readily within reach of plant roots.

Hydrology: Sites are somewhat excessively drained and are dry most of the growing season. Though the water table does not reach the surface, it is not extremely deep; many plant roots may reach an abundant water supply once established.

Vegetation: Vegetation structure is characteristic of most longleaf pine communities, with an open, patchy woodland to savanna canopy and a moderate to dense grassy herbaceous layer. *Pinus palustris* may solely dominate, or it may be mixed with *Pinus taeda*. A midstory of scrub oaks and a low shrub layer are sparse and patchy under a natural fire regime but become dense with long exclusion of fire. CVS data (Palmquist et al. in prep. c) show *Quercus hemisphaerica, Quercus laevis*, and *Quercus geminata* as most abundant in the midstory. *Sassafras albidum, Quercus incana, Quercus margaretiae*, and *Sassafras albidum* are frequent. *Quercus virginiana* is present in some occurrences. *Vaccinium arboreum* is the most frequent and abundant shrub in the plot data. *Vaccinium tenellum, Ilex vomitoria, Morella pumila, Morella cerifera*, *Amorpha herbacea*, *Gaylussacia dumosa*, *Cartrema americanum*, *Persea palustris*, and *Vaccinium stamineum* are frequent. The herb layer is dominated by *Aristida stricta*. Other frequent herbs in plots are *Schizachyrium scoparium*, *Cnidoscolus stimulosus, Euphorbia ipecacuanhae, Pityopsis graminifolia, Euphorbia pubentissima, and Solidago odora*. Lichens, both *Cladonia evansii* and other *Cladonia* species, are often abundant.

Range and Abundance: Ranked G2. The Coastal Fringe Subtype primarily occurs within a few miles of the coast in the southern half of the state. However, a few depauperate disjunct examples occur inland as far as Robeson County on sand dunes along rivers. This subtype also occurs in northern South Carolina.

Associations and Patterns: Pine/Scrub Oak Sandhill (Coastal Fringe Subtype) is a large patch community. It may occur in lower parts of relict dunes in mosaics with Xeric Sandhill Scrub (Coastal Fringe Subtype) and Sand Barren (Coastal Fringe Subtype). It may grade to Wet Pine Flatwoods in lower sandy areas, or to Pond Pine Woodland, Tidal Swamp, or other wetland communities.

Variation: The inland examples differ in having fewer of the coastal fringe species. Some are on isolated upland areas surrounded by swamp, where fire may have been infrequent but where extreme sandy substrates have prevented development of other communities. These may be recognized as a distinct variant. Other examples vary with the transition to adjacent wetter or drier communities, perhaps with distance from the coast, and perhaps with subtype variations in soil texture.

1. Typic Variant occurs within a few miles of the coast. It fits the above description closely.

2. Swamp Island Variant occurs farther inland, on isolated sand ridges along rivers or lakes. These isolated locations may burn infrequently even with a natural fire regime. This variant is floristically depauperate, having fewer of the coastal fringe species and therefore being conceptually transitional to the inland Pine/Scrub Oak Sandhill (Mixed Oak Subtype).

Dynamics: Dynamics are generally typical for longleaf pine/scrub oak communities. However, the evergreen oak litter may affect fire behavior on a fine scale. It has been suggested (Frost 2000) that the evergreen scrub oaks, especially *Quercus geminata*, once established, prevent fire from spreading into their microsites because their curled leaves can hold rainwater and stay wet much longer than other leaf litter. Thus, their patches within the community may expand and persist without burning even where fire occurs, and it may be particularly hard to reverse an increase in their abundance with fire suppression.

As with Coastal Fringe Evergreen Forest and the coastal fringe subtypes of other sandhill communities, the reasons for the distinctive flora of the Coastal Fringe subtypes in the area near the coast is not well known, and no published study specifically addresses it. The species are more widespread inland farther south, suggesting a moderated climate may be important. Input of nutrients by salt spray aerosols may also be important, as may the effects of sea breezes on fire regimes. But the occurrence of a few disjunct inland patches of this community and inland populations of its distinctive species may suggest other factors.

Comments: The Coastal Fringe Sandhill type of the 3rd Approximation has been reduced to a series of subtypes under the other sandhill types in the 4th. This represents a conclusion that the ecological and floristic differences caused by differences in moisture regime are more important than those related to the coastal fringe floristic component.

Rare species:
Vascular plants – *Aristida condensata, Corallorhiza wisteriana, Crocanthemum carolinianum, Crocanthemum nashii, Erythrina herbacea, Gaylussacia nana, Quercus minima, Solidago tortifolia,* and *Spiranthes eatonii*.

Nonvascular plants – *Campylopus carolinae* and *Cladonia submitis*.

Vertebrate animals – *Ambystoma mabeei, Dryobates borealis, Heterodon simus, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus*, and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Drasteria graphica* and *Catocala messalina*.

PINE/SCRUB OAK SANDHILL (NORTHERN SUBTYPE)

Concept: Pine/Scrub Oak Sandhills are dry longleaf pine communities that are less xeric and infertile than Xeric Sandhill Scrub, and that are characterized by a scrub oak layer containing a mixture of oak species or are dominated by species other than *Quercus laevis*. The Northern Subtype covers the now-very-rare examples that are north of the natural range of *Aristida stricta*. It conceptually includes a broader range of moisture and soil conditions than the other subtypes, because remaining examples are too few and too degraded to refine the category further.

Distinguishing Features: The Northern Subtype is distinguished from all other Coastal Plain Dry Longleaf Pine Communities by its geographic location north of the natural range of *Aristida stricta*, roughly at Pamlico Sound and the Tar River. The only other dry longleaf pine community that naturally lacks *Aristida stricta* is the Dry Piedmont Longleaf Pine Forest, of which none are known this far north and that differ in their composition and substrate. A number of species occur only in the Northern Subtype, including *Gaylussacia baccata* and *Kalmia angustifolia*. *Vaccinium pallidum*, absent in all other Coastal Plain longleaf pine communities, is abundant in the best known examples.

Crosswalks: *Pinus palustris – Pinus taeda / Quercus laevis / Gaylussacia frondosa – Gaylussacia baccata* Woodland (CEGL003592).
G154 Xeric Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).

Sites: Pine/Scrub Oak Sandhill (Northern Subtype) occurs on relict sand dunes and potentially in other sandy upland areas.

Soils: Soils of known remnants are deep sandy Entisols. Most of the few examples are mapped as Alaga (Typic Quartzipsamment) or Pactolus (Aquic Quartzipsamment).

Hydrology: The Northern Subtype, as defined, occupies a broader range of moisture conditions than most other longleaf pine communities, but all remaining examples are excessively drained and dry for most of the time in the growing season.

Vegetation: All of the few remaining examples have been substantially altered by past fire suppression as well as logging. The natural condition is less well known than for most longleaf pine communities. Natural vegetation structure is presumed to be similar, with an open savanna to woodland canopy, a sparse patchy midstory and shrub layer, and a moderate to dense grassy herb layer. *Pinus palustris* dominates the canopy; *Pinus taeda* is generally mixed with it at present, sometimes codominant or dominant, and may have been in the past as well. *Quercus laevis* characteristically dominated the midstory. *Diospyros virginiana* and *Sassafras albidum* are constant in plots (Palmquist et al. in prep. b) and likely are abundant under natural conditions. The other midstory species frequent in CVS plots (Palmquist et al. in prep. b), *Prunus serotina*, *Quercus nigra, Quercus falcata*, and *Pinus serotina,* likely are present only because of fire exclusion. Frequent shrubs in plots are *Gaylussacia frondosa, Castanea pumila, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia dumosa*, *Morella pumila, Lyonia mariana*, and *Toxicodendron pubescens*. *Gaylussacia baccata* and *Kalmia carolina* are fairly frequent and sometimes dominant in plots. *Schizachyrium scoparium* is frequent in the herb layer and likely dominates under natural frequently burned conditions. Other frequent herbs in plots are *Euphorbia ipecacuanhae, Carphephorus bellidifolius, Dichanthelium* spp., and *Cnidoscolus stimulosus*. Fairly frequent herbs, likely more abundant with more frequent fire, include *Tephrosia virginiana*, *Pityopsis graminifolia*, and *Lupinus perennis*. Several species are somewhat less frequent but are notable for their presence and are distinctive to this subtype. Besides *Gaylussacia baccata*, *Kalmia angustifolia* (narrow sense) has been found. One notable plot contained *Pinus rigida*. These species are not otherwise known in the Coastal Plain of North Carolina, but are frequent in dry sites in the Mountain Region, and are characteristic of sandy habitats in states to the north.

Range and Abundance: Ranked G1. Only a few examples remain, none in very good condition. This community occurs north of Pamlico Sound and the Tar River, extending into southern Virginia. It is unclear how extensive it was. Much of this region is peatland and swamp, and a significant portion of the well-drained uplands farther north in it appear to naturally support oak-hickory forests. All remaining examples are confined to unusual sand dune landforms, which are rare in the region.

Associations and Patterns: Natural patterns are not well known. Some of the remaining examples are large patch communities, some small patch. Associated communities include various floodplain communities, small depression wetlands, and sometimes oak-hickory forests. Some examples in the past likely graded to Northern Wet Pine Savanna.

Variation: This community is variable in apparent moisture levels and perhaps in soil texture, but the natural state is not well enough known to recognize variants. It is likely that analogues of Xeric Sandhill Scrub, Pine/Scrub Oak Sandhill, and Mesic Pine Savanna once existed north of the range of *Aristida stricta*.

Dynamics: It is not well known how the dynamics of this subtype might naturally differ from other longleaf pine communities. Canopy structure and tree regeneration probably were similar. Fire may have been somewhat less frequent: there may have been fewer thunderstorms, and the large estuaries and extensive peatlands and hardwood wetlands in the region would have provided more natural firebreaks. None of the herbaceous species is quite as flammable as *Aristida stricta*, and none will carry fire under as wide a range of conditions. However, the predominance of *Pinus palustris* indicates a regime of frequent fire.

Comments: This subtype, at least the remaining examples, appears to primarily be analogous to both the Mixed Oak Subtype and to Xeric Sandhill Scrub in its moisture and soil characteristics. Separate northern versions of both Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill likely could be recognized if intact remnants were numerous.

Rare species:
Vascular plants – *Dichanthelium fusiforme, Kalmia angustifolia,* and *Polygonella articulata*.

Vertebrate animals – *Dryobates borealis*.

MESIC PINE SAVANNA (SANDHILLS SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Sandhills Subtype covers the typical examples of the Sandhills Region, which differ floristically from the other subtypes.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. When scrub oaks are present, they often are combined with a small component of wetland species not found in sandhills, and with forest oaks such as *Quercus nigra, Q. falcata*, or *Q. stellata*. Invasion by *Liquidambar styraciflua* can be used to tell Mesic Pine Savannas from sandier communities such as Pine/Scrub Oak Sandhill (Mixed Oak Subtype) but not from the Mesic Transition Subtype.

Where land managers have removed oaks from Pine/Scrub Oak Sandhill, Mesic Pine Savannas in good condition can be distinguished from most sandhills by the distinctive mesic herbaceous flora with a high diversity of legumes, including *Lespedeza hirta, Lespedeza capitata, Crotalaria purshii*, and many species of *Desmodium*, and by other mesic species such as *Panicum virgatum* and *Gymnopogon brevifolius*. Pine/Scrub Oak Sandhill (Mesic Transition Subtype) shares many of these species and may remain difficult to distinguish. In this situation, the minor component of wetland species usually present in Mesic Pine Savannas may be helpful, but these species are less abundant in the Sandhills Mesic Transition Subtype.

The Sandhills Subtype is distinguished from the Lumbee Subtype and the Little River Subtype by the lesser presence of scrub oaks and by the lesser presence of wetland plants. The distinction with the Coastal Plain Subtype is based on floristic differences that are more subtle, but the two can readily be distinguished by geographic location, as no examples are known in North Carolina outside of their respective geographic areas. Plants that occur in the Coastal Plain Subtype and seldom or never in the Sandhills Subtype include *Amorpha herbacea* var. *herbacea, Trilisa odoratissima, Tephrosia hispidula,* and *Pterocaulon pycnostachyum*, along with many wetter savanna species. Plants that occur in the Sandhills Subtype and seldom or never in the Coastal Plain include *Baptisia cinerea, Vernonia acaulis, Coreopsis major, Coreopsis verticillata, Angelica venenosa, Helianthus atrorubens, Paspalum bifidum,* and *Tridens carolinianus*. The Coastal Plain Subtype usually occurs on flat terrain distant from drainages, in large to small patches, or often in a fine-scale mosaic with Wet Loamy Pine Savanna communities. The Sandhills Subtype usually occurs as small patches in upland swales or on lower slopes.

Crosswalks: *Pinus palustris / Aristida stricta - Sorghastrum nutans - Anthenantia villosa* Woodland (CEGL003570).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Mesic Pine Flatwoods (Sandhills Subtype).

Sites: The Sandhills Subtype occurs in swales or local flat areas in the rolling upland terrain of the Sandhills, or on lower slopes with loamy soil.

Soils: Soils in the Sandhills Subtype are loamy, with a mix of sand with finer material. Since patches are small, their soils are inclusions in map units. Most are mapped as widespread soil series, primarily Gilead (Aquic Hapludult), Blaney (Arenic Hapludult), and Fuquay (Plinthic Kandiudult).

Hydrology: Mesic Pine Savannas appear to have predominantly moist conditions. Seasonal high water tables may occur to some degree, but they are not sufficient to lead to dominance by wetland plants. However, mesic conditions may be marginal, as wetter microsites are common within them, and soils often show some mottling.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are absent or limited to sparse individuals of *Quercus marilandica, Quercus margaretiae,* or *Quercus incana*. However, forest oaks such as *Quercus stellata* and *Quercus falcata* are often present as sprouts, and they can grow into the canopy with long absence of fire. *Diospyros virginiana, Sassafras albidum, Benthamidia* (*Cornus*) *florida,* and *Acer rubrum* also are frequent as sprouts or taller stems. *Liquidambar styraciflua* invades quickly and heavily in the absence of fire.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep. c) show an average of 68 species per 1/10 hectare, the majority herbs, and it is much higher in some plots. *Aristida stricta* dominates, though *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. *Panicum virgatum* may be abundant. Other highly constant herb species in CVS plot data (Palmquist et al. in prep. c) are *Solidago odora, Iris verna, Ionactis linariifolia, Eupatorium rotundifolium, Symphyotrichum walteri, Symphyotrichum dumosum, Dichanthelium tenue, Euphorbia curtisii*, and *Rhexia alifanus*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Baptisia cinerea, Stylosanthes biflora, Galactia erecta, Tephrosia* (*virginiana, florida, spicata*), *Lespedeza* (*capitata, hirta, angustifolia, virginica, repens*), *Desmodium lineatum, Orbexilum psoralioides*, and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent, including *Danthonia sericea, Gymnopogon brevifolius, Sorghastrum nutans,* several *Dichanthelium* (*aciculare, strigosum, ovale*)*, Pityopsis graminifolia, Sericocarpus tortifolius, Coreopsis major, Coreopsis verticillata, Eupatorium album, Eupatorium mohrii, Eupatorium leucolepis, Euthamia caroliniana, Vernonia angustifolia, Vernonia acaulis, Sericocarpus linifolius, Helianthus atrorubens, Chrysopsis mariana, Silphium compositum, Hieracium marianum, Aletris farinosa, Scleria ciliata, Scleria nitida, Tragia urens, Lechea minor, Lobelia nuttallii, Oenothera fruticosa, Potentilla canadensis, Pycnanthemum flexuosum, Viola pedata, Rhexia mariana, Sisyrinchium capillare, Angelica venenosa,* and *Gentiana autumnalis*. Though somewhat less frequent, other frequent or characteristic species include *Parthenium integrifolium, Carphephorus bellidifolius, Cirsium repandum, Sericocarpus asteroides, Andropogon gerardii, Paspalum bifidum, Tridens carolinianus,* several more *Desmodium* (*strictum, ciliare, nuttallii,* *paniculatum*), *Lespedeza procumbens, Mimosa (Schrankia) microphylla, Crotalaria purshii,* and *Schwalbea americana*.

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. Highly constant species in CVS plot data are *Vaccinium tenellum*, *Gaylussacia dumosa, Ilex glabra*, and *Rhus copallinum*. Other frequent shrubs include *Toxicodendron pubescens, Gaylussacia frondosa, Lyonia mariana, Aronia arbutifolia, Hypericum hypericoides, Hypericum crux-andreae, Morella pumila*, and *Clethra alnifolia*.

Range and Abundance: Ranked G2G3 but probably appropriately G2 given the dependence of very frequent fire. About 20 occurrences are known in North Carolina but most are parts of clusters confined to Fort Liberty. Only a few good examples are known in the rest of the Sandhills. This community also occurs in the northern Sandhills of South Carolina.

Associations and Patterns: The Sandhills Subtype is a small patch community. Though some occurrences are complexes of tens of acres, most individual patches are no more than a few acres and are not a regularly occurring part of Sandhills landscapes. Mesic Pine Savannas are usually just downhill of Pine/Scrub Oak Sandhill (Mesic Transition Subtype or Blackjack Subtype). Unlike the Coastal Plain Subtype, the Sandhills Subtype is seldom associated with wetter savannas, though it may adjoin Streamhead Pocosin.

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Dynamics of the Sandhills Subtype appear to be similar to the Coastal Plain Subtype. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by hardwood trees without it. As discussed for the theme, the cause of the disappearance of scrub oaks in the transition from sandhills to Mesic Pine Savannas is unclear.

Mesic Pine Savannas are conceptually a slice of the moisture gradient between drier sandhill communities and wetter communities, but recognizable examples are not generally present in most places on the landscape. In the Sandhills region, they appear to depend on distinctive topography, perhaps a widening of the slope to provide enough space in the precise part of the moisture gradient needed. However, it may alternatively be that these landforms correlate with the loamy soil texture needed. The more common Sandhills region pattern of dense clay underlying sand tends to support abrupt transitions from Pine/Scrub Oak Sandhill (Blackjack Subtype) to Sandhill Seep or Streamhead Pocosin, as seepage causes a rapid shift from dry to saturated conditions.

Comments: Early recognition of this community used the name “pea swales” or “bean dips”, in recognition of their tendency to occur in local low areas and their tendency to have a very high diversity of legumes.

The distinction between the Coastal Plain and Sandhills subtypes needs further examination and clarification but appears warranted and is supported by analysis of plot data collected by the Carolina Vegetation Survey. However, these subtypes share virtually all of their dominant species.

Rare species:
Vascular plants – *Amorpha georgiana, Rhus michauxii, Schwalbea americana,* and *Solidago verna*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Dryobates borealis, Peucaea aestivalis,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Hesperia attalus*.

MESIC PINE SAVANNA (COASTAL PLAIN SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Coastal Plain Subtype covers the typical examples of the lower and middle Coastal Plain, which differ floristically and in landscape relations from the other subtypes.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. When scrub oaks are present in Mesic Pine Savannas, they often are combined with a small component of wetland species not found in sandhills, and additionally with forest oaks such as *Quercus nigra, Q. falcata*, or *Q. stellata*. A diverse herbaceous flora containing mesophytic species such as *Panicum virgatum* and *Gymnopogon brevifolius* and a large number of legumes also distinguishes Mesic Pine Savannas from all sandhill communities other than the Sandhills Mesic Transition Subtype and Coastal Plain Mesic Transition Subtype. The boundary with these two subtypes can be difficult to define if scrub oaks have been removed. The component of wetland species may be the most definitive indicator.

Mesic Pine Savannas are distinguished from Wet Loamy Pine Savannas and other wet pine savannas by having a substantial component of mesophytic and drier site plants and only small amounts of wetland plants. Mesic Pine Savannas contain a substantial and usually diverse collection of legume species, of which only a few occur in wetter pine savannas. They also contain a large number of species shared with sandhills but generally absent in wet savannas. Characteristic plants that occur in wet savannas and not in mesic savannas include *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, most *Rhynchospora* species, *Andropogon glomeratus, Andropogon cretaceus, Xyris* spp., *Eriocaulon* spp., *Bigelowia nudata, Zigadenus* spp., and all the carnivorous plants.

The Coastal Plain Subtype is distinguished from the other subtypes of Mesic Pine Savanna by geographic and floristic differences. The Little River and Lumbee Subtype each occur in a limited geographic area, and they generally have a mix of scrub oaks and wetland species in greater abundance than the other subtypes. The distinction with the Sandhills Subtype is based on floristic differences and is more subtle, but the two can readily be distinguished by geographic location, as no examples are known in North Carolina outside of their respective geographic areas. Plants that occur in the Coastal Plain Subtype and seldom or never in the Sandhills Subtype and are more characteristic of the outer Coastal Plain include *Amorpha herbacea var. herbacea, Trilisa odoratissima, Tephrosia hispidula,* and *Pterocaulon pycnostachyum*, along with many wetter savanna species. Plants that occur in the Sandhills Subtype and seldom or never in the Coastal Plain include *Baptisia cinerea, Vernonia acaulis, Coreopsis major, Coreopsis verticillata, Angelica venenosa, Helianthus atrorubens, Paspalum bifidum,* and *Tridens carolinianus*. The Coastal Plain Subtype usually occurs on flat terrain distant from drainages, in large to small patches, or often in a fine-scale mosaic with Wet Loamy Pine Savanna communities. The Sandhills Subtype usually occurs as small patches in upland swales or on lower slopes.

Crosswalks: *Pinus palustris / Amorpha herbacea var. herbacea / Aristida stricta - Sorghastrum nutans* Woodland (CEGL003569).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Mesic Pine Flatwoods (Coastal Plain Variant) (3rd Approximation).

Sites: The Coastal Plain Subtype occurs on upland flats or terraces, in shallow swales, and on low rises amid wetter areas, all where the substrate contains some silt or clay component and is not pure coarse sand.

Soils: Soils in the Coastal Plain Subtype are a variety of mesic to wet Ultisols. The largest number of occurrences is mapped as Rains (Typic Paleaquult), with multiple sites mapped as Lynchburg (Aeric Paleaquult) and Onslow (Spodic Paleudult), and a few with a wide variety of other Udults and Aquults. All of these series, as typically mapped, cross the boundary between Mesic Pine Savanna and Wet Loamy Pine Savanna.

Hydrology: Mesic Pine Savannas appear to have predominantly moist conditions. Seasonal high water tables may occur to some degree, but they are not sufficient to lead to dominance by wetland plants. However, mesic conditions may be marginal, as wetter microsites are common within them, and soils often show some mottling.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are absent or limited to sparse individuals of *Quercus marilandica, Quercus margaretiae,* or *Quercus incana*. However, taller oaks such as *Quercus stellata* and *Quercus falcata* are often present as sprouts, and they can grow into the canopy with long absence of fire. *Diospyros virginiana, Persea palustris, Magnolia virginiana,* and *Acer rubrum* also are frequent as sprouts or taller stems. *Liquidambar styraciflua* invades quickly and heavily in the absence of fire.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep. c) show an average of 57 species per 1/10 hectare, the majority herbs, and it is much higher in some plots. *Aristida stricta* dominates, though *Vaccinium crassifolium* or *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. Highly constant species in CVS plot data are *Pityopsis graminifolia, Ionactis linariifolia, Liatris* sp., *Solidago odora, Symphyotrichum walteri, Eupatorium rotundifolium, Sericocarpus tortifolius, Lespedeza angustifolia, Desmodium tenuifolium*, and *Dichanthelium ovale*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished. The herb layer includes a great diversity of species in the Fabaceae. Frequent species in CVS plot data include *Galactia erecta, Stylosanthes biflora, Tephrosia hispidula,* several *Desmodium* (*tenuifolium, lineatum, ciliare*), and *Lespedeza* (*capitata, hirta*), *Chamaecrista* spp., and *Crotalaria purshii*. Several other species are only slightly less frequent, including more *Lespedeza* (*virginica, stuevei*), and *Desmodium* (*ciliare, paniculatum, rotundifolium*), *Tephrosia florida, Tephrosia virginiana, Amorpha herbacea*, and *Baptisia tinctoria*. Other herb species that are frequent in plots include *Iris verna, Trilisa odoratissima, Eupatorium mohrii, Eupatorium leucolepis, Gymnopogon brevifolius, Danthonia sericea,* *Sericocarpus linifolius,* and *Symphyotrichum dumosum*. Several species typical of wet savannas are also frequent in plots but are confined to wetter microsites, including *Polygala lutea, Rhynchospora plumosa, Xyris caroliniana*, and *Anchistea virginica*, while species of drier sandhills, such as *Cnidoscolus stimulosus* and *Euphorbia ipecacuanhae,* are also frequent in minor amounts. Additional species less frequent in plots but characteristic of mesic rather than wet conditions include *Panicum virgatum, Chasmanthium laxum, Cirsium repandum,* and *Carphephorus bellidifolius*.

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. *Gaylussacia frondosa*, *Ilex glabra*, or *Gaylussacia dumosa* are highly constant and usually dominate. Other highly constant shrubs in CVS data are *Vaccinium tenellum, Morella pumila*, and *Lyonia mariana*, and additional frequent species include *Aronia arbutifolia, Hypericum hypericoides, Rhus copallinum,* and *Hypericum hypericoides*. *Smilax glauca, Smilax bona-nox*, *Muscadinia rotundifolia*, and *Gelsemium sempervirens* are frequent vines, though generally not extensive.

Range and Abundance: Ranked G2G3 but should be G2. Around 25 occurrences are known but many are not in good condition. This subtype probably was extensive in the outer, middle, and inner Coastal Plain, but has been widely converted to agriculture. Remnants are scattered throughout the southern half of the Coastal Plain but are more abundant in the outer portion. The NVC association also occurs in adjacent South Carolina.

Associations and Patterns: The Coastal Plain Subtype functions in current circumstances as a large patch community. Occurrences often are tens of acres, though often including multiple patches. In the past, this subtype probably was a matrix community in many places, making up a substantial portion of the landscape mosaic in areas that are now primarily agricultural. Some remaining examples of the Coastal Plain Subtype occur in fine-scale mosaics, closely intermixed with Wet Loamy Pine Savanna. Most examples would naturally grade downhill to Wet Loamy Pine Savanna and uphill to Pine/Scrub Oak Sandhill (Mesic Transition Subtype).

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by hardwood trees without it.

As discussed for the theme, the cause of the absence of scrub oaks in Mesic Pine Savannas is unclear, since the mesic sites seem favorable for most plants. Their absence in burned sites suggests that competition with mesophytic trees is not the cause, while their absence in unburned sites suggests increased fire intensity due to the dense herb layer is not the cause.

Mesic Pine Savannas are conceptually a slice of the moisture gradient between drier sandhill communities and wetter pine savannas. However, they occur as recognizable communities only on finer-textured soils. While distinct communities often are locally missing from gradients of communities, no mesic longleaf pine community has been found on pure sand. There, Wet Pine Flatwoods adjoin Xeric Sandhill Scrub communities without a mesic community between. Finer texture material allows differentiation into a larger number of distinct communities. This may be due to the larger pool of species on loamy soils, and the presence of multiple species with narrower niches due to competition. However, it may be that true mesic moisture conditions do not occur with the limited water-holding capacity of the pure sands, but rather that excessive drainage creates drier conditions in all places that lack a high water table.

Comments: The distinction between the Coastal Plain and Sandhills subtypes needs further examination and clarification, but appears warranted, and is supported by analysis of plot data collected by the Carolina Vegetation Survey (Palmquist, et al. in prep. c). However, these subtypes share virtually all of their dominant species.

The terms “savanna” and “flatwoods” have been used in various ways in the literature of the Coastal Plain (and in even more various ways in other regions). Communities named savannas may be wetter, shrubbier, or more diverse than those named flatwoods, with these usages sometimes contradicting each other. The 3rd Approximation used the name flatwoods for drier communities and savanna for wetter ones. This moisture-based use of the names has been dropped in favor of one based on diversity and possible natural structure. Mesic Pine Savannas are not naturally shrubby under a natural fire regime and can have extremely high species richness.

Rare species:
Vascular plants – *Amorpha confusa, Andropogon mohrii, Asclepias pedicellata, Hypericum brachyphyllum* (or new species), and *Solidago verna*.

Vertebrate animals – *Peucaea aestivalis, Ambystoma mabeei, Dryobates borealis, Ophisaurus mimicus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Arphia granulata* and *Neonympha areolatus*.

MESIC PINE SAVANNA (LITTLE RIVER SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Little River Subtype covers the rare examples on high river terraces in the Sandhills Region, which contain plants with atypically large differences in typical moisture tolerance and includes some plants characteristic of floodplains. This subtype is known only along the Little River of Cumberland, Hoke, and Moore counties.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. However, the Little River Subtype has more frequent and more diverse scrub oaks than the Sandhills or Coastal Plain Subtype. As with other Mesic Pine Savannas, it has a diverse suite of legumes that distinguish it from all sandhill communities other than Pine/Scrub Oak Sandhill (Mesic Transition Subtype).

The Little River Subtype is easily distinguished from the Sandhills and Coastal Plain subtypes by its location on the high, non-flooded terraces of the Little River. The differences in flora and vegetation that distinguish it from other subtypes are subtle. They include a greater range in moisture tolerance among the plant species present, with small but frequent presence of *Quercus marilandica* and other drier site species mixing with wetter site species such as *Bigelowia nudata* and *Ctenium aromaticum*. The overall flora shares most of the species of the Sandhills Subtype, including all that distinguish it from the Coastal Plain Subtype, but it also includes some, such as *Bigelowia nudata* and *Cyrilla racemiflora*, that are more characteristic of the Coastal Plain Subtype. It includes a number of species not typical of either, including *Eurybia compacta, Ageratina aromatica, Ludwigia virgata, Penstemon australis, Penstemon laevigatus, Comandra umbellata, Viola primulifolia, Eryngium yuccifolium, Stylisma humistrata, Vaccinium elliottii, Bignonia capreolata, Campsis radicans, Thyrsanthella difformis, Crataegus uniflora*, and *Chionanthus virginicus*.

Crosswalks: *Pinus palustris / Vaccinium elliottii - Clethra alnifolia / Aristida stricta - Panicum virgatum* Woodland (CEGL003573).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland Ecological System (CES203.254).
Mesic Pine Flatwoods (Little River Variant) (3rd Approximation).

Sites: All known sites for this subtype are located along the Little River in Cumberland, Moore, Hoke, and Harnett counties. The Little River is distinctive in being deeply entrenched and having relict floodplain terraces high above the present river floodplain, due to downcutting and perhaps recent geologic uplift. Sites have fluvial landforms but generally upland conditions, without influence of river flooding.

Soils: Soils of the Little River Subtype are poorly known. Soil mapping is extremely variable. The only soil that is mapped at more than one occurrence, Pactolus (Aquic Quartzipsamment), likely does not match the soil in the community. Other soils mapped include several Udults, a Udipsamment, and some alluvial soils.

Hydrology: Details of the hydrology in this subtype are uncertain. Though it occurs on river terraces, the terraces are high above the river and are unlikely to flood other than for brief times in the most extreme floods. Like other Mesic Pine Savannas, it appears to primarily be moist, with seasonal wetness that is not sufficient to promote dominance by wetland plants. However, the mixed vegetation suggests a greater role for wet microsites or intermittent wetness than in the Sandhills or Coastal Plain subtypes.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* or *Pinus echinata* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are limited, but *Quercus marilandica* is highly constant and *Quercus margaretiae, Quercus incana*, and even *Quercus laevis* are frequent, though sparse. Forest oaks, especially *Quercus stellata,* may also be present, and *Liquidambar styraciflua* often invades in the absence of fire. A number of understory hardwoods are frequent as sprouts or potentially midstory stems, including *Nyssa sylvatica, Diospyros virginiana, Benthamidia* (*Cornus*) *florida, Sassafras albidum, Chionanthus virginicus, Crataegus uniflora,* and *Magnolia virginiana*.

Where frequently burned, the herb layer is dense and diverse. CVS plots (Palmquist et al. in prep. c) show an extremely high species richness, averaging 98 species per 1/10 hectare, the majority herbs. Numbers in the vicinity of 130 species per 1/10 hectare were found in some plots, rivaling the highest values for any community in the state. *Aristida stricta* dominates, though *Pteridium pseudocaudatum* may be abundant and may come to dominate large portions with inadequate fire. Highly constant species in CVS data (Palmquist et al. in prep. c) include *Solidago odora, Tephrosia virginiana, Pityopsis graminifolia, Silphium compositum, Danthonia sericea, Rhexia alifanus, Parthenium integrifolium, Symphyotrichum walteri, Vernonia acaulis, Ionactis linariifolia, Lespedeza angustifolia, Mimosa (Schrankia) microphylla, Eupatorium rotundifolium,* and *Vaccinium crassifolium*. *Schizachyrium scoparium* and *Andropogon* spp. (*ternarius, gyrans, virginicus*) are collectively highly constant, though not well distinguished in plots. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Baptisia cinerea, Baptisia tinctoria, Stylosanthes biflora, Galactia erecta, Tephrosia florida, Tephrosia spicata*, several *Lespedeza* (*capitata, hirta, angustifolia, virginica, repens*), *Desmodium lineatum, Desmodium ciliare, Crotalaria purshii, Orbexilum psoralioides*, and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent. Grasses include *Panicum virgatum, Danthonia sericea, Gymnopogon brevifolius, Sorghastrum nutans,* several *Dichanthelium* (*aciculare, consanguineum, ovale, strigosum, dichotomum, sphaerocarpon, tenue*), *Aristida purpurascens*, and small amounts of *Ctenium aromaticum*. Composites include *Sericocarpus tortifolius, Sericocarpus linifolius, Coreopsis major, Coreopsis verticillata, Symphyotrichum dumosum, Symphyotrichum concolor*, several *Eupatorium* (*album, mohrii, leucolepis, pilosum*), *Carphephorus bellidifolius, Helianthus atrorubens, Eurybia compacta, Ageratina aromatica, Chrysopsis mariana,* and *Cirsium repandum*. Other herbs include *Aletris farinosa, Penstemon laevigatus, Penstemon australis, Potentilla canadensis, Stylisma* *humistrata, Viola primulifolia, Viola pedata, Polygala lutea, Comandra umbellata, Eryngium yuccifolium, Lachnocaulon anceps, Ludwigia virgata, Phlox nivalis, Scleria ciliata, Xyris caroliniana, Euphorbia ipecacuanhae,* and *Hypoxis hirsuta/curtisii*. Additional species that are less frequent in plots but that distinguish this subtype from others or appear characteristic in site descriptions include *Euthamia caroliniana, Helenium flexuosum, Bigelowia nudata, Chasmanthium laxum, Scleria pauciflora*, and more legumes: *Clitoria mariana* and *Desmodium* (*laevigatum, tenuifolium, obtusum, strictum*).

The shrub layer is naturally low in cover where frequently burned but becomes dense with inadequate fire. Highly constant species in CVS plot data are *Vaccinium tenellum*, *Gaylussacia dumosa, Ilex glabra*, *Lyonia mariana, Rhus copallinum*, and *Hypericum crux-andreae*. *Clethra alnifolia* is frequent and sometimes dominates patches. A great number of other shrub species are frequent in plots, including *Aronia arbutifolia, Toxicodendron pubescens, Amelanchier obovalis, Cyrilla racemiflora, Morella caroliniana, Vaccinium arboreum, Vaccinium elliottii, Vaccinium formosum, Ceanothus americana, Symplocos tinctoria*, and *Arundinaria tecta*. Less frequent but notable shrub species include *Rhododendron atlanticum* and *Amorpha georgiana*, the latter of which is nearly endemic to this community. Vines are more diverse than in other Dry Longleaf Pine Communities. Constant and frequent species in plots include *Smilax glauca, Gelsemium sempervirens, Smilax rotundifolia, Bignonia capreolata, Muscadinia rotundifolia*, and other notable species include *Thyrsanthella difformis, Campsis radicans*, and *Toxicodendron radicans*.

Range and Abundance: Ranked G1. This is one of the rarest natural communities in North Carolina. It is confined to a handful of occurrences in close proximity along the Little River. It is unclear that any other location was suitable for it in the past.

Associations and Patterns: The Little River Subtype may be regarded as a small patch or large patch community. Most occurrences are a few tens of acres. It is unlikely larger occurrences existed in the past. Occurrences may border floodplain communities closer to the river, or may border sandhill communities on higher areas. One notable example is associated with a Sand Barren on a dune on the river terrace.

Variation: Examples vary with the gradation to adjacent communities. No other patterns of variation are known.

Dynamics: Dynamics of the Little River Subtype are believed to be similar to the other subtypes. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by woody vegetation without it. However, the distinctive environment of the river terrace may lead to somewhat reduced natural fire frequency since fires would be unlikely to spread across the river and less likely to spread downhill from the uplands.

While some of the distinctive flora of this subtype is related to its occurrence in close association with floodplain communities, the cause of other aspects of its distinctive character are unclear. Variation in hydrology in the unique river terrace environment is likely important.

Comments: The Little River Subtype was recognized as a variant by early Natural Heritage Program biologists. It is recognized in Palmquist, et al. (in prep. c) but plots are not as strongly differentiated from those of the Sandhills Subtype in the analysis as most associations are.

Rare species:
Vascular plants – *Amorpha georgiana, Astragalus michauxii,* and *Solidago verna*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Dryobates borealis, Peucaea aestivalis,* and *Sistrurus miliarius miliarius*.

MESIC PINE SAVANNA (LUMBEE SUBTYPE)

Concept: Mesic Pine Savannas are longleaf pine communities of environments intermediate between sandhills and wet savannas. Scrub oaks are absent or sparse, though other oaks and various hardwoods may invade with fire suppression. The herb layer is dense and diverse, generally containing a diversity of legume species and limited wetland species. The Lumbee Subtype covers the rare examples on loamy inner Coastal Plain soils, which contain plants with large differences in typical moisture tolerance that are mesophytic on "average." These communities are presently known in North Carolina only in Robeson County and its vicinity, in the inner Coastal Plain.

Distinguishing Features: Mesic Pine Savannas are distinguished from Pine/Scrub Oak Sandhill and other dry longleaf pine communities by the absence or near absence of scrub oaks. However, the Lumbee Subtype, like the Little River Subtype, has more frequent and more diverse scrub oaks than the Sandhills or Coastal Plain Subtype. As with other Mesic Pine Savannas, it has a diverse suite of legumes which distinguish it from all sandhill communities other than Pine/Scrub Oak Sandhill (Sandhill Mesic Transition and Coastal Plain Mesic Transition Subtype). It is distinguished from the Mesic Transition sandhills by a lesser component of scrub oaks and by their occurrence in combination with numerous wetland species. Pine/Scrub Oak Sandhill (Clay/Rocky Hilltop Subtypes) combines lower abundance of scrub oaks with some wetland plants but is much less diverse and occurs in an entirely different environment.

The Lumbee Subtype is distinguished from the Sandhills and Coastal Plain subtypes of Mesic Pine Savanna, as well as from Wet Loamy Pine Savanna and Pine/Scrub Oak Sandhill, by having unusual combinations of plants that include some scrub oaks along with some wetland species, so that the overall "average" of the flora is mesic. It is distinguished from all other subtypes by the frequent presence of *Quercus elliottii*. Otherwise, it shares many species with the Sandhills Subtype, but combines them with species shared with the Coastal Plain Subtype and absent in the Sandhills. Other species frequent in plots of the Lumbee Subtype and not in other subtypes include *Balduina uniflora, Solidago virgata, Eupatorium semiserratum,* and *Vaccinium virgatum*. Because remnants of all savannas are so sparse in the middle Coastal Plain, it is unclear where the natural boundary between the Lumbee Subtype and the Coastal Plain Subtype would occur.

Crosswalks: *Pinus palustris - Pinus taeda - Pinus serotina / Quercus pumila / Aristida stricta* Woodland (CEGL003664).
G009 Dry-Mesic Loamy Longleaf Pine Woodland Group.
Atlantic Coastal Plain Upland Longleaf Pine Woodland Ecological System (CES203.281).
Pine Savanna (Lumbee Variant) (3^{rd} Approximation).

Sites: The Lumbee Subtype occurs on flat upland terraces of the inner or middle Coastal Plain in Robeson County and adjacent areas.

Soils: Soils in the Lumbee Subtype are mapped as a variety of mesic to wet Ultisols. Most occurrences are mapped as Rains (Typic Paleaquult), Lynchburg (Aeric Paleaquult), or Goldsboro (Aquic Paleudult), a couple as Plummer (Grossarenic Paleaquult), and several as other Udults and

Aquults. All of these series, as typically mapped, cross the boundary between Mesic Pine Savanna and Wet Loamy Pine Savanna.

Hydrology: Details of the hydrology in this subtype are uncertain. The mixed vegetation, with a greater component of wetland plants than other Mesic Pine Savannas but still many upland plants, suggests unusual micro-scale variation in wetness or perhaps temporal variation, which allows the species to coexist.

Vegetation: Mesic Pine Savannas in natural condition have a typical open, patchy canopy of *Pinus palustris*. More than most other longleaf pine communities, *Pinus taeda* may be present in minor amounts, sometimes increasing drastically with fire suppression. Scrub oaks are limited in cover even with fire suppression, but *Quercus marilandica* is highly constant. Forest oaks, especially *Quercus stellata* and *Quercus falcata*, may also be present, and *Liquidambar styraciflua* and *Quercus nigra* often invade in the absence of fire. A number of understory hardwoods are frequent as sprouts or potentially midstory stems, including *Nyssa sylvatica, Diospyros virginiana, Sassafras albidum, Magnolia virginiana,* and *Acer rubrum*.

The herb layer is presumed to be dense and diverse when frequently burned, but no examples remain in very good condition. Nevertheless, CVS plots (Palmquist et al. in prep. c) show an average of 85 species per 1/10 hectare, the majority herbs. *Aristida stricta* dominates naturally, with *Panicum virgatum* dominating some patches, but *Pteridium pseudocaudatum* and *Andropogon* spp. dominate parts of most plots at present. Highly constant herbs in CVS plots include *Eupatorium rotundifolium, Iris verna, Lespedeza capitata, Rhexia alifanus, Solidago odora, Symphyotrichum walteri, Xyris caroliniana, Dichanthelium strigosum, Pityopsis graminifolia, Stylosanthes biflora, Desmodium tenuifolium, Eupatorium leucolepis, Eupatorium pilosum*, and *Lobelia nuttallii*. Numerous additional herbaceous species are frequent in CVS plot data. These include many species in the Fabaceae: *Crotalaria purshii, Galactia* spp., several *Tephrosia (virginiana, hispidula, spicata*), several *Lespedeza* (*angustifolia virginica, procumbens, repens*), several *Desmodium* (*lineatum, ciliare, paniculatum*), *Orbexilum psoralioides, Baptisia cinerea,* and *Chamaecrista* spp. Many Poaceae, Asteraceae, and many other species are also frequent. Grasses include *Schizachyrium scoparium, Sorghastrum nutans, Gymnopogon brevifolius,* and several *Dichanthelium* (*ensifolium, tenue, ovale*). Composites include *Ionactis linariifolia, Sericocarpus tortifolius, Trilisa paniculata, Erigeron vernus, Chrysopsis mariana, Vernonia acaulis, Balduina uniflora, Bigelowia nudata, Carphephorus tomentosus, Eupatorium semiserratum, Solidago virgata*, and *Euthamia caroliniana*. Other frequent herbs include *Aletris farinosa,* several *Scleria* (*minor, ciliata, pauciflora*), *Sisyrinchium capillare, Rhynchospora plumosa* and other *Rhynchospora* species, *Cleistesiopsis divaricata, Scutellaria integrifolia, Hypoxis* sp., *Rhexia petiolata, Viola edulis/septemloba*, *Drosera capillaris, Juncus dichotomus,* and *Anchistea virginica*. Additional species that are less frequent in plots but distinguish this subtype from others or appear characteristic in site descriptions include *Anthenantia villosa, Ctenium aromaticum, Andropogon glomeratus, Dichanthelium aciculare, Dichanthelium webberianum, Chaptalia tomentosa, Eupatorium mohrii, Helianthus angustifolius, Hieracium gronovii, Ludwigia virgata, Helianthus atrorubens,* several species of *Ludwigia* (*linifolia, obtusifolia, aphylla, fasciculata*), and several more species of *Lespedeza* and *Desmodium*.

The shrub layer is presumably naturally low in cover where frequently burned but becomes dense with inadequate fire. Distinct to this subtype is high constancy and sometimes high cover of *Quercus elliottii*. Patches may be dominated by *Clethra alnifolia, Vaccinium tenellum, Gaylussacia frondosa*, and *Rhododendron atlanticum*, at least under current conditions. Other highly constant shrubs in plots include *Ilex glabra, Aronia arbutifolia, Morella pumila, Lyonia mariana, Gaylussacia dumosa*, and *Rhus copallinum*. Additional frequent species in plots include *Hypericum crux-andreae, Symplocos tinctoria, Amelanchier obovalis, Vaccinium formosum, Vaccinium fuscatum, Vaccinium virgatum, Vaccinium stamineum, Eubotrys racemosus*, and *Morella caroliniana*. *Smilax rotundifolia* and *Muscadinia rotundifolia* are also frequent.

Range and Abundance: Ranked G1. Fewer than 10 occurrences are known, perhaps none in good condition. A single example is apparently known in adjacent South Carolina. This subtype was likely once extensive in the southern inner Coastal Plain and perhaps in adjacent South Carolina, but this region has been heavily converted to agriculture.

Associations and Patterns: The Lumbee Subtype may be regarded as a small patch community, as only small remnants are left. It may have once been a matrix community within its primary range. Virtually all examples are surrounded by heavily altered landscapes, obscuring natural associations.

Variation: Examples are heavily altered by fire suppression and cutting, so that natural variation is not possible to determine.

Dynamics: Dynamics of the Lumbee Subtype are believed to be similar to the other subtypes. Most of the general dynamics discussed in the Dry Longleaf Pine Forests theme description apply to this community. Frequent fire is even more crucial in Mesic Pine Savannas than in sandhills, because of the high productivity and the rapid invasion by woody vegetation without it.

It is unclear what distinctive aspect of the environment allows plants to coexist that are normally more segregated by moisture. While great variation in microsites is not immediately obvious, it may be involved. It is possible that temporal variation in wetness allows different species to coexist. Cypress Savannas, which are concentrated in the same region as the Lumbee Subtype, show substantial variation in water level in multi-year cycles, leading to drastic variation in vegetation driven by a long-term seed bank. Because the Mesic Pine Savanna flora is long-lived and conservative, individuals may remain visible even in parts of the cycle that are not optimal for them.

Comments: Few plots are available for this subtype and almost all are more substantially altered by lack of fire and by logging than are typically accepted for analysis. This subtype and its equivalent association were recognized by Palmquist, et al. (in prep. c) and analysis showed it as a distinctive group of plots.

Rare species:
Vascular plants – *Eurybia spectabilis, Helianthus floridanus, Liatris squarrulosa,* and *Quercus elliottii*.

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Dryobates borealis, Peucaea aestivalis,* and *Sistrurus miliarius miliarius.*

COASTAL PLAIN FLOODPLAINS THEME

Concept: Coastal Plain Floodplain communities occur on alluvial soils in areas that are presently or were recently influenced by overbank flooding by rivers or streams. Characteristic vegetation distinguishes these communities even where flooding is rare or has been eliminated by dams, stream incision, or other alterations.

Distinguishing Features: Coastal Plain Floodplain communities are distinguished by occurring in floodplains, on alluvial soils, and by having vegetation characteristic of one of the included communities. Where vegetation of Coastal Plain Nonalluvial Wetland Forests and Freshwater Tidal Wetlands looks similar, they may be distinguished by evidence of river flooding, proximity to a river, or absence of tidal flooding.

Within this theme, communities are distinguished by water type (brownwater, blackwater, or intermediate), and by the landforms on which they occur, with vegetation, presumably fauna, and ecosystem processes varying accordingly.

Brownwater rivers are those that enter the Coastal Plain from the Piedmont and have turbid water with a high suspended load of clay and silt. They tend to have well-developed natural levees. Floodplain soils range from sandy loams to clayey; they are generally very fertile. Blackwater rivers and streams contain water primarily originating in the Coastal Plain. They have low suspended loads of silt and clay; the water is stained by tannins and may be dark but is not turbid. Floodplain soils tend to be sandy or organic and are low in fertility. Intermediate situations exist along streams that originate in clayey areas of the Coastal Plain or where calcareous rocks mitigate the acidity of blackwater streams. Most community types or subtypes have distinctly different vegetation associated with brownwater and blackwater, and sometimes distinct intermediate communities can be recognized.

Large floodplains have distinctive alluvial landforms that have different elevations relative to flood levels as well as soil differences, and these drive community patterns. Near the channel on brownwater rivers, Coastal Plain Levee Forests occur on the ridges formed by heavy deposition of coarser sediment. Away from the river, ridges and alluvial flats support Blackwater Bottomland Hardwoods. In both cases, several subtypes are differentiated by the height of these landforms. The lowest, wettest parts of the floodplain support Cypress—Gum Swamps. Blackwater river floodplains have similar ridges with Blackwater Bottomland Hardwoods and low areas with Cypress—Gum Swamps, but the poorly developed natural levees do not support a distinct community, though a distinctive Blackwater Levee/Bar Forest community may occur on forested point bar deposits. In smaller floodplains, the alluvial landforms are too small to differentiate separate communities, and a single Coastal Plain Small Stream Swamp, Sandhill Streamhead Swamp, or Cypress–Gum Swamp community occupies the entire floodplain.

Non-forested communities occur in areas with permanent water and on recently deposited surfaces. Sand and Mud Bar communities are distinguished by occurring on recently deposited sediments along the riverbank, lacking a full forest canopy because of frequent flood scouring or lack of time for primary succession to establish a forest. Coastal Plain Semipermanent Impoundments are communities influenced by impounded waters of beaver ponds; old mill ponds that resemble beaver ponds are also included. They range from open water to forests that resemble Cypress–Gum Swamp except in the permanent water and altered lower strata. Oxbow Lakes are permanently flooded communities in abandoned channel segments that are not connected to the river at normal low water. They may have little vegetation or may have open water surrounded by marshy or forested edge zones.

Sites: All Coastal Plain Floodplain communities occur in floodplains, where overbank flooding by a river or stream has shaped the community. Coastal Plain Floodplains usually have well-developed depositional landforms created by flooding, alluvial deposition, and channel migration. Meandering rivers erode portions of their banks and deposit material in point bars. Bars are habitat for distinctive early successional natural communities.

The landforms along brownwater rivers, those that originate in the Piedmont and carry large amounts of sediment, have been well described (Wharton, et al. 1982, Hupp, et al. 2009a, 2009b). Along the channel is a natural levee, where larger volumes of sediment of coarse texture have been deposited as the rapidly flowing river repeatedly overflowed its banks. The natural levee is generally higher than much of the floodplain behind it. Backswamp basins (backswamps) are fairly wide lower areas behind the natural levee. Sloughs are narrow lower areas, either abandoned segments of river channel or overflow channels that carry water in floods. Flood waters are often pooled in these areas, depositing finer sediment. These low areas may be separated by alluvial flats or by arcuate ridges that likely were originally deposited as natural levees along a channel. Some areas have large ridge-and-swale systems of alternating curved ridges and sloughs, created by past channel migration. Many rivers have terraces – floodplain areas created longer ago and left higher as the river entrenched further. The highest terraces may be uplands that would no longer naturally flood, but many terraces can still be flooded. The terraces have ridges and sloughs that are often larger than those in the lower, more recently deposited floodplain areas. These were created in higher flood flows during the Pleistocene. The relative proportions of the landforms varies along the length of rivers (Hupp 2009a, 2009b, White 2014). On the well-studied Roanoke River, where the river enters the Coastal Plain, the natural levees are high and wide, the backswamps narrow. In the middle reaches, levees are of medium height and overall floodplain relief is greatest. Near the river mouth, levees are low and large backswamp basins fill most of the floodplain. Tidal influence from the sound extends up the rivers from its mouth, placing that portion in the Freshwater Tidal Wetlands rather than Coastal Plain Floodplains theme. See the dynamics section for discussion of how these depositional patterns have been altered in recent times. Though less well studied, similar patterns of landforms occur on other brownwater rivers.

Blackwater rivers, which carry only local, usually sandy, Coastal Plain sediment, show most of these same depositional features, but the natural levees are not as large or well-developed and backswamps are often not recognizable. Much of the floodplain and terraces are occupied by ridge and swale topography. With little material of finer texture, the low areas often accumulate organic deposits.

On lower reaches of most rivers, the rise in sea level at the end of the Pleistocene has led to filling and burying of the older floodplain either by mineral sediment or organic matter, reducing relief. This is most extensive along the tidally influenced parts of rivers, covered under the Freshwater Tidal Wetlands theme, but occurs within this theme as well.

Smaller streams may have similar depositional landforms on a smaller scale, but some have uniformly flat floodplains. Beavers may impound sloughs or smaller streams to create ponds and areas with raised water tables.

Soils: Soils include a variety of alluvial types, often Inceptisols and Entisols, sometimes Ultisols on the older terraces. Histosols often occur in wetter swamp areas, especially on blackwater rivers and streams. They may be local, in sloughs, or may fill an entire floodplain. Soil textures vary widely, with much more extreme fine-scale variation than in most other communities. Sandy soils prevail on natural levees and may predominate on all higher landforms in blackwater floodplains. Brownwater floodplains may have extensive silty or loamy soils. Soils may be clay-rich in brownwater backswamps, while comparable sites on blackwater rivers have organic soils.

Hydrology: Coastal Plain floodplains generally flood more frequently and for longer duration than Piedmont and Mountain floodplains, but flooding regimes vary substantially on both fine and coarse scales. Limited areas such as beaver ponds and oxbow lakes are flooded all year, but more extensive low areas may be flooded well into the growing season. On brownwater rivers, natural levees prevent rapid equilibration of water levels in the floodplain with those of the river. White (2014) reported that on the Roanoke River, water in many parts of the floodplain was still rising and spreading out after 16 days of steady high flow in the river, and that some areas continued to rise for a month. Flooded areas are also slow to drain after the river falls. In contrast, higher terraces and the highest natural levees may be flooded only briefly, in the deepest floods. Floodwaters initially are flowing, but they may become stagnant in wetter backswamps and some sloughs, resulting in anoxic conditions and deposition of the clayey sediments or organic matter. Blackwater rivers have not had similar study. With smaller natural levees, equilibration of water levels with the river channel presumably is faster, but floodplains still have complex high water flow patterns that create lag times. It is a common experience even at moderate water levels to see substantial amounts of water flowing out of the river into sloughs.

Rivers that have large dams upstream have altered flood regimes. In particular, dams eliminate the more extreme floods, producing floods of lower elevation but longer duration. They also tend to eliminate the periods of very low flow. Dams also alter processes such as sediment transport and bank erosion, which have important effects on associated communities (Hupp, et al. 2009). See the discussion of altered flood regimes and their ecological effects in the section on dynamics.

When not flooded, soil drainage varies drastically. The sandy soils, especially on natural levees adjacent to steep banks, may be well drained. Clayey or organic soils in sloughs and backswamps may remain saturated well after surface water recedes.

River and stream channels may vary in form. Most Coastal Plain rivers are meandering single channels, but some have braided or anastomosing channel networks. A few small to medium size streams have no visible channel and carry floodwaters throughout a broad featureless floodplain. Pleistocene terraces occasionally show a different pattern from the present, with evidence of braided channels where rivers are now meandering (Leigh et al. 2004). The factors that cause these different patterns are not clear. Rivers or streams with different patterns sometimes occur just a few miles apart. `

Vegetation: Coastal Plain Floodplain vegetation varies extremely widely. Most communities are forested, and canopy composition varies in broad categories. Cypress–Gum Swamps, in the wettest forested sites, are dominated by *Taxodium* and *Nyssa* and tend to be low in species richness. Bottomland Hardwoods in less wet sites are dominated by *Quercus*, in combination with *Liquidambar*, *Carya*, or *Pinus*, and are moderate in species richness. Brownwater Levee Forests, on the natural levee deposits along the river, subject to greater deposition of nutrient-rich sediments, water-based transport of seeds, higher light levels adjacent to the channel edge, and more frequent gap formation, have a more diverse suite of characteristic trees, including *Platanus occidentalis*, *Betula nigra*, *Fraxinus pennsylvanica, Celtis laevigata, Ulmus americana, Juglans nigra, Acer negundo*, and others, along with species of oaks, hickories, and *Liquidambar*. In addition to understory trees, shrubs, and herbs, woody vines are more prominent and diverse in Coastal Plain floodplains than in any other communities. Communities of blackwater rivers are less diverse than those of brownwater rivers; their species composition is generally a subset of the same species but they may share some more acid-tolerant species with nonriverine wetlands.

Dynamics: Coastal Plain floodplains have complex dynamics because of the interplay of multiple processes, some of them common to most forests, some unique to floodplains.

Natural vegetation dynamics of most of the forest communities are similar to those of most upland hardwood forests, with long-lived trees dominating, tree populations being multi-aged, and tree replacement occurring primarily in small gaps. Robertson, et al. (1978) noted similar evidence of gap-phase replacement in similar Coastal Plain floodplain forests in southern Illinois, with at least the less shade-tolerant tree species occurring in small groves of similar size in an old-growth stand.

Despite the prevalence of flooding, most trees under natural conditions are killed by wind, lightning, or disease rather than wetness or scouring. Hurricanes may cause widespread canopy disruption, creating some medium or larger gaps as well as more numerous small gaps. Effects of more severe hurricanes in North Carolina would be similar to those of Hurricane Hugo on the Congaree River floodplain in South Carolina (Zhao et al. 2006). The storm created some large canopy gaps and numerous smaller gaps. Effects varied, favoring shade-intolerant trees in some areas but increasing shade-tolerant trees elsewhere. It had similar variable effects on species diversity.

The natural levees and channel banks are particularly susceptible to wind throw because of the sandy soils and exposure on the open edge. Tree species of these communities also tend to be shorter lived but are particularly fast-growing. Cypress–Gum Swamps may be particularly stable. *Taxodium* is one of the longest-lived tree species in the world. Both *Taxodium* and *Nyssa* are better adapted to withstanding wind than are most trees, and extensive wind throw is limited even in major hurricanes. *Quercus*-dominated bottomland hardwoods are intermediate; hurricanes have been observed to have caused substantial canopy tree mortality in patches, but the trees are otherwise capable of living several centuries.

Woody vines are a particularly prominent part of floodplain communities, representing more species and perhaps more biomass than in any other North Carolina communities. The author has observed proliferation of vines in floodplains following severe disturbance by both storms and logging. The vine cover appears to be heavy enough to inhibit tree regeneration, but the long-term development of such areas is not known. Older treeless vine-dominated areas are not generally seen, so it appears that trees have been able to regain dominance. Studies in South Carolina have suggested that vines may have increased in density in brownwater floodplains in both old-growth and second-growth forests in recent decades, a pattern also observed in some tropical forests (Allen et al. 2005, 2007). However, the extreme variability among sites, small number of plots, hurricane disturbance, and changes in density of understory trees make interpretation uncertain. Increases in atmospheric carbon dioxide levels could potentially allow vines to grow faster relative to trees, as observed by Mohan, et al. (2006) for *Toxicodendron radicans*, but climatic cycles or variation in natural disturbances such as storms could also cause reversible changes.

Most Coastal Plain floodplains show evidence of channel migration; indeed, scars of past migration structure the land surface over large portions of them. Most rivers show some recently deposited point bars inside meanders. However, migration is usually very slow or very infrequent. Rivers do not routinely change course in short time periods in North Carolina. Channels are substantially vegetation-bound (Riggs et al. 1999), limiting how readily they can shift. The author has observed only three cases of meanders being cut off and one case of a more substantial course change, over four decades of observations, despite the occurrence of record-breaking floods. One shift occurred slowly over many years, as a gradually increasing part of the river's flow followed a different course. Oxbow lakes are extremely scarce on brownwater floodplains; the frequency of their formation apparently is less than the time needed for alluvial deposition to fill them in. Oxbow lakes are more abundant on blackwater rivers, where much slower alluvial deposition allows them to last much longer, but they are still scarce. The presence of cut banks, fallen and leaning trees on banks, and unforested point bars indicates that meander migration remains active, but the small proportion of floodplains occupied by even older successional point bar vegetation demonstrates how slow the process is.

Most of the evidence of channel migration visible in the landforms of floodplains occurred in times of different climate. Less vegetation, more variable rainfall, and more extreme flows caused more rapid shifting in the past. Patterns on terraces provide evidence of these differences longer ago, showing wider channels, larger meander radii, and wider floodplains. Some terraces show that the Pleistocene river channel was braided, where a meandering channel now exists. Braided channels indicate greater sediment loading and reduced channel stability. Leigh et al. (2004) note that their existence in the recent geologic past is evidence that the current stability of rivers may be near a threshold and may be readily reversible with a small change in parameters.

Where channel migration is occurring, it creates new landforms that are colonized by natural communities that represent early primary succession, either on the bare sand of point bars or in the open water of oxbow lakes. While the results of channel migration create the environments that structure the community mosaic in most Coastal Plain floodplains, most of that mosaic does not appear to be primary successional communities. Dynamics suggested by Shankman and Drake (1990) and Shankman (1991) for western Tennessee, where cypress swamps established only as primary successional communities in abandoned channel segments, do not seem to be the norm in North Carolina.

Over most of the extent of floodplains, flooding is a natural process but not a significant natural disturbance. Sediment deposition may be extensive but generally is in relatively thin layers. Scouring may remove small amounts of sediment but only rarely uproots even small plants. Floods move leaf litter and woody debris, creating wrack piles that increase local heterogeneity. Large debris carried by the largest floods may batter plants but does not appear to be a major source of mortality. Floods bring nutrients, making floodplain soils more fertile than other soils. This is especially true for brownwater rivers, with their larger load of fine sediment and dissolved nutrients derived from a Piedmont watershed. This is also true, though to a less degree, for blackwater rivers. Their floodplain communities are less fertile and presumably less productive than brownwater communities but more so than nonriverine wetlands. Flooding does act as a natural disturbance on bars, which may be scoured, reworked, or shifted in location by individual floods. Undercutting of banks by normal flow and by flooding also acts as a local natural disturbance, toppling trees and adding woody debris to the river.

Movement of sediment by floods may at times cause natural changes in communities locally, probably usually slowly but occasionally quickly. If a slough is blocked by sediment deposition along the riverbank, it will become wetter, possibly even becoming an oxbow lake. Conversely, bank erosion may improve drainage locally. Migration of point bars may open blocked sloughs. Accretion of sediment may gradually raise land surfaces, resulting in drier conditions for newly established plants. Oxbow lakes and other abandoned channels become shallower over time, as alluvial deposition fills them in.

While flooding is not generally a significant natural disturbance, it is important in structuring communities and giving them their distinctive character. Throughout the Southeast, on both brownwater and blackwater rivers, communities are differentiated by small differences in elevation which generate different flood regimes, though these are also sometimes accompanied by differences in soil texture (Wharton, et al. 1982, Sharitz and Misch 1993). This is best studied on brownwater rivers, especially the Roanoke River (Rice, et al. 2001, Townsend 2001, White and Peet 2013, White 2014) but also the Tar River (Faestal 2012). Robertson, et al. (1978) remarked on how such variation could produce high beta diversity without the elevational range of mountainous terrain.

Because floodplain community patterns are closely related to details of flooding and fluvial landforms, alteration of flood regimes by dams or channelization is a major concern for them. Change may be slow and subtle but can be rapid in some situations. The Roanoke River has been studied extensively for these effects (Hupp 2000, Hupp, et al. 2009a, Hupp, et al. 2009b). All of the larger flood peaks were eliminated after the dams were built. While the flood discharges that still occur were common in the past, discharges that were two, three, even up to seven times as large once occurred but have not occurred since the dams. At the same time, since the same amount of water ultimately flowed down the river, the duration of the lower floods was increased. Because the dams tended to release water in specific amounts, almost all floods were at several levels. Townsend (2001), Peet and White (2013), and White (2014) elaborated on the details of this modification. Flooding became less variable at both the wet and dry extreme, while zones with intermediate levels were narrowed but experienced more variable flooding. Because of the long time it takes floodwaters to equilibrate with river levels, constant discharges have greater effect than short floods of the same volume. Operation of the dams for hydropower generation, resulting in peaking flows, further altered the flood regime when water levels were high.

This modified flood regime is affecting the forest vegetation. Several of the Roanoke River studies (Rice, et al. 2001, Peet and White 2013, White 2014) defined and described the community patterns included in the NVC and the 4th Approximation. But they noted a disparity of species between the sapling layer and the canopy, suggesting that the dominant trees were not successfully regenerating. This included abundant *Fagus grandifolia* saplings in higher bottomland hardwoods communities that had none in the canopy. It included lack of saplings of most tree species in lower bottomland hardwoods and levees. Most striking was the lower alluvial flats, where tree regeneration was insufficient to sustain any species but *Acer rubrum* in the long term.

The dams have substantially eliminated sediment deposition on the natural levees, forcing it into the backswamps and other low areas (Hupp 2000, Hupp, et al. 2009a, Hupp, et al. 2009b). This can have the effect of raising the floodplain and homogenizing it, reducing the differentiation among communities in the long term. Water emerging from the dam is largely free of sediment. The river has incised deeply in the reach immediately below the dams. In the middle reach, there is substantial bank erosion, including slumping of undercut banks, resulting in turbid water. Most of this sediment is redeposited in the floodplain nearby, so that by the mouth of the river the amount of sediment accumulation is very small.

The Roanoke River is the largest brownwater river in North Carolina and the most altered by dams. The degree to which similar effects can be seen on other rivers is unclear. Dams exist on the Neuse and Cape Fear rivers, but they were built more recently, and they are not managed for hydropower production. They might offer a chance to observe some of the alteration processes in action, but at present very little is known. No large dams are present on the Tar River, and none of the state's blackwater rivers have large dams.

All brownwater rivers have also been altered by a legacy of excessive sediment deposition caused by widespread erosion as colonial agriculture cleared vast areas in the hilly Piedmont watersheds. Deposits four to six meters thick were documented on the upper Coastal Plain part of the Roanoke River by measuring burial of the root crowns of old trees (Hupp et al. 2009a). The river has entrenched into these sediments, creating the high banks that are prone to erosion, undercutting below the stabilizing root zone, and slumping. Hupp, et al. (2009a) noted that on the upper river, a large majority of their measurement sites were eroding and that there was virtually no point bar deposition. This eliminates most of the habitat for Sand and Mud Bar communities. The natural levees of brownwater rivers presumably are higher and broader than they would have been before this unnatural influx of sediment. Modern agricultural practices and abandonment of much marginal farmland has led to less erosion, but most of the sediment was stored in floodplains and continues to work its way downstream. Natural sediment transport rates and dynamics are further confounded by additional potential alterations: urbanization, sometimes channelization, the creation and abandonment of numerous mill ponds in the Piedmont, the presence of medium to large reservoirs, the extirpation and recent resurgence of beavers, navigational improvements, and in downstream reaches, effects of rising sea level.

The most poorly known natural dynamic process of floodplains is that of beavers. Beavers can dam small stream channels or may impound tributary streams or sloughs within large floodplains. A beaver dam on an outlet slough (gut) through a natural levee can impound a large area of backswamp. Beaver ponds can raise the local water table beyond the extent of standing water, in a complex pattern determined by microtopography.

Beavers have been returning to North Carolina for several decades, after a much longer absence since they were extirpated from the entire state during the colonial period. Little is known about their natural population dynamics, predation, disease, nor about past pond longevity and return intervals. An important question for small streams is whether all parts of a stream are suitable for pond building, so that beaver ponds appear randomly and eventually affect the whole area, or if certain favored sites are chronically ponded while others never are. In large river floodplains, only specific sites can be flooded by beaver dams; the natural levees, high ridges, and some backswamps and sloughs are not susceptible.

Fire does not appear to be important in most Coastal Plain Floodplains communities. Fire could spread from uplands onto the outer parts of river terraces and to small floodplains, but only from one direction and only by spreading down a slope that is often more mesic that typical uplands. Natural levees and most bottomland ridges are isolated from uplands and from each other by areas of wet swamp, so that natural ignition is unlikely. Robertson, et al. (1978) indicated a belief that shade-tolerant understory species, *Asimina* and *Aesculus*, were inhibiting regeneration of canopy trees, a pattern reminiscent of more recent concern about inhibition of oak regeneration in uplands in the absence of fire. Nevertheless, these species are generally densest on natural levees, where they co-occur with several shade-intolerant tree species in the areas most isolated from fire spread. Little appears to be known about the fire tolerance of bottomland oaks, in contrast to upland oaks. Bottomland oaks are likely the most fire-tolerant trees of floodplains, but most species of natural levees have thin bark and presumably are not so well protected.

One additional uncertainty about floodplain community dynamics concerns canebrakes. *Arundinaria tecta* is common in several floodplain communities on both brownwater and blackwater rivers, where it can attain moderate densities in the higher light levels near riverbanks. Canebrakes of *Arundinaria gigantea* were historically associated with large floodplains in states farther west and south, but they have not been definitively linked to this setting in eastern North Carolina. The state's historically documented large canebrakes were in peatlands or nonriverine wetlands. Dense canebrakes are highly flammable and can burn intensely and frequently enough to exclude trees. At present densities, cane in floodplains is not continuous enough to promote fire spread, but it additionally occurs in the areas least likely to be ignited.

Comments: Coastal Plain Rivers in the Southeastern United States have been widely studied. Many but not all of the findings are applicable to North Carolina rivers. Much specific study has occurred on the Roanoke River, perhaps the least characteristic of other rivers because of the alteration by dams. Blackwater rivers have received much less study, with most of the information coming from Natural Heritage Program surveys and CVS plot data. Smaller streams have received less study still, though there are some CVS data. Their vegetation is extremely variable, and further study is greatly needed for them.

KEY TO COASTAL PLAIN FLOODPLAINS

1. Community forested, dominated by trees with closed to somewhat open canopy

2. Forest very wet, dominated by combinations of *Nyssa* spp. and *Taxodium* spp., with *Acer rubrum, Populus heterophylla*, and possibly *Fraxinus* spp. generally the only other canopy species present.

3. Canopy containing *Nyssa aquatica*, which may be dominant, codominant, or present in substantial numbers.

4. *Nyssa aquatica* dominant, or codominant with *Taxodium distichum*; *Nyssa biflora* absent or scarce; occurring on brownwater rivers such as the Roanoke, Tar, Fishing Creek, Neuse, and Cape Fear. .... **Cypress—Gum Swamp (Brownwater Subtype)**

4. *Nyssa aquatica* and *Nyssa biflora* codominant, with or without *Taxodium distichum*; occurring on rivers or streams with clay input from clay-rich Coastal Plain watersheds or with calcareous influence.........................**Cypress—Gum Swamp (Intermediate Subtype)**

3. Canopy lacking *Nyssa aquatica* or nearly so; occurring on blackwater rivers or smaller blackwater creeks with little to no clay input and low calcium levels.

5. Forest in deep bays ("coves") in abandoned channel segments connected to the river channel; exposed only at very low water; canopy usually open; *Taxodium distichum* or *Taxodium ascendens* usually dominant; trees generally with large buttresses and small trunks; often with a tall shrub/understory layer of *Cephalanthus occidentalis* or *Planera aquatica* ....**Cypress—Gum Swamp (Blackwater Cove Subtype)**

5. Forest in more typical sloughs or backswamps, including abandoned channel segments; flooded for long periods but exposed at normal low water; canopy generally dense if not recently disturbed; trees with large trunks if old; *Cephalanthus* and *Planera* absent or minor. ....**Cypress-Gum Swamp (Blackwater Subtype)**

2. Canopy with tree genera other than *Taxodium* and *Nyssa* dominant or at least abundant, though *Taxodium* or *Nyssa* may codominate.

6. Forest on a natural levee or point bar along the current (or recent past) channel of a brownwater river such as the Roanoke, Tar, Fishing Creek, Neuse, and Cape Fear; forest a mix of trees that includes *Platanus occidentalis, Betula nigra, Fraxinus pennsylvanica, Celtis laevigata*, or *Acer negundo*, as well as more widespread species.

7. Forest on a young point bar deposit, only newly dominated by trees; canopy generally dominated by *Platanus occidentalis, Betula nigra, Salix nigra*, or *Salix caroliniana*, with few other species; canopy often somewhat open; species shared with Sand and Mud Bar communities, such as *Coleataenia rigidula*, often present …………………………………… .... **Brownwater Levee Forest (Bar Subtype)**

7. Forest on a natural levee.

8. Forest on a high natural levee in the inner Coastal Plain; canopy a diverse mix of species, including the above but also including *Celtis laevigata, Fraxinus pennsylvanica, Acer negundo*, and others; community containing species such as *Aesculus sylvatica, Lindera benzoin, Laportea canadensis, Nemophila aphylla (microcalyx)*, and *Corydalis flavula* that are shared with Piedmont levees......... **Brownwater Levee Forest (High Levee Subtype)**

8. Forest on a natural levee of medium or lower height above the river; canopy may be a diverse mix of species but somewhat less so; the above suite of shrubs and herbs shared with Piedmont levees generally not present.

9. Forest on a natural levee or point bar of medium height above the river, in the inner to middle Coastal Plain, sometimes on the back slope of a higher natural levee; canopy

generally a diverse mix of species but usually dominated by *Fraxinus pennsylvanica, Ulmus americana*, and *Liquidambar styraciflua*; *Taxodium* and *Nyssa* minor or absent... .... **Brownwater Levee Forest (Medium Levee Subtype)**

9. Forest on a low natural levee along downstream (but non-tidal) parts of the river or on the back slope of a higher natural levee; canopy limited to more water-tolerant species such as *Fraxinus pennsylvanica, Quercus laurifolia, Quercus lyrata,* Carya *aquatica,* and *Taxodium distichum*. .... **Brownwater Levee Forest (Low Levee Subtype)**

6. Forest not on a natural levee on a brownwater river; located away from the river or located along the channel of a blackwater river or a smaller stream.

10. Forest in a small floodplain, with depositional landforms (ridges and sloughs) absent or too small to differentiate different communities (generally little more than 10 meters wide); canopy a mix of species of different moisture tolerance, often including *Liriodendron, Liquidambar, Quercus, Nyssa,* or *Taxodium* in varying combinations.

11. Forest dominated by a mix of species that are tolerant of extremely acidic, saturated conditions, including *Nyssa biflora, Acer rubrum, Pinus serotina, Pinus taeda*, and *Chamaecyparis thyoides*, along with *Liriodendron*, but almost never including *Quercus* or *Liquidambar*; forest generally with a dense shrub layer with species such as *Lyonia lucida, Cyrilla racemiflora,* and *Ilex coriacea* that are shared with Streamhead Pocosins; community in the Sandhills Region or rarely in similar terrain elsewhere in the Coastal Plain. .... **Sandhill Streamhead Swamp**

11. Forest dominated by a mix of species less confined to extremely acidic, saturated conditions, potentially including *Liriodendron, Liquidambar*, *Acer rubrum,* several species of oaks, *Pinus taeda, Nyssa biflora*, *Taxodium*, and occasionally species of mesic uplands but generally no *Pinus serotina* or *Chamaecyparis thyoides*; shrub layer open or dense but including species in addition to the above, such as *Eubotrys racemosus, Lindera benzoin, Morella cerifera*, or *Swida* (*Cornus*) *stricta*. .... **Coastal Plain Small Stream Swamp**

10. Forest in a large floodplain of a blackwater or brownwater river, limited to a particular set of large depositional landforms such as ridges, flats, or terraces of a particular elevation and occurring in a mosaic with other floodplain communities; canopy generally dominated by a set of species with a narrower range of moisture tolerances, generally with predominant or abundant *Quercus* spp.

11. Forest on a brownwater river floodplain; *Quercus pagoda, Fraxinus pennsylvanica,* or *Nyssa aquatica* may be present depending on moisture levels; associated wetter community is Cypress—Gum Swamp (Brownwater Subtype).

12. Forest dominated by combinations of *Quercus michauxii, Quercus pagoda, Quercus laurifolia, Liquidambar styraciflua*, and *Pinus taeda*; occurring on the highest ridges and terraces (short of upland communities) …………………………………………………... .... **Brownwater Bottomland Hardwoods (High Subtype)**

12. Forest dominated by *Quercus laurifolia, Quercus lyrata, Liquidambar styraciflua*, and other species more tolerant of prolonged flooding, but lacking *Quercus michauxii, Quercus pagoda*, and *Pinus taeda*.

13. Forest dominated by *Quercus laurifolia, Quercus lyrata,* and *Liquidambar styraciflua* but without *Nyssa* or *Taxodium* …………………………………………….. .... **Brownwater Bottomland Hardwoods (Low Subtype)**

13. Forest dominated by a mix of species that includes significant *Nyssa* or *Taxodium* as well as oaks, sometimes also *Fraxinus pennsylvanica* or *Fraxinus profunda*; herb

layer often sparse and consisting of the most water-tolerant species similar to those in Cypress—Gum Swamp; occurring at elevations only slightly higher than Cypress—Gum Swamp .. **Brownwater Bottomland Hardwoods (Swamp Transition Subtype)**

11. Forest on a blackwater river floodplain; *Quercus pagoda, Fraxinus pennsylvanica,* and *Nyssa aquatica* generally completely absent; *Quercus michauxii* may be present but is less likely to be.

14. Forest on a young point bar deposit, only newly dominated by trees; canopy generally dominated by *Betula nigra, Planera aquatica, Salix nigra*, or *Salix caroliniana*, with few other species; canopy often somewhat open; species shared with Sand and Mud Bar communities, such as *Coleataenia rigidula,* often present ………………………………..
.... **Blackwater Levee/Bar Forest**

14. Forest not on a young point bar deposit; on floodplain ridges, flats, or shallow sloughs, sometimes on the edge of the channel.

15. Forest containing *Quercus virginiana* or *Chamaecyparis thyoides* as well as *Quercus laurifolia* and *Pinus taeda*; occurring on high ridges and terraces; rare community known only along the Waccamaw River …………………………………
.... **Blackwater Bottomland Hardwoods (Evergreen Subtype)**

15. Forest not containing *Quercus virginiana* and only rarely containing *Chamaecyparis thyoides*; on the Waccamaw River or not.

16. Forest occurring in higher floodplain locations; dominated by combinations of *Quercus laurifolia* with *Pinus taeda, Liquidambar styraciflua*, *Quercus* nigra, and occasionally *Quercus michauxii; Quercus lyrata* and *Carya aquatica* generally absent .... **Blackwater Bottomland Hardwoods (High Subtype)**

16. Forest dominated by *Quercus laurifolia* in mixtures with *Quercus lyrata* and sometimes *Carya aquatica* or *Liquidambar styraciflua,* or more water-tolerant species; *Pinus taeda* and *Quercus michauxii* absent.

17. *Nyssa biflora*, *Taxodium distichum*, or *Taxodium ascendens* codominant or a significant minority in the canopy; herb layer often sparse and consisting of the most water-tolerant species similar to those in Cypress—Gum Swamp; occurring at elevations only slightly higher than Cypress—Gum Swamp ....
.... **Blackwater Bottomland Hardwoods (Swamp Transition Subtype)**

17. *Nyssa biflora*, *Taxodium distichum*, and *Taxodium ascendens* all absent or rare in the canopy; herb layer dominated by less water-tolerant species; occurring at slightly higher elevations. .. **Blackwater Bottomland Hardwoods (Low Subtype)**

1. Community not forested; vegetation may have sparse trees or have trees on the edge but is dominated by shrubs, herbs, or open water.

18. Community affected by impounded water, in a beaver pond or an old artificial pond that resembles a beaver pond, or formerly impounded and vegetation not yet recovered to that of an unimpounded community.

19. Community dominated by open water or by floating or submersed aquatic vegetation; other vegetation, including emergent herbs, herbs on stumps and snags, shrubs, and trees present only in limited amounts ………………………………………………………………………
…………………….. **Coastal Plain Semipermanent Impoundment (Open Water Subtype)**

19. Community not dominated by open water; dense to open herbaceous or woody vegetation dominant.

20. Community dominated by live *Taxodium distichum*, *Nyssa biflora,* or *Nyssa aquatica*.... .... **Coastal Plain Semipermanent Impoundment (Cypress—Gum Subtype)**

20. Community not dominated by *Taxodium* or *Nyssa*, though sparse individuals may be present; herb layer generally dense.

21. Community in the Coastal Plain outside of the Sandhills; pocosin shrubs generally absent though rarely a few may occur; substrate may be sand, clay, or muck; species of richer soils, such as *Persicaria* spp., *Typha latifolia*, *Leersia hexandra*, *Saururus cernuus*, *Cladium jamaicense*, *Sacciolepis striata, Scleria muhlenbergii*, and *Rhynchospora macrostachya*, usually present ………………………………………………………… .... **Coastal Plain Semipermanent Impoundment (Typic Marsh Subtype)**

21. Community in the Sandhills Region; occurring on small floodplains with substantial seepage and mucky substrates; woody species shared with pocosins are often present; species of richer soils such as those listed above generally absent; species of more acidic, nutrient-poor conditions, such as *Schoenoplectus subterminalis*, *Eriocaulon decangulare*, *Carex glaucescens*, *Carex striata*, most *Eleocharis* spp., *Schoenoplectus etuberculatus*, *Orontium aquaticum*, and *Sphagnum* spp., present.

22. Community with extensive *Sphagnum*, generally a moderate shrub layer, and a flora of species tolerant of strongly acidic, bog-like conditions. .... **Coastal Plain Semipermanent Impoundment (Sandhills Mire Subtype)**

22. Community with little or no *Sphagnum*; vegetation a dense herbaceous stand of various species ……………………………………………………………………… .... **Coastal Plain Semipermanent Impoundment (Sandhills Marsh Subtype)**

18. Community not impounded nor reflecting past impoundment.

23. Community with permanent standing or flowing but not impounded water; in abandoned channel segments or in the river or stream channel itself.

24. Community a mat of plants floating on the water surface in the active river channel or in backwater "coves."

25. Vegetation consisting of free-floating plants, naturally usually dominated by *Hydrocotyle ranunculoides* or *Sacciolepis striata* but now often by *Alternanthera philoxeroides* .... **Riverine Floating Mat**

25. Vegetation consisting of dense stands of *Nuphar sagittifolia*; extremely rare community of the Waccamaw River (consider also Tidal Freshwater Marsh (Narrowleaf Pond-lily Subtype). .... **Sand and Mud Bar (Narrowleaf Pond-lily Subtype)**

24. Community in an oxbow lake, with permanent standing water in an abandoned channel segment not connected to the river channel at normal low water levels; center filled with standing water with floating or emergent plants; wetland trees, shrubs, and herbs present on the edges but sparse or absent in the middle.

26. Oxbow lake on a brownwater river.................... **Oxbow Lake (Brownwater Subtype)**

26. Oxbow lake on a blackwater river. .... **Oxbow Lake (Blackwater Subtype)**

23. Community without permanent standing water; flooded for brief or long periods but exposed at least every few years at low water and vegetated with sparse or dense rooted non-floating plants; occurring along the river channel on point bars or other patches of recently deposited, reworked, or scoured alluvium.

27. Bar on a brownwater river. .... **Sand and Mud Bar (Brownwater Subtype)**

27. Bar on a blackwater river.

28. Community on regularly exposed bars, generally of coarse sand; vegetation generally containing large herbs, often including *Coleataenia rigidula*; trees or shrubs often present as seedlings, saplings, or sparse larger individuals.. **Sand and Mud Bar (Blackwater Sand Bar Subtype)**

28. Community on bars exposed only at very low water, generally of fine sand or silt; vegetation of small herbs capable of growing under water or of annual species that emerge at drawdown, such as *Juncus repens* or *Eleocharis baldwinii*, sometimes with rare diminutive species such as *Fimbristylis perpusilla*; rare community known only on the Waccamaw River............... **Sand and Mud Bar (Blackwater Drawdown Bar Subtype)**

BROWNWATER LEVEE FOREST (HIGH LEVEE SUBTYPE)

Concept: Brownwater Levee Forests are forest communities of natural levee deposits along brownwater Coastal Plain rivers, with a significant component of the suite of levee tree species: *Fraxinus pennsylvanica, Celtis laevigata, Platanus occidentalis, Betula nigra, Acer negundo*, and *Ulmus americana*. The High Levee Subtype covers the communities of the highest levees, in the inner to middle Coastal Plain stretches of rivers, where species of rich soils and those of marginal wetlands are a significant component. *Aesculus sylvatica, Lindera benzoin, Laportea canadensis, Nemophila aphylla (microcalyx)*, and *Corydalis flavula* are examples of such species.

Distinguishing Features: Brownwater Levee Forests usually are easily distinguished by their location adjacent to Coastal Plain Brownwater Rivers. The wide levees on the Roanoke River may extend up to a mile from the river, but those on all other rivers are proportionally smaller. Brownwater Levee Forests are distinguished from Brownwater Bottomland Hardwoods by having a significant component of the suite of levee species that includes *Fraxinus pennsylvanica, Celtis laevigata, Platanus occidentalis, Betula nigra, Acer negundo*, and *Ulmus americana* in natural condition. Heavily disturbed Brownwater Bottomland Hardwoods may be invaded by some of these species, particularly *Platanus* and *Betula*. *Liquidambar styraciflua* and various bottomland oaks may occur in Levee Forests but in smaller proportions than in Bottomland Hardwoods. Brownwater Levee Forests, especially this subtype, are similar to Piedmont Levee Forests, sharing much flora but showing differences in dominance and some regional differences. They can be distinguished readily by location. The abiotic dynamics of flooding and sediment deposition are significantly different, but examples in the Fall Zone may be somewhat intermediate.

The High Levee Subtype is distinguished from the Medium Levee Subtype by the presence of characteristic drier site species, many of them shared with Piedmont Levee Forest. These include *Aesculus sylvatica, Lindera benzoin, Laportea canadensis, Nemophila aphylla (microcalyx)*, and *Corydalis flavula*. There is a progression from the High Levee to Medium Levee to Low Levee Subtype as you move downstream, but large upstream levees also can have zoned vegetation. High levees sometimes drop off rapidly to sloughs or backswamps, but in other places have a broad zone of Medium Levee or even Low Levee on the side away from the river.

Crosswalks: *Celtis laevigata - Fraxinus pennsylvanica - (Juglans nigra) / Asimina triloba / Carex grayi* Floodplain Forest (CEGL004740).
G759 Southern Ash - Elm - Willow Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Brownwater Levee Forests occur on natural levee and point bar deposits along channels of rivers draining from the Piedmont. They may occasionally occur on recently abandoned channel segments farther from the active river. The High Subtype is limited to the inner and occasionally middle Coastal Plain.

Soils: Soils are coarse-textured alluvial soils, with little horizon development because of relatively recent deposition. Most levees are mapped as Chewacla (Fluvaquentic Dystrudept) or Congaree (Oxaquic Udifluvent).

Hydrology: The High Levee Subtype is intermittently or seasonally flooded, generally only for short periods. Soils are well drained when not flooded. The high microrelief of these levees leads to substantial variation in hydroperiod, though only small areas are very wet. Brownwater rivers, in contrast to blackwater, tend to have periods of sustained high flow, usually in winter and spring, where not controlled by dams. However, floods seldom remain deep enough to submerge higher levees for long periods.

Vegetation: Brownwater Levee Forests are naturally closed forests punctuated by canopy gaps. In the High Levee Subtype, the canopy is a varying mix, with *Celtis laevigata, Fraxinus pennsylvanica, Acer negundo, Platanus occidentalis*, and *Liquidambar styraciflua* most abundant. Other frequent or occasionally abundant canopy species include *Quercus pagoda, Carya cordiformis, Ulmus americana, Quercus laurifolia, Quercus michauxii*, *Pinus taeda, Juglans nigra*, and *Carya ovata*. The understory generally is dominated by *Acer negundo, Asimina triloba*, or *Carpinus caroliniana*, along with canopy species. *Ilex opaca, Crataegus viridis, Ulmus alata*, *Acer floridanum*, or *Morus rubra* may also be present. The shrub layer is usually well developed and may be dense. Frequent abundant species are *Lindera benzoin, Aesculus sylvatica, Ilex decidua*, and *Arundinaria tecta*. Woody vines are abundant and diverse, with *Muscadinia rotundifolia, Vitis aestivalis, Toxicodendron radicans, Parthenocissus quinquefolia, Smilax rotundifolia*, and *Smilax bona-nox* often abundant. *Berchemia scandens, Bignonia capreolata*, *Campsis radicans, Hydrangea* (*Decumaria*) *barbara*, and *Smilax hispida* may also be abundant. The herb layer is usually dense and often diverse. Widespread levee species such as *Boehmeria cylindrica, Leersia oryzoides, Elymus hystrix, Elymus canadensis, Elymus riparius, Chasmanthium latifolium*, *Carex grayi*, *Nemophila aphylla*, and *Viola* spp. are often abundant. Also present are species shared with rich mesic sites of the Mountains and Piedmont, such as *Laportea canadensis, Persicaria virginiana, Asarum canadense, Circaea canadensis,* and *Amphicarpaea bracteata*. Other species found in plot studies (Rice and Peet 1997, Rice et al. 2001, Faestal 2012) at moderate-to-high frequency include *Carex crebriflora*, *Carex abscondita, Carex amphibola, Commelina virginica, Leersia canadensis, Poa cuspidata, Gonolobus suberosus* var. *suberosus*, *Carex louisianica, Sanicula canadensis* var. *canadensis, Arisaema triphyllum, Arisaema dracontium, Dicliptera brachiata*, and in wet microsites, *Saururus cernuus*. Invasive exotic species are often abundant in the herb and shrub layers, particularly *Ligustrum sinense, Lonicera japonica, Microstegium vimineum,* and *Stellaria media*. The epiphyte *Tillandsia usneoides* may have high cover, and *Pleopeltis michauxiana* may cover trunks and branches of some trees.

Range and Abundance: Ranked G3G5. The uncertainty in the G-rank may be at least partly because of confusion in the NVC between several associations of Coastal Plain and Piedmont natural levees.

Associations and Patterns: Brownwater Levee Forest occurs as linear bands along most of the river frontage on brownwater rivers. The High Subtype predominates along upper Coastal Plain reaches. It grades to other floodplain communities behind. Well-developed examples of the

Medium Levee Subtype may occur if the back slope of the levee is broad, but in other places levees slope rapidly into Cypress–Gum Swamp. Occasional segments of Brownwater Levee Forest may adjoin upland communities along bluffs or may occur along sloughs away from the river channel. Sand and Mud Bar communities may occur below the levee, on the edge of the river channel.

The High Levee Subtype grades downstream to the Medium Levee Subtype as natural levee deposits become lower. It grades upstream to Piedmont Levee Forest.

Variation: No variants are recognized. Examples may vary substantially in composition of the canopy, with any of a substantial pool of species dominating. There are some differences observable among rivers of different sizes and among individual rivers. The Cape Fear River is distinctive, at least in its middle reach, in the height of the floodplain above the river. Nevertheless, communities recognizable as Brownwater Levee Forest occur 30 feet or more above the river, though only in a narrow band.

Dynamics: Flooding is of brief duration but may be energetic enough to locally scour the soil surface, cause substantial movement of organic debris, or batter trees with floating debris. Alluvial deposition is naturally heaviest in this community; though still generally just a thin layer of sediment in any given flood, it brings in substantial nutrient subsidies.

Canopy gap dynamics typical of most floodplain forests apply, but levee forests may be somewhat more dynamic. They are subject to more frequent wind disturbance because of their exposure to the open river channel and their low-density soils. They are more exposed to water disturbance as well, including development of new areas on aging point bars, erosion on cut banks, and local scouring by floods. Given the slow migration of channels under present conditions, most examples are long-established, but some patches represent late stages of primary succession.

Hupp, et al. (2009a, 2009b) noted that, on the Roanoke River, deposition has largely ceased on the high levees because dams have eliminated the higher floods. Instead, sediment deposition is occurring on lower parts of the floodplain and is now heaviest downstream in the middle part of the river's Coastal Plain course.

Comments: The NVC classification of associations has been confusing, as associations were defined in local studies of different major rivers but not harmonized with those from other studies or addressed to the intervening areas. The large species pool and variation in canopy dominants potentially allows a large range of associations to be defined, which may not be helpful.

Platanus occidentalis - Celtis laevigata - Fraxinus pennsylvanica / Lindera benzoin - Ilex decidua / Carex retroflexa Forest (CEGL007730) is an association which appears to be redundant with the one crosswalked.

Pinus taeda - Fraxinus pennsylvanica - Ulmus americana - Celtis laevigata Temporarily Flooded Forest [Provisional] (CEGL007559), previously treated as a separate High Pine subtype, is no longer recognized in the 4th approximation or in the NVC. *Pinus taeda* is one tree component that may or may not be present and may sometimes codominate.

There is concern in these communities about excessive sediment deposition caused by anthropogenically-induced erosion in the watersheds over the last several centuries. While this is a concern in all brownwater and Piedmont rivers, it has affected the High Levee Subtype more than others because they are the sites of the heaviest sediment deposition. Hupp, et al. (2009a) reported three to four meters of sediment deposition on the Roanoke River. Excess sediment deposition has raised ground levels, reduced flood frequency and duration, and probably altered plant composition. On the best-studied river in North Carolina, the Roanoke, the flood regime is also altered by dams. This makes determination of the natural state difficult, and our understanding of these communities may need revision in the future.

Rare species:
Vascular plants – *Carex jamesii, Carex socialis, Carya laciniosa, Enemion biternatum, Phacelia covillei, Ruellia strepens, Scutellaria nervosa, Trillium sessile,* and *Urtica chamaedryoides*.

Vertebrate animals – *Setophaga cerulea.*

Invertebrate animals – *Catocala orba, Cerma cora,* and *Loscopia roblei*.

BROWNWATER LEVEE FOREST (MEDIUM LEVEE SUBTYPE)

Concept: Brownwater Levee Forests are forest communities of natural levee deposits along brownwater Coastal Plain rivers, with a significant component of the suite of levee tree species. The Medium Levee Subtype covers levees of intermediate height, typically in the middle Coastal Plain stretches of rivers and sometimes on lower parts of high upstream levees. The rich-site species and marginal wetland species of the High Levee Subtype are minor or absent, plant species richness is generally lower, and more water-tolerant species are usually present in small numbers. Also included is one example dominated by a disjunct population of *Populus deltoides*, with an admixture of other levee species.

Distinguishing Features: Brownwater Levee Forests usually are easily distinguished by their location adjacent to Coastal Plain Brownwater Rivers. Levee Forests are distinguished from Brownwater Bottomland Hardwoods communities by having a significant component of the suite of levee species that includes *Fraxinus pennsylvanica, Celtis laevigata, Platanus occidentalis, Betula nigra, Acer negundo*, and *Ulmus americana* in natural condition. The Medium Levee Subtype is distinguished from the High Levee Subtype by the absence of characteristic species of rich sites shared with Piedmont levees, such as *Aesculus sylvatica, Lindera benzoin, Laportea canadensis, Nemophila aphylla (microcalyx)*, and *Corydalis flavula.* Species of wetter sites, such as *Carya aquatica, Nyssa aquatica*, *Quercus lyrata*, and *Taxodium distichum,* may be present but only in small numbers or in wetter microsites.

Crosswalks: *Fraxinus pennsylvanica - Ulmus americana / Carpinus caroliniana / Boehmeria cylindrica* Floodplain Forest (CEGL007806).
G759 Southern Ash - Elm - Willow Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: The Medium Levee Subtype occurs along channels and on point bar deposits of brownwater rivers. It may occasionally occur on recently abandoned channel segments farther from the active river. The Medium Levee Subtype most often borders rivers in the middle Coastal Plain but may occur in the inner Coastal Plain where broad levees slope away from the river.

Soils: Soils are coarse-textured alluvial soils, with little horizon development because of relatively recent deposition. Most levees are mapped as Chewacla (Fluvaquentic Dystrudept) or Congaree (Oxaquic Udifluvent). A few are mapped as Chastain or Wehadkee (Fluvaquentic Endoaquepts).

Hydrology: The Medium Levee Subtype is intermittently or seasonally flooded, generally only for short periods but longer than in the High Levee Subtype. Soils are well drained when not flooded but are closer to the water table than in the High Levee Subtype. These levee areas have substantial microrelief, which leads to variation in hydroperiod, though only limited areas are very wet. Brownwater rivers, in contrast to blackwater, tend to have periods of sustained high flow, usually in winter and spring, where not controlled by dams. However, floods seldom remain deep enough to submerge levees for long periods.

Vegetation: Brownwater Levee Forests are naturally closed forests punctuated by canopy gaps. In the Medium Levee Subtype, the canopy is a varying mix that has *Fraxinus pennsylvanica, Ulmus americana*, and *Liquidambar styraciflua* as the most frequent dominant species. Plot data (Rice and Peet 2001, Faestal 2012, CVS data) show *Platanus occidentalis, Celtis laevigata, Quercus laurifolia,* and *Acer rubrum* var. *trilobum* also frequent and sometimes dominant, and these data show *Carya aquatica, Carya cordiformis*, *Populus heterophylla, Acer saccharinum*, *Ulmus alata, Diospyros virginiana,* and *Taxodium distichum* as fairly frequent at least on some rivers. The dominant understory species most frequently include *Carpinus caroliniana, Acer negundo*, and less frequently *Ilex opaca, Crataegus viridis*, and *Fraxinus caroliniana*, in addition to various canopy species. *Ilex decidua* is most often the dominant shrub. *Arundinaria tecta* may be fairly frequent but is less abundant than in the High Levee Subtype. Woody vines are also prominent. *Smilax rotundifolia, Toxicodendron radicans, Campsis radicans, Parthenocissus quinquefolia, Berchemia scandens, Smilax bona-nox, Muscadinia rotundifolia*, *Bignonia capreolata*, and *Nekemias arborea* all occur with high frequency and sometimes high cover in plot data. *Thyrsanthella difformis, Smilax hispida, Vitis aestivalis*, and other *Vitis* species also may be fairly frequent. The herb layer is generally dense and fairly diverse. Species at high to moderate frequency, at least on some rivers, include *Commelina virginica, Saururus cernuus, Carex louisianica, Lobelia inflata, Viola sororia*, *Mitchella repens*, *Leersia oryzoides, Leersia virginica, Solidago caesia, Persicaria punctata, Persicaria hydropiperoides, Onoclea sensibilis, Carex grayi, Carex typhina*¸ and a number of other *Carex* species. Species shared with the Piedmont and species shared with rich mesic sites are notably less numerous and less abundant than in the High Levee Subtype, while species of wetter sites are more abundant. Exotic plants, especially *Lonicera japonica* and *Microstegium vimineum*, may be abundant. The epiphyte *Tillandsia usneoides* may have high cover, and *Pleopeltis michauxiana* may cover trunks and branches of some trees.

Range and Abundance: Ranked G4? In North Carolina, the Medium Levee Subtype is locally abundant along the middle Coastal Plain reaches of the several brownwater rivers. It is sometimes present in the upper reaches, where it occurs on the lower edges of high levees. Narrow strips of Brownwater Levee Forest often are left where the rest of the floodplain has been logged. The equivalent NVC association ranges from North Carolina to Alabama.

Associations and Patterns: The Medium Levee Subtype occurs as linear bands along most of the frontage of brownwater rivers in the middle Coastal Plain. In the inner Coastal Plain, it may occur on the lower slope of wide levees away from the river and occasionally along sloughs away from the river. Most examples grade to Cypress–Gum Swamp or Brownwater Bottomland Hardwoods, and they may be bordered by Sand and Mud Bar along the river.

Variation: Some differences among different rivers can be seen in existing data and these warrant further investigation. *Acer saccharinum* is widespread on the Roanoke River and not present on other rivers. Other differences visible in plot data, such as occurrence of frequent *Quercus laurifolia* in levee forests only on the Roanoke River, may be coincidental. For the present, one pair of variants is distinguished, recognizing the distinctive disjunct population of *Populus deltoides* on the Roanoke River.

1. Typic Variant encompasses most examples on all brownwater rivers. More variants may be recognized within it in the future.

2. Cottonwood Variant is dominated by *Populus deltoides*, which occurs as a disjunct population along the upper Coastal Plain portion of the Roanoke River. The Cottonwood Variant occurs along a part of the river where the High Levee Subtype prevails, but it occurs in locally lower areas embedded within it. The NVC association *Populus deltoides* - *Salix caroliniana* Forest (CEGL007343) has been attributed to North Carolina to account for this vegetation. *Populus deltoides / Acer negundo / Boehmeria cylindrica* Floodplain Forest (CEGL007731) has also been applied to it at times. However, except for the *Populus*, the vegetation does not appear to be a close match to these associations in other places. It seems best to treat the Roanoke River cottonwood sites at the variant level within the Medium Levee Subtype.

Dynamics: Dynamics of the Medium Levee Subtype are similar to the High Levee Subtype. Flooding is of somewhat longer duration and frequency but still tends to be brief. Hupp, et al. (2009a, 2009b) noted that, on the Roanoke River, deposition has largely ceased on the levees, presumably including the Medium Levee Subtype, because dams have eliminated the higher floods. Instead, sediment deposition is occurring in lower parts of the floodplain. Both erosion and deposition were heaviest in the middle part of the river where the Medium Levee Subtype predominates along the river.

Rare species:
Vascular plants – *Cardamine douglassii, Carex socialis, Carya laciniosa, Oplismenus setarius, Stachys tenuifolia, Trillium sessile,* and *Urtica chamaedryoides*.

Invertebrate animals – *Apameine* new genus 2 sp. 1, *Apameine* new genus 2 sp. 3, *Apameine* new genus 2 sp. 4, *Catocala marmorata, Catocala orba, Cerma cora,* and *Leucania calidior*.

BROWNWATER LEVEE FOREST (LOW LEVEE SUBTYPE)

Concept: Brownwater Levee Forests are forest communities of natural levee deposits along brownwater Coastal Plain rivers, with a significant component of the suite of levee tree species. The Low Levee Subtype covers levees on the lower reaches of rivers or on lower parts of upstream levees, where more water-tolerant species such as *Quercus lyrata* and *Carya aquatica* are major components, but where characteristic levee species such as *Fraxinus pennsylvanica* and *Ulmus americana* are still significant. In contrast to other subtypes, the Low Levee Subtype often has little understory or shrub layer. It may have a dense herb layer dominated by *Carex* spp. Also included here are communities of relict natural levees in the tidally influenced lower reaches of brownwater rivers, which have similar vegetation.

Distinguishing Features: Brownwater Levee Forest communities are distinguished by their occurrence along brownwater rivers and by the presence of at least some of the suite of levee tree species such as *Fraxinus pennsylvanica*, *Ulmus americana*, and *Platanus occidentalis*. The Low Levee Subtype is distinguished from other subtypes by the dominance of more water-tolerant tree species, particularly *Quercus laurifolia, Quercus lyrata*, *Carya aquatica*, *Nyssa aquatica*, and *Taxodium distichum*, in combination with the more water-tolerant levee species such as *Fraxinus pennsylvanica*, *Ulmus americana*, *Platanus occidentalis*, and *Betula nigra*. While *Taxodium distichum* and *Nyssa aquatica* are generally present, they do not strongly dominate as they do in the Cypress–Gum Swamp type. These communities also may look similar to Brownwater Bottomland Hardwoods (Swamp Transition Subtype), which can have a substantial amount of *Fraxinus pennsylvanica*, but which occurs farther from the river and lacks *Platanus occidentalis* and *Betula nigra*.

Crosswalks: *Fraxinus pennsylvanica - Quercus laurifolia - Quercus lyrata - Carya aquatica* Floodplain Forest (CEGL004695).
G759 Southern Ash - Elm - Willow Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: The Low Levee Subtype occurs along channels of brownwater rivers. It may occasionally occur on recently abandoned channel segments farther from the active river. The Low Levee Subtype most often borders rivers in the outer Coastal Plain, including tidally influenced stretches, but it may also occur in the inner or middle Coastal Plain where broad levees slope gradually away from the river. It tends to be narrower as well as lower than the other subtypes. It may occasionally occur on backwater streams -- tributary streams that join brownwater rivers and have sediment-laden flood waters pushed up into them from downstream.

Soils: Soils are coarse-textured or medium-textured alluvial soils, with little horizon development because of relatively recent deposition. Examples are mapped as Chewacla (Fluvaquentic Dystrudept), Congaree (Oxaquic Udifluvent), Chastain or Wehadkee (Fluvaquentic Endoaquepts), or Muckalee (Typic Fluvaquent). Some examples are small enough to not be distinguished in mapping.

Hydrology: The Low Levee Subtype is intermittently or occasionally flooded, probably usually for short periods. Though wetter than the Medium Levee Subtype because of finer texture soils, lower elevation, and higher water table, the lower river reaches where most examples occur have less flood amplitude. It is unclear if the low levees stay flooded longer than those upstream, or even as long. Those along tidal reaches are not flooded in normal high tides but may be flooded by river floods or storm surges. Examples on lower reaches of rivers are also particularly susceptible to the gradual effects of rising sea level. In contrast, examples on upstream reaches do stay flooded longer than higher levee communities, and dam control may keep them flooded even longer.

Vegetation: Brownwater Levee Forests are naturally closed forests punctuated by canopy gaps. In the Medium Levee Subtype, the canopy is a varying mix that includes some *Taxodium distichum, Quercus lyrata, Quercus laurifolia,* and *Carya aquatica*, along with the more water-tolerant of the characteristic natural levee species such a *Fraxinus pennsylvanica* and *Ulmus americana*. Other characteristic species, such as *Acer negundo* and *Celtis laevigata*, may be present but are not abundant. The understory consists primarily of *Carpinus caroliniana* but may include *Crataegus viridis* and other species. The shrub layer is generally not dense. *Ilex decidua* usually dominates, though *Arundinaria tecta* may dominate patches. Vines may be prominent, with *Smilax rotundifolia, Campsis radicans, Toxicodendron radicans, Smilax hispida, Smilax bona-nox, Thyrsanthella difformis, Muscadinia rotundifolia*, and *Berchemia scandens* all occurring with high to moderate frequency in CVS and other plot data (Rice and Peet 1997; Rice et al 2001; Faestal 2012). Herbs range from sparse to dense. Frequent species in plots include *Saururus cernuus, Boehmeria cylindrica, Viola sororia, Symphyotrichum lanceolatum, Carex louisianica, Carex tribuloides, Leersia virginica, Carex corrugata, Carex abscondita, Leersia oryzoides,* and *Mitchella repens*. Species abundant on higher levees, such as *Chasmanthium latifolium* and *Elymus virginicus*, may be present but generally with low cover. Other species, such as *Onoclea sensibilis, Cinna arundinacea, Persicaria punctata, Persicaria hydropiperoides, Persicaria setacea, Pluchea camphorata, Impatiens capensis, Juncus effusus*, and other species of *Carex* are less frequent but indicate the wetness of this subtype compared to the Medium Levee Subtype. Exotic plants, especially *Lonicera japonica* but also *Alternanthera philoxeroides*, may be abundant. Though not presently widespread in North Carolina, *Triadica sebifera* may become more frequent in this community. The epiphyte *Tillandsia usneoides* may have high cover, and *Pleopeltis michauxiana* may cover trunks and branches of some trees.

Range and Abundance: Ranked G3G4. North Carolina's examples are scattered along the brownwater rivers. They are more widely scattered farther inland on lower slopes of large natural levees and on tidal reaches of brownwater rivers. The equivalent NVC association is attributed only to North Carolina and questionably to Virginia. However, similar communities must occur in South Carolina and Georgia. It seems unlikely that it should have a narrower range than the other brownwater levee associations. However, it is possible that the increasing tidal amplitude southward may affect the development of this subtype.

Associations and Patterns: The Low Subtype occurs as linear bands along the frontage of lower brownwater rivers or on the slopes of natural levees farther upstream. It may also border distributary channels or sloughs away from the main river channel. The bands are more often narrow and discontinuous than in the other subtypes. Patches are most often bordered by Cypress–Gum Swamp or Tidal Swamp.

Variation: No variants are recognized. This subtype is less diverse and consequently has a narrower range of variation. Differences among flowing brownwater riverbanks, upstream back levee slopes, and tidal examples should be sought.

Dynamics: Dynamics of the Low Levee Subtype are generally similar to the Medium Levee Subtype. However, flooding dynamics may be different.

Most examples of this subtype occur far downstream, where excessive sedimentation and altered flood regimes created by Piedmont dams have less effect. However, examples on the lower parts of upstream levees are affected by them. Because they lie at a low elevation relative to the river, dam-altered flows that increase the duration of low-level floods may have a particular impact on this community in upstream sites. Hochman (2004) outlined many of the consequences of increased duration of flooding including reduced ability of seedlings to grow before canopies leaf out in spring, slower seedling growth rates, and stress to older trees that established under different flooding conditions. White's (2014) finding that some lower areas lacked sufficient saplings to replace the canopy trees of most species may apply to this community on the upper and middle Roanoke.

Comments: The Low Levee Subtype often has a distinctly different aspect than the other subtypes, especially where it does not border the river. Instead of the complex multi-layered structure of the higher levees, the vegetation instead is a two-layered forest, with a canopy and sedge-dominated herb layer but little in the intermediate strata.

Inclusion of the levees along tidally influenced reaches is somewhat questionable. However, their vegetation appears indistinguishable from those upstream. They are included only if tides do not flood them. River flood amplitudes are muted in tidal reaches, but sometimes may flood the low levees. When not flooded, the water table remains high because of their low elevation. The water table may, of course, be affected by tides.

Rare species:
Vascular plants – *Carex crus-corvi, Carex socialis, Leersia lenticularis, Oenothera riparia,* and *Stachys tenuifolia*.

Vertebrate animals – *Corynorhinus rafinesquii* and *Myotis austroriparius*.

Invertebrate animals – *Loscopia roblei*.

BROWNWATER LEVEE FOREST (BAR SUBTYPE)

Concept: The Bar Subtype of Brownwater Levee Forest is a middle stage of primary succession on relatively young point bar deposits. It is intermediate between other Brownwater Levee Forest communities and Sand and Mud Bar, both temporally and spatially. Similar vegetation occurs in a narrow band along the riverbank in some places but is extensive enough to recognize as a community patch only in larger areas on the inside of point bars.

Distinguishing Features: The Bar Subtype is distinguished by dominance of tree species characteristic of primary succession, particularly *Platanus occidentalis*, *Betula nigra*, *Salix nigra*, *Salix caroliniana*, or *Acer saccharinum*. Most other trees of Brownwater Levee Forest, if present, are primarily seedlings or saplings.

Crosswalks: *Betula nigra - Platanus occidentalis / Alnus serrulata / Boehmeria cylindrica* Floodplain Forest (CEGL007312).
G673 South Central-Appalachian-Northeast Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: The Bar Subtype occurs on the insides of migrating meanders, where newly deposited material has accumulated high enough and stabilized enough to support trees but has not been stable long enough to have developed into another subtype of Brownwater Levee Forest.

Soils: Soils are recently deposited coarse alluvium that lacks horizon development. Patches are too small to distinguish in soil mapping but would presumably be some kind of Fluvent or Fluvaquent. They are subject to flood scouring and sediment deposition to a greater degree than other subtypes but less so than in Sand and Mud Bar. The substrate may be locally reworked in floods but is relatively stable.

Hydrology: The Bar Subtype is seasonally to intermittently flooded. Its sites are lower and more frequently flooded than other subtypes of Brownwater Levee Forest but higher and less frequently flooded than most Sand and Mud Bars.

Vegetation: The vegetation of the Bar Subtype may have a closed or open tree canopy. Trees are generally relatively small and young, but a few individuals may be old, or significant tree cover may come from leaning large trees rooted in adjacent forests. Dominant species generally are *Platanus occidentalis, Betula nigra, Salix nigra*, *Fraxinus pennsylvanica*, or on the Roanoke River, *Acer saccharinum*. Less often abundant are *Carya aquatica, Celtis laevigata, Acer negundo*, or *Carpinus caroliniana*. Other trees species are often present as seedlings or saplings. Shrubs are generally sparse. *Ilex decidua* is the only fairly frequent species in plot data (Peet and Rice 2001, Faestal 2002), but *Hibiscus laevis, Hibiscus moscheutos, Alnus serrulata,* or *Swida* (*Cornus*) *amomum* are sometimes observed. Vines are frequent in plots, especially *Toxicodendron radicans, Muscadinia rotundifolia,* and *Vitis cinerea* var. *floridana*, but don't generally have large cover. *Nekemias arborea, Smilax rotundifolia*, and *Campsis radicans* are fairly frequent. Herbs generally are sparse to moderate in density. As in Sand and Mud Bar, they may differ greatly in cover from year to year. Frequent species in plot data include *Pluchea camphorata, Boehmeria cylindrica, Echinochloa crus-galli, Leersia virginica*, *Erechtites hieracifolia*, *Commelina virginica, Coleataenia rigidula, Lindernia dubia,* and on the Roanoke, *Leersia oryzoides, Bidens discoidea, Mollugo verticillata,* and *Oxalis dillenii*. Several species of *Carex* are frequent in plots from the Neuse and Cape Fear but not the Roanoke: *Carex tribuloides, Carex louisianica, Carex lupulina,* and *Carex typhina*. Other fairly frequent species include *Commelina communis, Eclipta prostrata, Bidens bipinnata*, and *Bidens frondosa*. A great diversity of additional species may be present in small numbers or as seedlings. Exotic plants may be present, including *Murdannia keisak* and *Microstegium vimineum*.

Range and Abundance: Ranked G4G5. This subtype is scattered in North Carolina along the brownwater rivers in the upper to middle Coastal Plain but generally is absent downstream. Its overall frequency is not well known, as it often is overlooked in site descriptions. However, its overall extent is small. The global range of this subtype also is unclear. The linked NVC association is reported to range to Kentucky, Arkansas, and Texas, but this almost certainly is because it has not been carefully considered and has been defined too broadly. Though the early successional condition may conceivably be less differentiated than more stable floodplain forests, there is no reason to think it is uniform across such a wide geographic and physiographic range while other associations have much narrower ranges.

Associations and Patterns: The Bar Subtype occurs in small patches on the insides of meanders, generally between a Sand and Mud Bar and another subtype of Brownwater Levee Forest, though potentially adjacent to Cypress–Gum Swamp or Brownwater Bottomland Hardwoods. It is not present on all meanders.

Variation: Variation has not been well defined. The numerous differences in frequent species on different rivers, described above, may represent distinct variants. However, with the exception of a few species with biogeographic limits, such as *Acer saccharinum*, the differences may equally plausibly represent differences in the time of sampling or in types of areas selected for sampling.

Dynamics: The Bar Subtype is a community of middle primary succession on recently deposited landforms, with Sand and Mud Bar (Brownwater Subtype) representing the early stage and the other subtypes of Brownwater Levee Forest the climax stage. Though this general pattern appears obvious from spatial relationships and vegetation, the details of successional dynamics are not well known. It is driven by migration of meanders. This process is slow but not necessarily uniform. Much of the migration may occur in uncommon very large floods. Creation of bars may vary with rainfall cycles, such as those on a scale of 30 years documented by Stahle et al. (1988). The occurrence of a dry period after a wet period may lead to a temporary abundance of these mid successional communities.

Sand and Mud Bars do not steadily succeed to Brownwater Levee Forest. They appear to be maintained as sparse and young vegetation by scouring and reworking of their substrate and also by long and frequent flooding. Development of the Bar Subtype requires stabilization of the substrate, which appears to come about because of protection by more recently deposited bars. It also requires accretion to a higher elevation above the river, which may result from stabilization or may be a cause of it. The Bar Subtype remains more disturbed than higher parts of the floodplain. Between this disturbance and the input of propagules by water, the vegetation often includes a significant component of ruderal species and of young individuals of herbaceous and woody species. This component can vary substantially from time to time. Eventually, the young individuals mature and the community succeeds to one of the other subtypes.

The huge influx of sediment in the colonial period and the alterations caused by upstream dams have affected this subtype even more than others. Rivers have become more entrenched within thick sediment deposits, and this inhibits meandering and bar formation. Hupp, et al. (2009a, 2009b) noted that point bars are no longer forming on the Roanoke River. Indeed, altered flows may have eroded what point bars existed previously, while increased low level floods are a particular stress on these communities. An artificially prolonged flood on the Roanoke River in the growing season of 2003 appears to have resulted in mortality of most established trees on the lower banks and bars.

Comments: This subtype is less well understood than the other subtypes. It was documented by Rice and Peet (2001) and Faestal (2002) but is little reported in site surveys.

The NVC crosswalk for this community appears be problematic. Though the association consists primarily of the same plant species, the characterization of it as occurring on levees on small rivers does not match. The placement of the association in the South Central-Appalachian-Northeast Floodplain Forest group does not fit North Carolina's brownwater rivers. The NVC description notes the need to divide it into several associations fitting the changed group hierarchy.

Populus deltoides - Salix caroliniana Floodplain Forest (CEGL007343) and *Salix nigra - Fraxinus pennsylvanica* Forest (CEGL007734) are additional bar forest associations that have been attributed to North Carolina. The limited frequency of brownwater bar communities and their natural variability does not appear to warrant such fine distinctions. However, the latter, a more narrowly defined Atlantic Coastal Plain association, might, with modification, be a better fit than the current broadly defined association.

Rare species: No rare species are known to be specifically associated with this community.

BLACKWATER LEVEE/BAR FOREST

Concept: The Blackwater Levee/Bar Forest type consists of forests and woodlands on the interior of point bars and along banks of blackwater rivers, where *Betula nigra* or *Planera aquatica* are a significant component. These communities represent the middle stages of primary succession on point bar deposits along migrating river meanders.

Distinguishing Features: Blackwater Levee/Bar Forest is distinguished from Blackwater Bottomland Hardwoods by the presence of more than very small amounts of *Betula nigra* or (on the lower Lumber and Waccamaw Rivers) *Planera aquatica* in a natural riverbank or sand bar location. It is distinguished from Sand and Mud Bar by having substantial cover of trees rooted in the community. It is distinguished from Brownwater Levee Forest by the absence or near absence of *Platanus occidentalis, Fraxinus pennsylvanica, Acer negundo, Acer saccharinum*, and other characteristic brownwater species.

Crosswalks: *Betula nigra - Quercus laurifolia - Taxodium (distichum, ascendens) / Crataegus aestivalis* Riparian Forest (CEGL004282).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Blackwater Levee/Bar Forest generally occurs on point bar deposits on the inside of active river meanders. It occurs on surfaces that are fairly recently deposited but which are higher above the river and older than those that support Sand and Mud Bar.

Soils: Soils are sandy and have little or no horizon development. Patches are too small to be distinguished on soil mapping.

Hydrology: Blackwater Levee/Bar Forests are seasonally to frequently flooded. Being close to the river, they may be subject to significant currents during floods. They are generally high enough to be well drained when the river is low.

Vegetation: The vegetation may have a dense or open canopy. *Betula nigra* or, on the Waccamaw and Lumber River, *Planera aquatica*, are abundant and usually dominant. *Acer rubrum* var. *trilobum*, *Quercus lyrata, Quercus laurifolia,* or *Taxodium distichum* are often present but primarily as young individuals. *Crataegus* sp. and *Fraxinus caroliniana* also are frequent. Shrubs are generally limited, other than shrub-sized tree saplings, but *Vaccinium elliottii*, *Cyrilla racemiflora*, *Ilex amelanchier*, or other species of the riverbanks may be present. *Muscadinia rotundifolia, Smilax rotundifolia*, or other vines may dominate patches. Herbs are often patchy, with dense cover in some areas, sparse cover in others. Frequent species include *Boehmeria cylindrica, Persicaria* spp., *Justicia ovata* var. *ovata*, and on the Waccamaw River, *Hymenocallis pygmaea*. Other species may include a number shared with more open sand bars, such as *Phanopyrum gymnocarpon, Coleataenia rigidula*, and *Gratiola neglecta*. As with open bars, many species may be young individuals or be short lived. The exotic species *Murdannia keisak* and *Alternanthera philoxeroides* are sometimes present and may dominate patches.

Range and Abundance: Ranked G2G3. In North Carolina, this community is well developed only on the large blackwater rivers such as the Lumber, Waccamaw, Black, and Northeast Cape Fear and is very limited in extent. It also occurs in South Carolina. The synonymized NVC association is questionably attributed to Georgia and is likely to be there.

Associations and Patterns: Blackwater Levee/Bar Forest occurs in small patches that are scattered along meandering portions of rivers. Not every meander has a well-developed patch. Patches tend to be bordered by Sand and Mud Bar on the youngest part of the point bar and to give way to Blackwater Bottomland Hardwoods on older portions. They may also be bordered by Cypress–Gum Swamp in a slough behind them.

Variation: Two variants are recognized, based on range limits of frequent species.

1. Water Elm Variant occurs in areas within the range of *Planera aquatica*. This species tends to be important in the community within its range, though *Betula nigra* is also abundant in many examples.

2. Northern Variant occurs in areas outside the range of *Planera aquatica*, where *Betula nigra* is the predominant species.

Dynamics: Blackwater Levee/Bar Forests are the middle stage of a primary succession, developing when point bar deposits have become high and stable enough to allow trees to establish. *Betula nigra* and *Planera aquatica* are the first tree species to become dominant, and they are eventually supplanted by the oaks of Blackwater Bottomland Hardwoods. It is not well known how long this process takes. It is also unclear whether all sites are on a steady successional trajectory or if some are maintained or periodically reset by natural disturbance. While point bars are deposited where normal current is slow on the inside of meanders, flood water can flow across them with substantial velocity. New layers of sand may be deposited, and the surface may be scoured. While young individuals of the succeeding species are often present, it is not clear if they will mature. Intermediate age individuals often are lacking. Ongoing succession may not be possible until additional deposition raises the surface or until further channel migration and bar deposition leads to greater stability.

As in the Brownwater Levee Forests, frequent sediment deposition presumably provides an important nutrient subsidy; however, the low nutrient content of blackwater and the limited nutrient-holding capacity of the sand likely make this a marginal benefit on blackwater rivers.

Comments: Blackwater rivers do not generally have well-developed natural levees of the sort created by overbank flooding on brownwater rivers, because of their low suspended sediment load. While the 3rd Approximation had a Blackwater Subtype of Coastal Plain Levee Forest that was conceived as being analogous to the Brownwater Subtype, it was dropped because none of the communities to which it was applied were very distinctive. Levee species such *Betula nigra* may occur along blackwater rivers outside of point bars, but generally only as scattered individuals rooted in the bank. The narrow band of bank vegetation is too limited in area to be recognized as a distinct community.

Though there are not well-developed natural levees, movement of sand by blackwater rivers does create point bars which are young substrates suitable for this community. This community is analogous to the Bar Subtype of Brownwater Levee Forest.

This community has received virtually no study, and it is seldom described or distinguished in site reports.

Rare species:
Vascular plants – *Gratiola aurea* and *Hymenocallis pygmaea.*

BROWNWATER BOTTOMLAND HARDWOODS (HIGH SUBTYPE)

Concept: Brownwater Bottomland Hardwoods communities are forests of Coastal Plain floodplain terraces and ridges other than active natural levees, lacking a significant component of levee tree species, and naturally dominated by bottomland oaks, hickories, sweetgum, and locally, pine. The High Subtype covers examples that are the farthest above the river. They are thus flooded relatively infrequently and for short periods. They are generally dominated by combinations of *Quercus michauxii, Quercus pagoda, Quercus laurifolia*, and *Liquidambar styraciflua*.

Distinguishing Features: Brownwater Bottomland Hardwoods are distinguished by occurrence on floodplains of brownwater rivers but away from the riverbank or natural levees. However, overbank flooding is, or was in the past, important. The canopy is dominated by wetland oaks and *Liquidambar*, and characteristic levee species such as *Platanus occidentalis, Betula nigra*, and *Celtis laevigata* are generally absent except in disturbed areas. Other levee species such as *Fraxinus pennsylvanica, Acer negundo*, and *Ulmus americana* may be present but in smaller numbers than in levee forests. In contrast to Nonriverine Wet Hardwood Forests with similar canopies, Brownwater Bottomland Hardwoods generally lack a significant component of acidic wetland shrubs such as *Lyonia lucida, Ilex glabra*, and *Cyrilla racemiflora*, while species such as *Ilex decidua* are often present.

The High Subtype is distinguished from the Low Subtype and Swamp Transition Subtype by canopy dominance by the more mesophytic bottomland hardwoods such as *Quercus michauxii* and *Quercus pagoda*, with only a small component of wetter site species such as *Quercus lyrata, Carya aquatica*, and *Taxodium distichum*. *Quercus laurifolia* may be abundant in all subtypes and does not readily distinguish among them.

The High Subtype is distinguished from Mesic Mixed Hardwood Forest by the dominance of the species above. *Fagus grandifolia* typically is abundant in Mesic Mixed Hardwoods but scarce or absent in Brownwater Bottomland Hardwoods canopies, though it may be present in the understory. *Liquidambar styraciflua* and *Quercus laurifolia* are scarce or absent in natural Mesic Mixed Hardwoods. *Quercus pagoda* and, more often, *Quercus michauxii* may be in both but are more frequent and more abundant in floodplains. While Mesic Mixed Hardwood Forest near rivers is usually on distinct upland slopes, the highest ridges on river terraces may support patches of it.

Crosswalks: *Quercus laurifolia - Quercus michauxii - Liquidambar styraciflua / Carpinus caroliniana* Floodplain Forest (CEGL004678).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Brownwater Bottomland Hardwoods occur in the interior and outer parts of brownwater river floodplains, away from the natural levees and from the active river channel. They occur on the higher areas of the floodplain: former natural levees abandoned by channel shifts, ridges in scrollwork ridge-and-swale systems, and potentially on more extensive flats on terraces.

Soils: Brownwater Bottomland Hardwoods generally have sandy or silty soils with high fertility. Examples are mapped with a variety of soils, with no series predominant. Many are alluvial soils such as Chewacla (Fluvaquentic Dystrudept), Chastain, or Wehadkee (Fluvaquentic Endoaquepts). Many others are mapped as older soils shared with wet uplands, such as Roanoke (Typic Endoaquult), Tarboro (Typic Udipsamment), Altavista (Aquic Hapludult), Wickham (Typic Hapludult), or a number of others. Given the heterogeneity of floodplain soils, many of these may be inclusions or may not be typical of the named soil series. In any case, those mapped with upland soils have vegetation distinct from upland communities.

Hydrology: The High Subtype is intermittently flooded. Flooding probably occurs naturally only in the highest floods and only for relatively brief periods. Nevertheless, the nutrient enrichment brought by flooding likely is important to the distinctive character of these communities. Soils may also sometimes be saturated by floods that don't inundate them. When rivers are not in flood, the sites are well-drained.

Vegetation: The High Subtype is a forest that is typically dominated by a varying mix of *Quercus laurifolia, Quercus michauxii, Quercus pagoda*, and *Liquidambar styraciflua*. A diversity of other trees is often present. Species showing high frequency in CVS and other plot data (Rice and Peet 1997; Rice et al. 2001; Faestal 2012), and sometimes locally abundant, include *Carya cordiformis, Quercus phellos, Pinus taeda, Fraxinus pennsylvanica, Ulmus americana, Carya ovata, Quercus shumardii,* and *Quercus lyrata*. Though not characteristic, *Platanus occidentalis, Betula nigra*, or *Celtis laevigata* often are present as small individuals and may be abundant in heavily disturbed areas. On the highest ridges, transitional to Mesic Mixed Hardwood Forest, a few *Fagus grandifolia* or *Quercus alba* may be present. The understory is usually dominated by *Carpinus caroliniana*. Other species frequent along at least some rivers and potentially abundant include *Ilex opaca, Asimina triloba, Acer rubrum, Ulmus alata, Acer negundo*, *Crataegus marshallii*, *Crataegus macrosperma*, *Diospyros virginiana*, and *Nyssa sylvatica*. Shrubs are generally moderate to low in density. The only species with very high constancy is *Ilex decidua*. *Arundinaria tecta* often dominates patches. *Lindera benzoin, Euonymus atropurpureus, Euonymus americanus*, and *Viburnum prunifolium* are at least fairly frequent in plots from some rivers. *Vaccinium elliottii, Vaccinium fuscatum, Itea virginica*, *Eubotrys racemosa*, and *Symplocos tinctoria* are less frequent in plots but often noted in site descriptions. Woody vines are notably diverse, and many can be locally abundant. Species with high-to-moderate frequency in plots include *Toxicodendron radicans, Bignonia capreolata, Parthenocissus quinquefolius, Muscadinia rotundifolia, Smilax rotundifolia, Smilax bona-nox, Smilax glauca, Smilax hispida, Smilax smallii, Campsis radicans, Nekemias arborea, Thyrsanthella difformis, Berchemia scandens, Hydrangea (Decumaria) barbara*, several species of *Vitis*, and the exotic *Lonicera japonica*. Herbs are generally sparse to moderate in density. None have the frequency in plot data that many of the woody species do. Frequent species at least along some rivers include *Dichanthelium commutatum, Boehmeria cylindrica, Leersia virginica, Mitchella repens, Festuca subverticillata, Cinna arundinacea, Leersia oryzoides, Triadenum walteri, Saururus cernuus*, and many species of *Carex* (*abscondita, typhina, crinita, corrugata, louisianica, crebriflora, radiata, grayi,* and *amphibola* are at least fairly frequent). A great variety of other herbs of rich, mesic, or wet forests may be present, such as *Arisaema triphyllum, Chasmanthium latifolium, Chasmanthium laxum, Osmorhiza longistylis, Polystichum acrostichoides, Geum canadense, Persicaria virginiana, Glyceria striata, Sanicula* *canadensis, Elymus virginicus*, and *Mikania scandens*. *Tillandsia usneoides* may be abundant on trees.

Range and Abundance: Ranked G3G4. In North Carolina the High Subtype occurs along the inner and middle Coastal Plain portions of all brownwater rivers but becomes scarce in the outer Coastal Plain. This subtype, being drier, has more often been converted to agriculture or pine plantation. It also is the most easily logged. Its original extent has been greatly reduced, and it is now one of the rarest floodplain communities. The synonymized NVC association ranges from Virginia to Georgia.

Associations and Patterns: The High Subtype usually occurs in a mosaic with Cypress–Gum Swamp and sometimes with the Low or Swamp Transition Subtype. It may border Brownwater Levee Forest and may border Mesic Mixed Hardwood Forest but more often is separated by wetter communities.

Variation: No variants are recognized at present but the possibility warrants further investigation. A separate High Pine-Oak Subtype was recognized in earlier drafts of the Fourth Approximation and was also provisionally included in the NVC as *Pinus taeda - Quercus (pagoda, michauxii, shumardii)* Temporarily Flooded Forest (CEGL007550). Both were later lumped. *Pinus taeda* patches are generally regarded as successional after natural or human disturbance rather than an enduring distinct community. However, old stands are known. Consistent differences in sites or associated vegetation have not been identified, but it is possible that they might be found. Substantial disturbances in recent years have not that often led to regeneration of pines.

Rice et al. (2001) on the Roanoke River recognized a rarely flooded community and a temporarily flooded community, the latter most typical of the High Subtype and the former transitional to Mesic Mixed Hardwood Forest. They also recognized phases within each. It is unclear if these variations are repeated beyond the Roanoke River. Alternatively, differences in the High Subtype among rivers could be great enough to recognize as variants.

The NVC description of *Quercus michauxii - Quercus shumardii - Liquidambar styraciflua / Arundinaria gigantea* Forest (CEGL002099), a floodplain community of states farther west, emphasizes *Quercus shumardii* as an indicator. Given the irregular occurrence of this species in North Carolina's examples, its ecological significance here may be worth investigating.

Dynamics: The dynamics of Brownwater Bottomland Hardwoods are similar to most Coastal Plain Floodplain communities and to many other forests. Flooding does not represent a significant disturbance, but the nutrient enrichment brought by even the infrequent flooding presumably is important.

The presence of occasional patches dominated by *Pinus taeda* in this community suggests questions about its dynamics. Most forests dominated by this species represent successional stands following past agricultural clearing. However, some are in remote locations where it is unclear if farming would have been attractive. A study of pine stands on the Congaree River in South Carolina (Pederson et al. 1997) found that even recent severe hurricane disturbance was not sufficient to allow regeneration of current pine dominance. They concluded that these stands result from undocumented agricultural fields and suggest that *Pinus taeda* probably occurred only as scattered individuals or groves before settlement.

White and Peet (2013) and White (2014) noted that many of the examples of this community that they sampled on the Roanoke River had understories that did not match the canopy, often including numerous *Fagus grandifolia*. The forest composition appears to be changing as a result of the elimination of peak floods by the upstream dams. Flooding, relatively brief under natural conditions, now does not occur at all.

Comments: Study of vegetation at Congaree National Park in South Carolina (Landaal et al. 1998) resulted in creation of NVC associations that appear similar or equivalent to the High Subtype as defined here. *Liquidambar styraciflua - Quercus laurifolia - (Pinus taeda) / Arundinaria gigantea / Carex abscondita* Forest (CEGL007732) has been attributed to North Carolina. It seems to overlap with the concept of the High Subtype. A segregation of *Quercus laurifolia* from *Quercus michauxii* and *Quercus pagoda*, implied by the name, does not appear to occur in North Carolina within higher bottomland hardwoods, though *Quercus laurifolia* occurs without the others in wetter subtypes.

Rare species:
Vascular plants – *Baptisia alba, Cardamine douglassii. Carex socialis, Scutellaria nervosa, Stachys tenuifolia,* and *Trillium sessile*.

Vertebrate animals – *Setophaga cerulea*.

Invertebrate animals – *Leucania calidior* and *Loscopia roblei*.

BROWNWATER BOTTOMLAND HARDWOODS (LOW SUBTYPE)

Concept: Brownwater Bottomland Hardwoods communities are forests of Coastal Plain floodplain terraces and ridges other than active natural levees, lacking a significant component of levee tree species, and naturally dominated by bottomland oaks, hickories, and sweetgum. The Low Subtype covers examples at intermediate elevations above the river on lower ridges, alluvial flats, and edges of higher ridges. They are dominated by more flood-tolerant species such as *Quercus lyrata, Carya aquatica, Ulmus americana*, and *Quercus laurifolia*. While this subtype conceptually lies between the High Subtype and Swamp Transition Subtype, it is not always developed in recognizable form.

Distinguishing Features: Brownwater Bottomland Hardwoods are distinguished by occurrence on floodplains of brownwater rivers, but away from the riverbank or natural levees, and by dominance by bottomland oaks or sweetgum. The Low Subtype is distinguished from the High Subtype by dominance by *Quercus lyrata, Carya aquatica*, or *Quercus laurifolia*, and absence or low numbers of more mesophytic species such as *Quercus michauxii* and *Quercus pagoda*. *Quercus laurifolia* may be abundant in all subtypes and does not readily distinguish among them.

Crosswalks: *Quercus lyrata - Carya aquatica* Floodplain Forest (CEGL007397).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Brownwater Bottomland Hardwoods occur in the interior of brownwater river floodplains, away from the natural levees and from the active river channel. The Low Subtype occurs on low ridges and flats on active floodplains and potentially on lower parts of terraces.

Soils: Soils of the Low Subtype are generally mapped as alluvial soils such as Chewacla (Fluvaquentic Dystrudept), Bibb (Typic Fluvaqent), Chastain, or Wehadkee (Fluvaquentic Endoaquepts). They tend to be silty or sandy and high in fertility.

Hydrology: The Low Subtype is seasonally to intermittently flooded. Its flood regime is intermediate between the High Subtype and higher Brownwater Levee Forests and the Low Subtype and Cypress–Gum Swamp. When not inundated, the water table may still be high and the soil saturated for significant periods.

Vegetation: The Low Subtype is a forest that is typically dominated by varying combinations of *Quercus laurifolia, Quercus lyrata*, and *Carya aquatica*. *Acer rubrum* var. *trilobum*, *Liquidambar styraciflua, Ulmus americana*, and *Quercus phellos* are frequent. The understory is generally dominated by *Carpinus caroliniana*, but *Ulmus alata* is also frequent, and *Crataegus viridis, Fraxinus caroliniana,* and *Acer negundo* may also occur. The shrub layer generally is sparse to moderate in density; *Ilex decidua* is the only frequent species. Woody vines are diverse and sometimes extensive, though less so than in the High Subtype. *Smilax rotundifolia, Toxicodendron radicans, Campsis radicans, Nekemias arborea, Parthenocissus quinquefolia, Muscadinia rotundifolia, Smilax bona-nox, Thyrsanthella difformis*, and *Berchemia scandens* are at least fairly frequent, and *Gelsemium sempervirens, Smilax glauca*, *Smilax walteri*, and several species of *Vitis* are also encountered. The herb layer is usually sparse to moderate but is fairly low in diversity. *Boehmeria cylindrica* is the most constant species; it and *Carex* spp. (*ludoviciana, typhinia, tribuloides, lupulina, radiata, abscondita, gigantea, intumescens*, or others) may be abundant. Frequent herbs on at least some rivers include *Saururus cernuus, Mitchella repens, Viola sororia, Leersia virginica,* and *Leersia oryzoides*. *Tillandsia usneoides* may be abundant on trees.

Range and Abundance: Ranked G4? In North Carolina, the Low Subtype occurs along all of the brownwater rivers and may be in any part of the Coastal Plain. It appears to be rarer than the High Subtype or Swamp Transition Subtype, occupying less area in floodplain community mosaics and less often being present as well-developed examples. The synonymized NVC association ranges to Kentucky and Texas but this probably is a result of uneven treatment and may reflect more limited knowledge and attention. There does not appear to be any reason to expect this wetter bottomland hardwood community to be more widespread than drier ones which are more finely divided and separated by region.

Associations and Patterns: The Low Subtype usually occurs in a mosaic with Cypress–Gum Swamp and sometimes with the High or Swamp Transition Subtype. It may border Brownwater Levee Forest. It may border Mesic Mixed Hardwood Forest on upland slopes but more often is separated by wetter communities.

Variation: No variants are recognized. This subtype is narrowly defined. The distinction between those with *Carya aquatica* and *Quercus lyrata* and those without them warrants investigation.

Dynamics: The dynamics of Brownwater Bottomland Hardwoods are similar to those of most Coastal Plain Floodplain communities and to many other forests. Flooding does not represent a significant disturbance, but the nutrient enrichment and exclusion of less water-tolerant species brought by even the infrequent flooding presumably is important.

Some areas of the Low Subtype are susceptible to flooding by beaver ponds, turning them into Coastal Plain Semipermanent Impoundment communities. See the discussion under Coastal Plain Semipermanent Impoundment. Because the trees in this subtype are not tolerant of permanent flooding, the pond will generally develop the Coastal Plain Marsh or Open Water Subtype, even if deeper parts of the pond are the Cypress–Gum Subtype. When a beaver pond is abandoned and drained, it may take some years for the community to return to Bottomland Hardwoods. In addition, deposition of clay in the pond may potentially change the nature of the site.

Comments: In North Carolina, this subtype is less common than the other two, and often in smaller patches. As defined, it presumably occupies a narrower segment of the wetness gradient. The vegetation description is less precise and detailed than that for the High Subtype because there are fewer plots and the attribution of them to this subtype is less reliable. Nevertheless, vegetation units that seem equivalent to it were distinguished by both Faestal (2012) and Rice et al. (2001).

Rare species:
Vascular plants – *Carex lupuliformis, Carex socialis,* and *Leersia lenticularis*.
Vertebrate animals – *Liodytes rigida* and *Setophaga cerulea*.

BROWNWATER BOTTOMLAND HARDWOODS (SWAMP TRANSITION SUBTYPE)

Concept: Brownwater Bottomland Hardwoods communities are forests of Coastal Plain floodplain terraces and ridges other than active natural levees, lacking a significant component of levee tree species, and naturally dominated by bottomland oaks, hickories, and sweetgum. The Swamp Transition Subtype encompasses communities that are transitional to Cypress–Gum Swamp, having a mix of oaks with *Taxodium* or *Nyssa* in the canopy and having lower strata that are similarly intermediate.

Distinguishing Features: Brownwater Bottomland Hardwoods are distinguished by occurrence on floodplains of brownwater rivers but away from the riverbank or natural levees, and by dominance by bottomland oaks or sweetgum. The Swamp Transition Subtype is distinguished from other subtypes by the absence of the less water-tolerant species and by vegetation transitional to Cypress–Gum Swamp. It has significant *Taxodium, Nyssa*, or *Fraxinus*, and the shrub and herb layers are more similar to Cypress–Gum Swamp than to other subtypes of Bottomland Hardwoods. Oaks are less strongly dominant, though *Quercus lyrata* or *Quercus laurifolia* are generally abundant. Though this subtype has a significant component of Cypress–Gum Swamp species, and the abundance of *Fraxinus pennsylvanica* may give it affinities with Levee Forest, it lacks the strong dominance of species typical of those communities.

The Swamp Transition Subtype may resemble the Oak-Gum Slough subtype of Nonriverine Wet Hardwood Forest but occurs on brownwater river floodplains rather than on nonriverine wet flats. The distinction could become difficult on remote high river terraces that no longer flood, but no extant examples of such ambiguous situations are known. The Swamp Transition Subtype may also resemble Tidal Swamp but may be distinguished by a substantial oak component.

Crosswalks: *Taxodium distichum - Fraxinus pennsylvanica - Quercus laurifolia / Acer rubrum / Saururus cernuus* Floodplain Forest (CEGL007719).
G033 Bald-cypress - Tupelo Floodplain Forest.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Brownwater Bottomland Hardwoods occur in the interior of brownwater river floodplains, away from the natural levees and from the active river channel. The Swamp Transition Subtype may occur on the lowest ridges or alluvial flats, on the edges of higher ridges, or, not infrequently, in sloughs on higher floodplains or terraces. Relict ridges in the tidal reaches of brownwater rivers, but above the level of tidal flooding, may also support this community.

Soils: Soils of the Low Subtype are generally mapped as alluvial soils such as Chewacla (Fluvaquentic Dystrudept), Bibb (Typic Fluvaqent), Chastain, or Wehadkee (Fluvaquentic Endoaquept). They tend to be silty or sandy and high in fertility. Given the heterogeneity of floodplain soils, many of these may be inclusions or may not be typical of the named soil series.

Hydrology: The Swamp Transition Subtype is seasonally flooded. Its flood regime is intermediate between the Low Subtype and Cypress–Gum Swamp, and it may be inundated well into the growing season. When not inundated, the water table may still be high and the soil saturated for significant periods. Patches in sloughs may carry flowing water with enough current to cause some local scouring.

Vegetation: The Swamp Transition Subtype is a forest dominated by a mix of trees that includes both *Quercus laurifolia, Quercus lyrata*, or *Carya aquatica*, and *Taxodium distichum, Nyssa aquatica*, or *Nyssa biflora*. *Populus heterophylla, Liquidambar styraciflua, Fraxinus pennsylvanica*, *Fraxinus profunda*, *Acer rubrum* var. *trilobum*, or *Ulmus americana* may also be present in the canopy. Trees of drier bottomland hardwoods, such as *Quercus pagoda* or *Quercus michauxii* are present only in drier microsites, if at all. The understory may be dominated by *Carpinus caroliniana*, *Fraxinus caroliniana*, or one of the species in the canopy. Other understory species sometimes present include *Crataegus marshallii* and young individuals of species shared with the levees, such as *Celtis laevigata* or *Platanus occidentalis*. The shrub layer is generally sparse. *Ilex decidua* is the most frequent species, but *Itea virginica, Eubotrys racemosus,* or *Cephalanthus occidentalis* may be present. The herb layer is usually patchy, with some dense areas and some areas nearly devoid of cover. *Saururus cernuus* and various species of *Carex* (*louisianica, crinita, lurida, gigantea, lupulina, radiata*, or others) are most often dominant, but *Boehmeria cylindrica*, *Leersia oryzoides, Persicaria punctata, Persicaria hydropiperoides*, *Juncus effusus, Justicia ovata, Pilea pumila*, or *Pluchea camphorata* may dominate patches. Other characteristic species include *Lobelia inflata, Mecardonia inflata, Triadenum walteri*, *Glyceria septentrionalis,* and *Peltandra virginica*. *Tillandsia usneoides* may be abundant on trees.

Range and Abundance: Ranked G3G4. In North Carolina, the Swamp Transition Subtype occurs along all of the brownwater rivers and may be in any part of the Coastal Plain. This subtype tends to become more prominent in the downstream portions of rivers. However, it may also be abundant in the lowest parts of upstream floodplains that are high enough to have little Cypress–Gum Swamp. The synonymized association is attributed to South Carolina, Mississippi, and questionably to Louisiana. As with the Low Subtype, this broad range suggests it may be too broadly defined. At the same time, the disjunct distribution suggests that something like it may be going unrecognized in the intermediate states.

Associations and Patterns: The Swamp Transition Subtype occurs in a mosaic, potentially with any other brownwater floodplain communities. It often grades to Cypress–Gum Swamp, but in higher floodplains it may take the place of Cypress—Gum Swamp as the wettest community of the local mosaic. It may grade to the Low or High Subtype, sometimes to Brownwater Levee Forest of any subtype. Conceptually, this subtype occurs on the slopes of ridges, but often it is not recognizable there unless there is a broad area at the right elevation.

Variation: No variants are recognized at present. This subtype appears to be narrowly defined. However, the distinction between those with *Quercus lyrata* or *Carya aquatica* and those with *Quercus laurifolia* as the only oak warrants investigation.

Dynamics: The dynamics of the Swamp Transition Subtype are similar to most Coastal Plain Floodplain communities and to many other forests. The influx of nutrients brought by flooding likely is a significant influence on them. Flooding is not generally a disturbance, but examples in sloughs that carry current may be subject to local scouring. Because they are low but not as flood-tolerant as Cypress–Gum Swamps, the Swamp Transition Subtype may be one of the communities most strongly affected by dam-caused alterations that increase the duration of low-level floods. Increased flooding and tree mortality or failure of regeneration would eventually make it indistinguishable from Cypress—Gum Swamp.

The Swamp Transition Subtype may be particularly susceptible to impoundment by beaver ponds, converting them into Coastal Plain Semipermanent Impoundment communities. See the discussion under Coastal Plain Semipermanent Impoundment. Because some of the trees in the Swamp Transition Subtype are tolerant of prolonged flooding, they may survive as a partial canopy in beaver ponds. The initial density of *Taxodium* and *Nyssa* may thus determine whether the Coastal Plain Semipermanent Impoundment community is the Cypress–Gum Subtype or the Coastal Plain Marsh Subtype. When a beaver pond is abandoned and drained, it may take some years for the community to return to Bottomland Hardwoods. In addition, deposition of clay in the pond may potentially change the environment. The natural abundance of beavers, how long their ponds lasted, and how much of the floodplain their ponds should affect under natural conditions is not known. Within large floodplains, sites where beavers can impound significant areas and escape destruction by flood flows are probably limited.

Comments: This subtype is compositionally intermediate between Bottomland Hardwoods and Cypress–Gum Swamp. Vegetation structure resembles a Cypress–Gum Swamp, with a low-diversity herb layer containing species such as *Saururus cernuus* or sedges. The boundaries between this community and adjacent ones do not seem to be defined in the same place in different studies and analyses, suggesting a very gradual transition. Attribution of CVS plots is somewhat uncertain. Nevertheless, a vegetation group comparable to this is apparent in both Rice et al. (2001) and Faestal (2012) on the Roanoke and the Tar River.

Rare species:
Vascular plants – *Cardamine douglassii*, *Carex lupuliformis, Carex socialis,* and *Leersia lenticularis*.

Vertebrate animals – *Liodytes rigida*.

BLACKWATER BOTTOMLAND HARDWOODS (HIGH SUBTYPE)

Concept: Blackwater Bottomland Hardwoods are forests of blackwater river terraces and floodplain ridges, generally dominated by wetland oaks and lacking a significant component of *Betula nigra* or *Planera aquatica*. The High Subtype covers higher examples which lack significant *Quercus lyrata* and which often have a significant component of *Pinus taeda* along with bottomland oaks.

Distinguishing Features: Blackwater Bottomland Hardwoods are distinguished by dominance or codominance by bottomland oaks on blackwater river floodplains, in sites where overbank flooding is, or has been, a significant ecological influence. They are distinguished from Brownwater Bottomland Hardwoods by more acid-tolerant composition and absence of brownwater species such as *Quercus pagoda, Fraxinus pennsylvanica*, *Acer negundo*, and *Asimina triloba*. Most of the plants typical of Blackwater Bottomland Hardwoods are also present in Brownwater Bottomland Hardwoods, but the more acid-tolerant species, such as *Persea palustris, Magnolia virginiana, Lyonia lucida*, and *Cyrilla racemiflora* generally are not, and *Clethra alnifolia* is more likely to be in the blackwater type. Nonriverine Wet Hardwood Forests may share some of these acid-tolerant undergrowth plants but generally have codominant or abundant *Quercus pagoda* or *Quercus michauxii*. Blackwater Bottomland Hardwoods are distinguished from Blackwater Levee/Bar Forest by lacking appreciable numbers of *Betula nigra* or *Planera aquatica*.

The High Subtype is distinguished from the Low Subtype and Swamp Transition Subtype by the absence or limited abundance of *Quercus lyrata, Nyssa biflora*, and *Taxodium distichum*. It is distinguished from the Evergreen Subtype by the absence of *Quercus virginiana* and the absence or near absence of *Chamaecyparis thyoides*.

Crosswalks: *Pinus taeda - Quercus laurifolia / Vaccinium elliottii - Arundinaria gigantea* Riparian Forest (CEGL004736).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Blackwater Bottomland Hardwoods occur on large blackwater river floodplains. The High Subtype occurs on the highest portions of the floodplain, on terraces and on the highest ridges in scrollwork ridge-and-swale systems. In contrast to brownwater rivers, where levee forests separate bottomland hardwoods from the river, Blackwater Bottomland Hardwoods often border the channel.

Soils: Blackwater Bottomland Hardwoods generally have sandy alluvial soils. Johnston (Cumulic Humaquept) is the only frequently mapped soil series, but Bibb (Typic Fluvaquent), Pactolus, or Chipley (Aquic Quartzipsamment) are sometimes mapped.

Hydrology: The High Subtype is intermittently flooded. Flooding probably occurs only in the highest floods and only for relatively brief periods. Soils may also sometimes be saturated by floods that don’t inundate them. When rivers are not in flood, the sites are well drained.

Vegetation: The High Subtype is a forest typically dominated by *Quercus laurifolia*. *Pinus taeda* is frequent and may codominate locally. *Liquidambar styraciflua, Acer rubrum* (var. *trilobum*?), and *Quercus nigra* are often present, and less frequently, *Quercus michauxii* may occur. The understory is usually dominated by *Ilex opaca, Carpinus caroliniana*, or *Persea palustris*, along with canopy species. *Magnolia virginiana* and *Diospyros virginiana* are also fairly frequent. The shrub layer is usually moderate to fairly dense. *Vaccinium elliottii* or *Arundinaria tecta* dominate patches. Other shrubs may include *Cyrilla racemiflora, Clethra alnifolia, Eubotrys racemosus*, or *Hypericum hypericoides*. Woody vines are frequent and maybe be locally abundant, especially *Smilax rotundifolia, Muscadinia rotundifolia*, and *Toxicodendron radicans*, but also fairly frequently *Gelsemium sempervirens, Campsis radicans, Smilax laurifolia*, and other *Smilax* spp. The herb layer usually is sparse. *Mitchella repens* or *Chasmanthium laxum* sometimes dominate patches. *Lorinseria areolata, Osmunda spectabilis,* or *Osmundastrum cinnamomeum* may occur, presumably in local wet spots though this is not always obvious. *Dichanthelium* spp. and *Elephantopus nudatus* may be scattered. *Tillandsia usneoides* and *Phoradendron serotinum* may be abundant as epiphytes. In a few places, blackwater bottomlands on riverbanks, where they are well drained when the river is low, may support some upland species in combination with the floodplain species. *Vaccinium arboreum* is the most frequent of these, but occasionally *Pteridium aquilinum, Carya pallida,* or *Quercus stellata* may occur.

Range and Abundance: Ranked G3G4. In North Carolina, this community is well developed only on the large blackwater rivers such as the Lumber, Black, and Northeast Cape Fear. It was once extensive in these areas, but as the driest of floodplain communities it is the most frequently altered by logging. On the Waccamaw River, it is largely replaced by the Evergreen Subtype. The community also occurs in South Carolina. The synonymized NVC association occurs in Georgia and potentially in Virginia and northern Florida.

Associations and Patterns: The High Subtype occurs as part of a floodplain mosaic with other subtypes and with Cypress–Gum Swamp.

Variation: No variants are recognized. Variation within a site often is greater than among sites. The presence of *Quercus michauxii* is infrequent, and it may be worth investigating whether it is indicative of different ecological conditions.

Dynamics: Dynamics are similar to other floodplain forests. While nutrient input from blackwater flooding is small compared to brownwater, it presumably is an important subsidy and contributes to making the community more productive than other forests of sandy soils.

The High Subtype is dry enough much of the time that fire is a possibility, and pines, when present, would provide flammable litter. However, individual patches are small and are separated by vegetation that is less flammable. The lack of a continuous flammable landscape presumably makes natural fire a rare event.

The mechanism for coexistence of shade-intolerant pines with more shade-tolerant oaks in the High Subtype and Evergreen Subtype, as in maritime forests and a few other communities, is not well known.

Comments: Plot data for this subtype appear to be scarce. There have not been intensive studies on any blackwater rivers comparable to those on the Roanoke and Tar. Most of the vegetation description here is based on site reports and the author's experience.

Rare species:
Vascular plants – *Carex reniformis* and *Ditrysinia fruticosa*.

Vertebrate animals – *Myotis rafinesquei*. Other rare bats likely also use this community.

BLACKWATER BOTTOMLAND HARDWOODS (LOW SUBTYPE)

Concept: Blackwater Bottomland Hardwoods are forests of blackwater river terraces and floodplain ridges, generally dominated by wetland oaks and lacking a significant component of *Betula nigra* or *Planera aquatica*. The Low Subtype encompasses examples at intermediate local elevations, which have a significant component of *Quercus lyrata* and generally lack a significant component of either *Pinus taeda*, *Taxodium distichum,* or *Nyssa biflora*.

Distinguishing Features: Blackwater Bottomland Hardwoods are distinguished by dominance or codominance by bottomland oaks on blackwater river floodplains, in sites where overbank flooding is, or has been, a significant ecological influence. The Low Subtype is distinguished from the High Subtype and the Evergreen Subtype by having abundant *Quercus lyrata* or occasionally by being almost pure *Quercus laurifolia* without plants indicative of drier sites. It is distinguished from the Swamp Transition Subtype by having little or no *Nyssa biflora* and *Taxodium distichum*, by having an herb layer dominated by more mesophytic species than *Saururus cernuus*, and generally by a well-developed shrub layer. It is distinguished from Blackwater Levee/Bar Forest, which may contain *Quercus lyrata*, by lacking appreciable numbers of *Betula nigra* or *Planera aquatica*.

Crosswalks: *Quercus laurifolia - Quercus lyrata / Carpinus caroliniana - Persea palustris / Vaccinium elliottii* Forest (CEGL004737).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Blackwater Bottomland Hardwoods occur on large blackwater river floodplains. The Low Subtype occurs at intermediate elevations relative to the river, on lower ridges or in lower parts of terraces. In contrast to brownwater rivers, where levee forests separate bottomland hardwoods from the river, Blackwater Bottomland Hardwoods of all subtypes often border the channel.

Soils: The Low Subtype generally has wet sandy alluvial soil that may be organic-rich. Johnston (Cumulic Humaquept) is the most frequently mapped soil series, but many examples are mapped as Muckalee (Typic Fluvaquent).

Hydrology: The Low Subtype is seasonally to frequently flooded. Flooding may last for significant periods but seldom through much of a growing season. Soils may also be saturated by floods that don't inundate them.

Vegetation: The Low Subtype is a forest dominated by *Quercus laurifolia* or *Quercus lyrata*, usually by both. *Acer rubrum* var. *trilobum* and *Liquidambar styraciflua* are frequent. Less frequent but characteristic species include *Carya aquatica* and *Ulmus americana*. The understory is frequently dominated by *Carpinus caroliniana* or *Acer rubrum* var. *trilobum*. *Ilex opaca* is frequently present but not usually dominant. *Persea palustris*, understory size *Cyrilla racemiflora, Crataegus* spp., *Diospyros virginiana*, or *Magnolia virginiana* may sometimes be abundant. The shrub layer is generally moderate or fairly dense. *Vaccinium elliottii* or *Ilex decidua* usually dominate. Other shrubs may include *Cyrilla racemiflora, Eubotrys racemosus*, *Vaccinium* *fuscatum*, *Sabal minor*, and on the Lumber River, *Ditrysinia fruticosa*. Vines may be locally abundant. *Muscadinia rotundifolia, Smilax rotundifolia, Smilax walteri, Smilax glauca, Campsis radicans, Berchemia scandens, Bignonia capreolata,* and *Thyrsanthella difformis* are all at least fairly frequent, and *Smilax laurifolia, Wisteria frutescens*, and *Gelsemium rankinii* sometimes occur. The herb layer is generally sparse. *Mitchella repens* or *Chasmanthium laxum* may dominate patches. *Boehmeria cylindrica, Mikania scandens,* and *Hypoxis curtisii* are fairly frequent, as are the epiphytes *Tillandsia usneoides* and *Pleopeltis michauxiana*. The latter sometimes forms extensive mats on spreading branches of oak trees in this community near the river, and these are occasionally habitat for the rare *Epidendrum conopseum*. *Dichanthelium yadkinense*, other *Dichanthelium* spp., *Centella erecta*, *Pluchea camphorata*, *Hymenocallis crassifolia*, and, on the Waccamaw River, *Hymenocallis pygmaea* are other characteristic species, while species of wetter areas, such as *Saururus cernuus* and various *Carex* species, may be present in small numbers.

Range and Abundance: Ranked G4? but possibly rarer. In North Carolina, the Low Subtype occurs on all the large blackwater rivers and is an important part of the floodplain mosaic of communities. It occurs in South Carolina. The synonymized NVC association has not been attributed to any other states but it or something comparable likely exists.

Associations and Patterns: The Low Subtype occurs as part of a floodplain mosaic with other subtypes and with Cypress–Gum Swamp. Conceptually it falls between the High or Evergreen Subtype and the Swamp Transition Subtype but well-developed patches of these are often not present adjacent to it.

Variation: No variants are recognized. Variation within a site often is greater than among sites. More systematic differences should be sought between the occurrences on the Waccamaw River and those on the other rivers.

Dynamics: Dynamics are similar to other floodplain forests. Unlike the brownwater rivers, no blackwater rivers have been altered by large dams. The influx of sediment during colonial times also was much less, since the watersheds contain only flatter Coastal Plain terrain with less clay and silt.

Comments: *Quercus laurifolia* / *Carpinus caroliniana* / *Justicia ovata* Forest (CEGL07348) is an association of low blackwater bottomland hardwoods that has been attributed to North Carolina. It appears to be more similar to the Swamp Transition Subtype but also appears to be redundant.

Rare species:
Vascular plants – *Carex reniformis, Ditrysinia fruticosa, Epidendrum conopseum, Hymenocallis pygmaea,* and *Rhynchospora decurrens*.

Vertebrate animals – *Corynorhinus rafinesquii macrotis, Liodytes rigida,* and *Rana heckscheri*.

BLACKWATER BOTTOMLAND HARDWOODS (EVERGREEN SUBTYPE)

Concept: Blackwater Bottomland Hardwoods are forests of blackwater river terraces and floodplain ridges, generally dominated by wetland oaks. The Evergreen Subtype covers examples on high to medium-height ridges and terraces that have a substantial component of *Quercus virginiana* or *Chamaecyparis thyoides*. This subtype is known to occur in North Carolina only on the Waccamaw River and its tributary Juniper Creek.

Distinguishing Features: Blackwater Bottomland Hardwoods are distinguished by dominance or codominance by bottomland oaks on blackwater river floodplains, in sites where overbank flooding is, or has been, a significant ecological influence. The Evergreen Subtype is distinguished from all other subtypes by having *Quercus virginiana* or *Chamaecyparis thyoides* present. The Evergreen Subtype is distinguished from Coastal Fringe Evergreen Forest and Swamp Island Evergreen Forest, which contain *Quercus virginiana*, by having floodplain species such as *Quercus laurifolia* and *Vaccinium elliottii*, by having acidic wetland species such as *Chamaecyparis thyoides*, and by generally lacking the drier upland species such as *Quercus hemisphaerica* and *Quercus geminata*. It can usually be distinguished by its topographic setting, but Swamp Island Evergreen Forest occurs on some higher ridges on terraces along the Waccamaw River in close proximity to Blackwater Bottomland Hardwoods.

Crosswalks: *Pinus taeda - Quercus laurifolia - Chamaecyparis thyoides - (Quercus virginiana) / Vaccinium elliottii* Riparian Forest (CEGL007548).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Blackwater Bottomland Hardwoods occur on larger blackwater river floodplains. The Evergreen Subtype occurs primarily on terraces but may occur on higher ridges in the active meander belt. It is only known on the Waccamaw River.

Soils: The Evergreen Subtype occurs on sandy alluvial soils. Most are mapped as Muckalee (Typic Fluvaquent).

Hydrology: The Evergreen Subtype is intermittently flooded. Flooding probably occurs only in the highest floods and only for relatively brief periods. Soils may also sometimes be saturated by floods that don't inundate them. When the river is not in flood, the sites are well drained.

Vegetation: The Evergreen Subtype is a forest typically dominated by *Quercus laurifolia*. *Pinus taeda* is usually present and sometimes codominates. *Chamaecyparis thyoides* or *Quercus virginiana*, often both, are widely distributed in stands. They seldom occur together in the limited number of plots but can be observed in close proximity. Other canopy species that are frequent and sometimes abundant are *Acer rubrum*, *Liquidambar styraciflua*, and somewhat less frequently, *Quercus nigra, Taxodium ascendens*, and *Nyssa biflora*. The understory is usually dominated by *Quercus laurifolia*, but *Ilex opaca, Persea palustris*, *Magnolia virginiana,* or tall *Cyrilla racemiflora* may have high cover. The shrub layer is often moderate to fairly dense. *Vaccinium elliottii* is most often dominant. Other frequent species, sometimes locally abundant, include

Clethra alnifolia, Lyonia lucida, Eubotrys racemosus, *Hypericum hypericoides,* and *Ilex myrtifolia*. Drier areas may have some *Vaccinium arboreum* or *Symplocos tinctoria*. Less frequent but notable species include *Sabal minor, Vaccinium formosum*, *Ilex decidua*, and *Diospyros virginiana*. Vines are common, though they are less prominent and less diverse than in wetter subtypes. Frequent species includer *Smilax laurifolia, Smilax rotundifolia, Smilax walteri, Smilax glauca, Muscadinia rotundifolia*, *Gelsemium sempervirens*, and *Toxicodendron radicans*. The herb layer is generally sparse. The only species with high constancy in the limited CVS plot data are *Mitchella repens* and epiphytic *Tillandsia usneoides*. Fairly frequent in plots or observations are *Osmunda spectabilis, Lorinseria areolata*, *Anchistea virginica*, *Centella erecta*, and *Zephyranthes atamasco*. *Sphagnum* is often present in scattered clumps. Other herbs that are less frequent but may be characteristic include *Chasmanthium laxum, Dichanthelium dichotomum* var. *dichotomum*, *Carex glaucescens, Carex verrucosa, Carex debilis*, *Rhynchospora perplexa*, other species of *Carex* and *Rhynchospora*, and epiphytic *Pleopeltis michauxiana*.

Range and Abundance: Ranked G2?, but the question mark probably is not needed. As far as is known, this community occurs only along the Waccamaw River and Juniper Creek, in North and South Carolina. The well-drained sites are suitable for loblolly pine plantation, and many examples have been converted.

Associations and Patterns: The Evergreen Subtype occurs as part of a floodplain mosaic on the Waccamaw River, along with the Low and Swamp Transition Subtypes and Cypress–Gum Swamp. It seems to take the place of the High Subtype that occurs along other rivers. Conceptually it grades to the Low Subtype.

Variation: Two variants are recognized, based on wetness:

1. Live Oak Variant occurs on the higher areas. *Quercus virginiana* is present but *Chamaecyparis thyoides* may be present or absent. *Taxodium ascendens* may also be present in these communities, though they occur at higher elevations than the Swamp Transition Subtype.

2. Atlantic White Cedar Variant occurs on somewhat lower areas. *Chamaecyparis thyoides* is common and *Quercus virginiana* is usually absent. *Taxodium ascendens* is more likely to be present and often is abundant, even co-dominant While this variant is interpreted as part of the Evergreen Subtype, it may be more like the Low Subtype in wetness. It may warrant recognition as a new subtype that is analogous to the Low Subtype in the same way that the Live Oak Variant of the Evergreen Subtype is analogous to the High Subtype.

Dynamics: Dynamics of the Evergreen Subtype are probably largely similar to other floodplain communities, especially to the High Subtype. As with the High Subtype, it is dry enough of the time that fire is a possibility, and pines, when present, would provide flammable litter. However, individual patches are small and generally are separated by sloughs that are not very flammable. The lack of a continuous flammable landscape presumably makes natural fire a rare event.

The factors that lead to the formation of this subtype on the Waccamaw River and not on other rivers are not known. Possible causes include the specific flood regime of the Waccamaw River, the elevation of the terraces relative to the river, the large size of the terraces, or something related to the nature of the alluvium. A number of species are shared with nonriverine wetlands, more than in other blackwater floodplain communities. This may suggest a reduced influence of flooding and a greater role of rainwater. At the same time, the mix of species includes ones with an unusually wide range of moisture tolerances, including a number that suggest wetter conditions than would be expected given the elevation above the river and the sandy soil.

The southerly location may also be important. *Quercus virginiana* is largely confined to maritime settings in North Carolina and does not range this far inland farther north. Nevertheless, while *Quercus virginiana* is common along rivers in states farther south, communities with the distinctive composition of the Evergreen Subtype are not known. The occurrence of *Chamaecyparis* is notable. Populations of this species to the north are in nonriverine wetlands with organic soils. Populations to the south are along small streams with mucky soils and seepage input. The occurrence on sandy mineral soils on the large floodplain of the Waccamaw River is unlike either.

The mechanism for coexistence of shade-intolerant pines with more shade-tolerant oaks in the High Subtype and Evergreen Subtype, as in maritime forests and a few other communities, is not well known. The question is more complex for the Evergreen Subtype, where the dynamics of the generally short-lived *Chamaecyparis* and means for its coexistence need explanation.

Comments: Though *Quercus laurifolia* is indicated as the dominant oak species, the identity of the laurel oaks on the Waccamaw River is somewhat uncertain. They seem different from the species elsewhere, with smaller and narrower leaves. A few observers have interpreted them as *Quercus hemisphaerica*, and many others have noted their unusual character.

Rare species:
Vascular plants – *Helenium brevifolium, Hymenocallis pygmaea,* and *Rhynchospora decurrens.*

BLACKWATER BOTTOMLAND HARDWOODS (SWAMP TRANSITION SUBTYPE)

Concept: Blackwater Bottomland Hardwoods are forests of blackwater river terraces and floodplain ridges, generally dominated by wetland oaks and lacking a significant component of *Betula nigra* or *Planera aquatica*. The Swamp Transition Subtype encompasses communities that are transitional to Cypress–Gum Swamp, having a mix of oaks with *Taxodium* or *Nyssa* in the canopy and having lower strata that are intermediate or are more similar to Cypress–Gum Swamp.

Distinguishing Features: Blackwater Bottomland Hardwoods are distinguished by dominance or codominance by bottomland oaks on blackwater river floodplains, in sites where overbank flooding is, or has been, a significant ecological influence. The Swamp Transition Subtype is distinguished from other subtypes by having a significant component of *Taxodium* and *Nyssa*, by lacking most herbs less water tolerant that *Saururus cernuus*, and usually by the absence of a well-developed shrub layer. It is distinguished from Cypress–Gum Swamp by having a substantial component of oaks.

The Swamp Transition Subtype may resemble the Oak-Gum Slough subtype of Nonriverine Wet Hardwood Forest but occurs on blackwater river floodplains rather than on nonriverine wet flats.

Crosswalks: *Quercus lyrata - Quercus laurifolia - Taxodium distichum / Saururus cernuus* Floodplain Forest (CEGL004735).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Blackwater Bottomland Hardwoods occur on large blackwater river floodplains. The Low Subtype occurs at elevations just above those that support Cypress–Gum Swamp, on lower ridges or in shallow sloughs. In some upstream areas, Cypress–Gum Swamp may be limited and the Swamp Transition Subtype may occupy the lowest areas.

Soils: The Swamp Transition Subtype has wet sandy alluvial soil that may be organic-rich. Johnston (Cumulic Humaquept) is the most frequently mapped soil series, but many examples are mapped as Muckalee (Typic Fluvaquent).

Hydrology: The Swamp Transition Subtype is seasonally flooded. Its flood regime is intermediate between the Low Subtype and Cypress–Gum Swamp, and it may be inundated well into the growing season. When not inundated, the water table may still be high and the soil saturated for significant periods. Patches in sloughs may carry flowing water with enough current to cause some local scouring.

Vegetation: The Swamp Transition Subtype is a forest dominated by combinations of *Quercus laurifolia* and *Quercus lyrata* with *Nyssa biflora* and *Taxodium distichum. Acer rubrum* var. *trilobum* or *Liquidambar styraciflua* are usually present and may be abundant. Small numbers of *Ulmus americana* or other species may be present in the canopy. The understory usually is dominated by *Fraxinus caroliniana, Carpinus caroliniana*, or *Acer rubrum* var. *trilobum*. *Persea palustris, Ilex opaca*, or large *Cyrilla racemiflora* may also be present. The shrub layer is usually sparse. Species may include *Ilex decidua, Vaccinium elliottii, Ilex laevigata, Eubotrys racemosus*, and *Alnus serrulata*. Vines are often prominent. High frequency species include *Muscadinia rotundifolia*, *Toxicodendron radicans, Smilax rotundifolia, Smilax walteri, Berchemia scandens, Bignonia capreolata, Campsis radicans, Parthenocissus quinquefolia*, *Smilax bona-nox*, and *Smilax glauca*. The herb layer generally is sparse, with the predominant species shared with Cypress–Gum Swamp as much as with other Bottomland Hardwoods subtypes. Frequent species include *Saururus cernuus, Boehmeria cylindrica, Triadenum walteri, Lorinseria areolata, Mikania scandens, Mitchella repens, Persicaria* spp., *Carex intumescens, Carex bromoides*, and other *Carex* spp. Other characteristic species include *Hypoxis curtisii, Lycopus virginicus, Osmunda spectabilis*, *Peltandra virginica, Apios americana,* and epiphytic *Tillandsia usneoides, Phoradendron leucarpum*, and *Pleopeltis michauxiana*.

Range and Abundance: Ranked G3G5, but probably truly G3. In North Carolina, the Low Subtype occurs on all the large blackwater rivers and may be an important part of the floodplain mosaic where it remains intact. However, the presence of this subtype often is not apparent in site descriptions, making it difficult to be certain how much remains. This community occurs in South Carolina but the synonymized NVC association has not been attributed to any other states.

Associations and Patterns: The Swamp Transition Subtype occurs as part of a floodplain mosaic with other subtypes and with Cypress–Gum Swamp. Conceptually it falls between the Low Subtype and Cypress–Gum Swamp, but well-developed patches of these are often not present adjacent to it.

Variation: No variants are recognized. Variation within a site is often greater than among sites.

Dynamics: Dynamics are similar to other floodplain forests.

Comments: The vegetation description for this subtype has less detail than for other subtypes. Plot data are scarce or are not recognized as this community. This subtype is also often not recognizable in site descriptions. It is, however, readily recognizable in the field, where it is seen in most segments of blackwater river floodplain.

Quercus laurifolia / Carpinus caroliniana / Justicia ovata Forest (CEGL07348) is an NVC association of low blackwater bottomland hardwoods defined in South Carolina and attributed to North Carolina. It appears to overlap the concept of this subtype but does not seem distinct enough to warrant recognition as a separate element. Areas with abundant *Justicia ovata* are present on the Black River.

Rare species:
Vascular plants – *Carex reniformis, Epidendrum conopseum, Hymenocallis pygmaea,* and *Sagittaria weatherbiana.*

Vertebrate animals – *Corynorhinus rafinesquii macrotis, Liodytes rigida,* and *Rana heckscheri*.

CYPRESS–GUM SWAMP (BROWNWATER SUBTYPE)

Concept: Cypress–Gum Swamps are wet forests dominated by combinations of *Nyssa* and *Taxodium*, flooded for long periods by overbank flow from rivers or streams. The Brownwater Subtype encompasses examples along large brownwater (alluvial) rivers which receive clay-rich floodwaters and have *Nyssa aquatica* as the primary canopy hardwood species.

Distinguishing Features: The Cypress–Gum Swamp type is distinguished by canopy dominance of combinations of *Taxodium* and *Nyssa* in a nontidal river floodplain setting that is not impounded. The distinction from Tidal Swamp (Cypress–Gum Subtype) can be subtle on the edges of tidal influence and where tidal flooding is primarily from irregular wind tides. However, *Morella cerifera, Juniperus silicicola,* and many herbs associated with Tidal Freshwater Marsh communities are good indicators of tidal conditions. Tidal swamps usually have a more open canopy created by stress from rising sea level, but this is not always the case.

Nonriverine Swamp Forests may also resemble Cypress–Gum Swamps, and the distinction may occasionally be subtle. Nonriverine conditions are marked by a substantial component of acid-loving understory and shrub species typical of pocosins, such as *Persea palustris, Magnolia virginiana, Lyonia lucida, Leucothoe axillaris*, and *Clethra alnifolia*.

Coastal Plain Semipermanent Impoundment (Cypress–Gum Subtype) is distinguished from Cypress–Gum Swamp by the presence of impounded water that does not drain with the fall of floods. This is generally marked by the loss of all but the most water-tolerant species, or by their confinement to elevated microsites such as tree bases. Floating aquatic plants often are present. The canopy generally is somewhat open in Semipermanent Impoundments.

The Brownwater Subtype is distinguished from the other subtypes by its association with brownwater rivers and by the strong dominance of *Nyssa aquatica* with little or no *Nyssa biflora* in the canopy. Backwater creeks, Coastal Plain tributaries that receive muddy water backing up from brownwater rivers as they flood, should be treated as the Brownwater Subtype if *Nyssa aquatica* is the primary hardwood.

Crosswalks: *Taxodium distichum - Nyssa aquatica / Fraxinus caroliniana* Floodplain Forest (CEGL007431).
G033 Bald-cypress - Tupelo Floodplain Forest.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Cypress–Gum Swamps occur in the lowest parts of floodplains, in sloughs, abandoned channel segments, overflow channels, swales, and backswamp basins. They may be present in sloughs on river terraces if they are low enough to flood frequently.

Soils: The Brownwater Subtype occurs on wet alluvial soils. Most have a higher clay content than those in the other brownwater communities, but those in overflow channels may be sandy. Most occurrences are mapped as Wehadkee (Fluvaquentic Endoaquept), Bibb (Typic Fluvaquent), Chewacla (Fluvaquentic Dystrudept), or Chastain (Typic Fluvaquent). A few areas, generally downstream, have organic soils and are mapped as Dorovan (Typic Haplosaprist).

Hydrology: Cypress–Gum Swamps are seasonally to frequently flooded. They may stay flooded well into the growing season and may be flooded again during the growing season by major storms or wet periods. While water may flow rapidly down the floodplain in major floods, in most Cypress–Gum Swamps the flood waters are stagnant for long periods. In the Brownwater Subtype, natural levees slow drainage when the river falls and prolong floods. Clay deposited in the still waters leads to impermeable soils that may perch water at the surface.

Vegetation: The Brownwater Subtype is dominated by varying combinations of *Nyssa aquatica* and *Taxodium distichum*. Most examples have at least a small amount of both, but a few may be exclusively one or the other. *Populus heterophylla* is fairly frequent, sometimes abundant, and may occasionally dominate. Other trees, such as *Acer rubrum* var. *trilobum*, *Fraxinus pennsylvanica*, and *Ulmus americana*, are present only in small numbers or in transitions to drier communities. The understory usually is dominated by *Fraxinus caroliniana*, but *Acer rubrum* var. *trilobum* may be abundant and *Acer negundo* is fairly frequent. Shrubs are sparse. *Ilex decidua, Itea virginica*, and *Cephalanthus occidentalis* are fairly frequent in plot data (Rice et al. 2001, Faestal 2012, CVS data). Woody vines are diverse and may have high cover locally, but their density is fairly low. Constant or fairly frequent species are *Toxicodendron radicans, Campsis radicans, Smilax rotundifolia, Muscadinia rotundifolia, Berchemia scandens,* and *Nekemias arborea*. *Smilax walteri* is recorded less frequently but is often observed. The herb layer ranges from largely absent to locally dense in patches. *Boehmeria cylindrica* and *Saururus cernuus* are highly constant and often dominant in patches. *Carex* species, most frequently *ludoviciana, lupulina, typhina, tribuloides*, but also often *gigantea* or *crinita*, may dominate patches. Other fairly frequent herbs in plots include *Bidens discoidea, Leersia oryzoides, Commelina virginica, Ludwigia palustris*, and the exotic *Murdannia keisak*. Less frequent characteristic species include *Lobelia inflata, Gratiola virginiana, Leersia virginica, Persicaria hydropiperoides*, *Viola* sp., and *Pluchea camphorata*. The epiphyte *Tillandsia usneoides* may have high cover, and *Pleopeltis michauxiana* may cover trunks and branches of some trees.

Range and Abundance: Ranked G5?. Examples are abundant along all of North Carolina's brownwater rivers and can cover large areas in the middle and outer Coastal Plain portions. Because wetness prevents conversion of these forests to agriculture or pine plantation and makes logging more difficult, more examples remain in relatively natural condition than is the case for most communities.

The synonymized NVC association ranges throughout the Southeast, from Virginia to Texas, making it one of the most wide-ranging communities in the NVC. The low species richness imposed by extreme wetness limits variation, but whether the community is sufficiently uniform through such a large range, more uniform than most other communities in the region, is unclear.

Associations and Patterns: Cypress–Gum Swamps occur in mosaics with other floodplain communities. In downstream parts of rivers, they may form large patches that occupy much of the area. In the middle and inner Coastal Plain, patches may be large in backswamp basins on large rivers but otherwise are linear bands or irregular patches along sloughs or swales. The Brownwater

Subtype usually grades to Brownwater Bottomland Hardwoods or Brownwater Levee Forest. While the Swamp Transition Subtype and the Low Levee Subtype, respectively, are conceptually the adjacent communities along the moisture gradient, they are not always recognizable. In practice, any brownwater community may be found bordering swamps. Coastal Plain Semipermanent Impoundment or Oxbow Lake communities may also be interspersed. Cypress–Gum Swamp grades downstream to Tidal Swamp.

Variation: With limited diversity of trees, examples vary primarily in the relative amounts of *Taxodium* and *Nyssa*, which may be natural or may be a result of past logging. Vegetation may vary among examples in backswamp basins, sloughs, and sandy overflow channels, but this is not well understood. The occasional examples dominated by *Populus heterophylla* may potentially be recognized as a Cottonwood Variant, but it is not clear what the ecological significance is of the different dominant.

Dynamics: While the dynamics of Cypress–Gum Swamps are similar to other floodplain communities, several aspects are different. Mattoon (1915) suggests reproduction is episodic and infrequent well beyond areas of permanent inundation. His observations in virgin stands found a patchy age structure, with even-aged groups making up a multi-aged stand. He reported some patches with concentric, progressively younger tree zones toward the middle. This suggests trees establishing as a basin was filled in, but he did not suggest this was the predominant means of regeneration. Any abandoned channel segments or isolated depressions in brownwater floodplains will be filled in by ongoing sediment deposition fairly quickly. Shankman (1991, 1993) suggested that all cypress regeneration was tied to channel migration in the Interior rivers he studied. This is not apparently so in North Carolina, but Stahle et al. (2012) confirmed the patchy age structure in the Blackwater Subtype in the Black River Swamp and the Brownwater Subtype likely is similarly patchy. The uncommon conditions that can lead to establishment of patches of cypress in the absence of geologically-created new habitat are not well known. Both dominant trees in this community are very tolerant of wind, and wind-thrown *Taxodium* are virtually never observed. *Nyssa aquatica* too is very tolerant of wind, but canopy gaps created by the most severe storms probably are important for *Taxodium* regeneration.

Taxodium distichum is highly tolerant of water and can survive even permanent flooding, but it cannot survive if its leaves are submersed. Thus, prolonged flooding prevents regeneration. In the wettest areas, seedlings may be able to establish only in unusually dry periods. In other settings, wet periods that reduce competition from other trees may be necessary.

It has been widely noted that cypress often failed to regenerate after early logging. It appears that the amount of *Taxodium* in most examples is now much less than in the past, though it is difficult to know how abundant it was and how it was distributed in the past. Broadwell (2000) emphasized that swamps logged after 1959 had good regeneration on the Roanoke River while stands logged before that did not, regardless of the logging technique or intensity. He suggested that the altered flood regime caused by dams constructed around that time is responsible, perhaps by causing longer low-level flooding that is stressful for competing trees.

Despite the wet habitat, Stahle et al. (1988) found that tree ring growth in *Taxodium* was positively related to rainfall. Stahle et al. (2012) suggested that flowing water brings oxygen and nutrients that enhance tree growth. They also noted the ability of *Taxodium* to adapt to changing water levels by producing new fine roots from trunks, knees, and upper roots at levels with good oxygenation. These fine roots can readily be seen at unusually low water levels. They noted that this adaptation is effective enough that the tree rings are a poor indicator of longer-term water level changes even as they are a good indicator of short-term rainfall patterns.

As the lowest elevation communities in the floodplain, Cypress–Gum Swamps along downstream parts of rivers are the first to be affected by the inland spread of tidal influence with rising sea level. While the canopy initially remains the same, as saturation becomes permanent and flooding becomes more frequent, the lower strata change to those characteristic of Tidal Swamp. Over time, increasing stress leads to thinning of crowns and eventually increasing tree mortality. In the Brownwater Subtype, sediment deposition may raise the floodplain surface enough to partly offset slow sea level rise. This is hard to demonstrate, but the extent of stressed Tidal Swamp is less at the mouths of most brownwater rivers than of blackwater rivers.

Cypress–Gum Swamps are the most susceptible brownwater floodplain communities to impoundment by beavers. Beaver dams on sloughs can flood narrow bands or larger backswamp basins. See the discussion under Coastal Plain Semipermanent Impoundment. Because *Taxodium* and *Nyssa aquatica* can tolerate permanent flooding, the swamp canopy often survives to become the canopy of the Cypress–Gum Subtype of Coastal Plain Semipermanent Impoundment. When the beaver pond is abandoned and drains, the canopy remains, and the community reverts to typical Cypress–Gum Swamp without having to regenerate. However, the speed at which the characteristic understory and herbs return is not well known.

Comments: *Nyssa aquatica* Forest (CEGL002419), which was recognized provisionally as a Tupelo subtype in earlier 4th approximation draft, has been dropped from the NVC. There is no clear way to distinguish swamps that naturally lack *Taxodium* from those that have lost it because of early logging. Virtually all examples are now dominated by *Nyssa*, with *Taxodium* occurring as a minority. It is unclear if any swamp forests that naturally lacked *Taxodium* occurred in North Carolina, but equally unclear that all swamps had it.

Rare species:
Vascular plants – *Carex crus-corvi, Carex lupuliformis, Carex socialis, Hottonia inflata, Leersia lenticularis, Lilaeopsis caroliniensis, Macbridea caroliniana, Oplismenus setarius, Paspalum fluitans, Phanopyrum gymnocarpon, Ranunculus flabellaris, Sagittaria weatherbiana, Torreyochloa pallida,* and *Triadenum* (*Hypericum*) *tubulosum*.

Vertebrate animals – *Elanoides forficatus, Liodytes rigida, Necturus lewisii, Noturus furiosus and Rana heckscheri*. The fishes can inhabit the swamp when it is flooded.

Invertebrate animals – *Catocala marmorata* and *Iridopsis cypressaria*.

CYPRESS–GUM SWAMP (INTERMEDIATE SUBTYPE)

Concept: Cypress–Gum Swamps are wet forests dominated by combinations of *Nyssa* and *Taxodium*, flooded for long periods by overbank flow from rivers or streams. The Intermediate Subtype covers examples where *Nyssa aquatica* and *Nyssa biflora* are both important components of the canopy or where *Nyssa aquatica* dominates along rivers or streams that are not brownwater rivers. They occur on rivers or creeks that have mineral sediment and pH levels between those of the Brownwater Subtype and Blackwater Subtype, or they may occur where calcareous influence in the river allows *Nyssa aquatica* to be abundant without mineral sediment input. This concept was included in the Blackwater Subtype of the Third Approximation but has been split out, narrowing the concept of the Blackwater Subtype.

Distinguishing Features: The Cypress–Gum Swamp type is distinguished by canopy dominance of combinations of *Taxodium* and *Nyssa* in a nontidal river floodplain setting that is not impounded. The Intermediate Subtype is distinguished from other subtypes by a canopy containing substantial amounts of both *Nyssa aquatica* and *Nyssa biflora* in a setting with some mineral sediment input or calcareous influence. Swamps that are more dominated by *Nyssa aquatica* but which are clearly not brownwater are also included here.

The distinction from Tidal Swamp (Cypress–Gum Subtype) can be subtle on the edges of tidal influence and where tidal flooding is primarily from irregular wind tides. However, *Morella cerifera, Juniperus silicicola,* and many herbs associated with Tidal Freshwater Marsh communities are good indicators of tidal conditions. Tidal swamps usually have a more open canopy created by stress from rising sea level, but this is not always the case.

The Intermediate Subtype is distinguished from Coastal Plain Small Stream Swamp, where occurring on small stream floodplains, by the strong canopy dominance by *Nyssa* or *Taxodium* throughout the community (sometimes *Acer rubrum* in successional condition). Coastal Plain Small Stream Swamp is reserved for floodplain communities having a more mixed forest composition driven by more microsite heterogeneity or by shorter hydroperiod. The 3rd Approximation was ambiguous about how to treat the uniformly wet small stream floodplains, but they are now classified as Cypress–Gum Swamp.

Crosswalks: *Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica* Floodplain Forest (CEGL007432).
G033 Bald-cypress - Tupelo Floodplain Forest.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).

Sites: The Intermediate Subtype occurs on rivers or creeks that originate in the Coastal Plain but that have characteristics between those of brownwater and blackwater streams. This subtype is most typically found along streams that drain clay-rich areas in the northeastern Coastal Plain. It may also occur where limestone increases the pH of river water, as along the upper Waccamaw River. It can also develop locally along backwater creeks, where blackwater and brownwater mix as floodwaters from a brownwater river are pushed upstream on a blackwater tributary. The swamp may occupy the full width of uniformly wet small to medium floodplains or may occur in mosaics on floodplains with more topographic variation.

Soils: Most Intermediate Subtype occurrences have organic soils, usually mapped as Dorovan (Typic Haplosaprist). Some are mapped as Johnston (Cumulic Humaquept) and a few as the alluvial soils of brownwater floodplains.

Hydrology: The Intermediate Subtype is seasonally to frequently flooded, with hydroperiods comparable to other Cypress–Gum Swamp subtypes. It may stay flooded well into the growing season and may be flooded again during the growing season by major storms or wet periods. In most settings the water flows slowly or may become stagnant. Streams that support the Intermediate Subtype lack the well-developed natural levees of the Brownwater Subtype, so water levels probably equilibrate more quickly with the changes in river levels.

Vegetation: The Intermediate Subtype is either dominated by a mix of *Nyssa aquatica, Nyssa biflora*, and varying amounts of *Taxodium distichum* or by *Nyssa aquatica* with or without *Taxodium*. Other trees are scarce or absent from the canopy. The understory may include *Fraxinus caroliniana, Acer rubrum* var. *trilobum*, *Fraxinus profunda, Persea palustris, Carpinus caroliniana*, or *Ilex opaca*. Shrubs are generally sparse. *Eubotrys racemosus, Itea virginica, Viburnum nudum, Alnus serrulata, Ilex verticillata, Arundinaria tecta*, or other species may be present in small numbers. Woody vines are often abundant, including *Toxicodendron radicans*, *Smilax rotundifolia, Smilax walteri, Muscadinia rotundifolia, Berchemia scandens, Smilax glauca, Bignonia capreolata*, and *Campsis radicans*. Herbs range from nearly absent to moderate in density. *Boehmeria cylindrica* and *Saururus cernuus* are the most constant. Other herbs include *Hydrocotyle prolifera, Persicaria punctata,* other *Persicaria* species, *Triadenum walteri, Lorinseria areolata, Osmunda spectabilis, Bidens discoidea, Pilea pumila, Carex gigantea*, other *Carex* species, and, at least on the Waccamaw River, *Rhynchospora corniculata* and *Hymenocallis pygmaea*.

Range and Abundance: Ranked G3G4. In North Carolina, the Intermediate Subtype is most widespread in the northern part of the Coastal Plain and is scattered elsewhere. Many examples are on short streams that drain to estuaries, suggesting its abundance may decline with rising sea level. The synonymized NVC association ranges from Virginia to Florida. It apparently is more abundant than the Blackwater Subtype in states to the south.

Associations and Patterns: The Intermediate Subtype most often occurs as large patches, filling featureless small to medium size floodplains. Many grade downstream to Tidal Swamp. A few occur in mosaics with other floodplain forests, which may be either blackwater or brownwater in character.

Variation: Too little is known to recognize variants. Differences between those on small floodplains and larger examples should be investigated. The large example on the upper Waccamaw River may be different from other examples.

Dynamics: The dynamics of this subtype are not specifically well known. The distinctive dynamics of *Taxodium distichum*, as discussed for the Brownwater and Blackwater subtypes, presumably apply to this subtype.

Because most examples of the Intermediate Subtype grade downstream to Tidal Swamp, their lower ends are subject to rising sea level and the inland extension of tidal influence. While the canopy initially remains the same, as saturation becomes permanent and flooding becomes more frequent, the lower strata change to those characteristic of Tidal Swamp. Over time, increasing stress leads to thinning of crowns and eventually increasing tree mortality.

Comments: The Intermediate Subtype is relatively recently recognized and needs further clarification. Plot data are not reliably attributed to it and many known sites are not well described, leaving only limited vegetation data. Beyond the mix of canopy dominants, its vegetation seems more generally to be intermediate between the Blackwater and Brownwater subtypes, with a varying mix of the plants of both.

Nyssa aquatica - *Nyssa biflora* Forest (CEGL007429) is an association that has been created for mixed *Nyssa* swamps on the edges of brownwater floodplains. Scarcity of *Taxodium* is believed to be natural in this situation, though the reason for it is not clear. It has been questionably attributed to North Carolina but no examples are known. It is unclear if it would be recognizable from the Intermediate Subtype described here, although the setting is different.

Rare species:
Vascular plants – *Carex lupuliformis, Carex reniformis, Chelone obliqua* var. *erwiniae*, *Epidendrum conopseum, Hymenocallis pygmaea, Leersia lenticularis, Macbridea caroliniana,* and *Sagittaria weatherbiana.*

Vertebrate animals – *Elanoides forficatus, Liodytes rigida,* and *Rana heckscheri*.

Invertebrate animals – *Iridopsis cypressaria* and *Viviparus intertextus*.

CYPRESS–GUM SWAMP (BLACKWATER SUBTYPE)

Concept: Cypress–Gum Swamps are wet forests dominated by combinations of *Nyssa* and *Taxodium*, flooded for long periods by overbank flow from rivers or streams. The Blackwater Subtype covers examples on Coastal Plain floodplains which lack clay sediment, where *Nyssa aquatica* is not a significant component of the canopy. They occur commonly both in sloughs of large blackwater rivers and filling the entire floodplain of many small streams.

The concept of the Blackwater Subtype has been narrowed from that in the 3rd Approximation, where it was defined to cover all streams with headwaters in the Coastal Plain. Here it includes only the most acidic and clay-free streams, those which lack *Nyssa aquatica*. Most of these are in the southern half of the state.

Distinguishing Features: The Cypress–Gum Swamp type is distinguished by canopy dominance by combinations of *Taxodium* and *Nyssa* in a nontidal river floodplain setting that is not impounded. The distinction from Tidal Swamp (Cypress–Gum Subtype) can be subtle on the edges of tidal influence and where tidal flooding is primarily from irregular wind tides. However, *Morella cerifera, Juniperus silicicola,* and many herbs associated with Tidal Freshwater Marsh communities are good indicators of tidal conditions. Tidal swamps usually have a more open canopy created by stress from rising sea level. This is not always the case but seems to be more frequent for blackwater swamps than brownwater.

The Blackwater Subtype is distinguished from the Intermediate and Brownwater subtypes by the absence of *Nyssa aquatica* as a significant canopy component, and by a more acid-tolerant flora in general. It is distinguished from the Blackwater Cove Subtype by a lack of the distinctive open canopy, large buttresses, and deep flooding of that subtype, and corresponding lack of abundant *Cephalanthus occidentalis* and *Planera aquatica*. The Blackwater Subtype is distinguished from Coastal Plain Small Stream Swamp, where occurring on small stream floodplains, by the strong canopy dominance by *Nyssa* or *Taxodium* throughout the community (sometimes *Acer rubrum* in successional condition). *Quercus* is absent and *Liquidambar* scarce or absent. Coastal Plain Small Stream Swamp is reserved for floodplain communities having a more mixed forest composition driven by more microsite heterogeneity or by a shorter hydroperiod. The 3rd Approximation was ambiguous about how to treat the uniformly wet small stream floodplains, but they now should be classified as Cypress–Gum Swamp.

Nonriverine Swamp Forest resembles the Blackwater Subtype more than other subtypes. Its setting is usually clearly not associated with a flowing river, but in ambiguous settings it may be distinguished by a more strongly acid-tolerant flora and dominant plants. While species such as *Lyonia lucida, Ilex glabra, Clethra alnifolia,* and *Smilax laurifolia* may occur in either community, they are usually moderate to dense in Nonriverine Swamp Forest and limited in Cypress—Gum Swamp.

Crosswalks: *Taxodium distichum - Nyssa biflora / Fraxinus caroliniana / Lyonia lucida* Floodplain Forest (CEGL004733).
G033 Bald-cypress - Tupelo Floodplain Forest.

Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: The Blackwater Subtype occurs along rivers and streams that originate in sandy parts of the Coastal Plain and carry very little clay or silt. Blackwater floodplains vary substantially in their microrelief. Some larger rivers have well-developed ridge-and-swale systems, numerous sloughs, terraces, and other evidence of widespread channel migration, though they have little natural levee development. In these complex floodplains, Cypress–Gum Swamp occurs in the lower portions, in sloughs and overflow channels, including those on the terraces. Small streams may sometimes have complex microtopography but many instead have flat, featureless floodplains which support Cypress–Gum Swamp throughout their width.

Soils: Soils in the Blackwater Subtype are sometimes a mix of sand and organic matter, sometimes deep organic material. Many are mapped as alluvial soils such as Muckaelee or Bibb (Typic Fluvaqents) but many others are mapped as Johnson (Cumulic Humaquept) or Dorovan (Typic Haplosaprist).

Hydrology: Like other Cypress–Gum Swamps, the Blackwater Subtype is seasonally to frequently flooded, with water often lasting well into the growing season and potentially rising again at any season. The blackwater rivers that flood this subtype are tannin-stained but not turbid and usually are very acidic. Blackwater rivers tend to have more variable water levels than the larger brownwater rivers, so floods may be more frequent but have shorter duration.

Vegetation: The Blackwater Subtype is dominated by *Nyssa biflora*, generally along with *Taxodium distichum* or *Taxodium ascendens*. With the exception of *Acer rubrum*, other trees are scarce or absent from the canopy. The understory may be dominated by *Fraxinus caroliniana,* by *Acer rubrum* var. *trilobum*, *Persea palustris,* or rarely by tree-size *Cyrilla racemiflora*. It may contain small numbers of *Carpinus caroliniana, Fraxinus profunda, Liquidambar styraciflua*, *Quercus laurifolia*, or *Ilex opaca*. Shrubs may be sparse to moderate in density. Most constant in CVS plot data and field observations are *Cyrilla racemiflora* and *Eubotrys racemosus*. Also fairly frequent in plots are *Itea virginica, Clethra alnifolia*, and *Ilex myrtifolia*, while *Lyonia lucida, Vaccinium formosum, Cephalanthus occidentalis*, or *Alnus serrulata* may be present. Woody vines are often abundant. *Toxicodendron radicans*, *Smilax rotundifolia, Smilax walteri,* and *Smilax laurifolia* are most constant in plot data, while *Muscadinia rotundifolia, Smilax glauca, Bignonia capreolata*, and *Campsis radicans* are frequently observed in plots or in site reports. Herbs range from nearly absent to moderate in density. *Boehmeria cylindrica* is the most constant species. *Mitchella repens, Lorinseria areolata,* and *Osmunda spectabilis* are frequent in plots. *Carex* spp. are collectively frequent; they include species shared with the Brownwater Subtype, such as *Carex louisianica, tribuloides, lupulina,* and *gigantea*, but also include species more typical of acidic wetlands such as *Carex glaucescens* and *radiata*. Other herbs may include *Ludwigia palustris, Bidens discoidea, Dulichium arundinaceum, Triadenum walteri, Mikania scandens, Pilea pumila*, *Persicaria hydropiperoides*, and other *Persicaria* species. *Hymenocallis crassifolia* or, on the Waccamaw River, *Hymenocallis pygmaea* may be locally abundant.

Range and Abundance: Ranked G3G4. This community is present on all of North Carolina's blackwater rivers and many of its smaller streams. The synonymized NVC association is attributed only to North Carolina and South Carolina. The conditions that give rise to the extreme development of blackwater become less prevalent farther south, and Coastal Plain rivers there are more closely related to the Intermediate Subtype.

Associations and Patterns: The Blackwater Subtype may occur as large patches, filling a featureless small to medium size floodplain. These may have a distinct channel, a network of anastomosing channels, or have no visible channel at all. On larger rivers, it occurs as part of a floodplain mosaic with various subtypes of Blackwater Bottomland Hardwoods and other floodplain communities. In the downstream parts of large floodplains it may again dominate large featureless flats that fill most or all of the floodplain. It may grade downstream to Tidal Swamp.

Variation: Two variants are presently defined, but several other kinds of variation warrant investigation.

1. Typic Variant includes most examples on large rivers and small streams.

2. Waccamaw Variant includes swamps on the Waccamaw River as well as Juniper Creek and potentially other tributaries. These have *Cyrilla racemiflora, Lyonia lucida*, and *Ilex myrtifolia* as prominent components and lack *Fraxinus caroliniana*. Their vegetation suggests a transition from blackwater to nonriverine conditions, though they do not fit Nonriverine Swamp Forest better in their vegetation or environment. *Hymenocallis pygmaea*, a narrow endemic species, often is an abundant herbaceous component.

Within the Typic Variant, examples on large floodplains and those on smaller ones likely have somewhat different dynamics and may have differences in biota driven by them. Examples also vary in the relative amounts of *Taxodium* and *Nyssa*, which may be natural or may be a result of past logging. The occurrence of *Taxodium distichum* and *Taxodium ascendens* needs further clarification and may suggest variants. Many individuals are ambiguous, making it difficult to sort out patterns of their abundance.

Dynamics: As discussed for the Brownwater Subtype, the population dynamics of *Taxodium distichum* are distinctive. Stahle et al. (2012) confirmed the patchy age structure suggested by Mattoon (1915) as general for cypress. Reproduction thus appears to occur in uncommon episodes in different small patches. Stahle et al. (1988) and Stahle et al. (2012) clarified the extreme longevity of *Taxodium distichum*. Under natural conditions, reproduction would not need to be very frequent to maintain its dominance. The conditions required for it are not known. Blackwater rivers and streams may undergo substantial channel migration, shifting microhabitats and creating new open areas where *Taxodium* could establish. However, it does not appear that most patches in North Carolina are of such geologic origin. It is possible that the cycles of wetter or drier weather on the scale of 30 years documented by Stahle (1988) could affect it. *Taxodium* is more tolerant of inundation than other trees, including *Nyssa biflora*.

Stahle et al. (2012) (and ongoing work) have documented the extreme age of cypress trees in this subtype along the Black River. Trees exceeding 2600 years old have been found, some of the oldest nonclonal plants in the world.

As in other Cypress–Gum Swamps, *Taxodium* often failed to regenerate after early logging, leaving most examples depleted in it. Regeneration appears limited in recently logged areas as well. In the absence of its regeneration, *Nyssa biflora*, already present at least as an understory, became dominant. The natural range of variation in relative abundance of these two species is not well known. While *Taxodium* likely was more abundant than now in any swamp that was logged, it is not obvious that it was the uniform dominant that is sometimes assumed. Where the author has observed second growth swamps that were apparently first logged more recently, so that ancient cypress stumps remain visible, the stumps are patchy in distribution and suggest in irregular varying mixture, as would be seen for any pair of codominant species in a forest.

As in the other subtypes, downstream parts of the Blackwater Subtype are being affected by rising sea level and are developing into Tidal Swamp. Without substantial new sediment deposition to raise ground levels as sea level rises, tidal influence often extends farther up blackwater rivers than brownwater. *Nyssa biflora* appears to be more susceptible to rising sea level, showing stress and then dying quickly, while what *Taxodium* is present survives as a sparse canopy into the stage of fully developed marsh. *Nyssa biflora* also appears less tolerant of rising sea level than *Nyssa aquatica*, but the different environment of brownwater and blackwater settings may explain this. Differences between lunar and wind tides may be important too. Low tide periods allow soil to drain and reduce stress on the trees, and the regular occurrence of low tides may help trees survive longer.

Comments: *Nyssa biflora - (Taxodium distichum)* Semi-natural Forest (CEGL004640) was defined as an association for modified versions of this subtype, where *Taxodium* has been removed by logging. It is now inactive and not treated as a standard association. It is generally impossible to determine how much *Taxodium* was present before early logging. Remnants of decay-resistant stumps suggest it was a patchy minority component even long ago, but it is not clear if this reflects conditions before the first logging. For conservation purposes, all examples should be regarded as the same subtype, in varying conditions.

Rare species:
Vascular plants – *Acmella repens, Bacopa caroliniana, Carex lupuliformis, Coreopsis palustris, Epidendrum conopseum, Ditrysinia fruticosa, Gelsemium rankinii, Hymenocallis pygmaea, Isoetes microvela, Leersia lenticularis, Ludwigia linifolia, Macbridea caroliniana, Oenothera riparia, Ponthieva racemosa, Rhynchospora decurrens, Rhynchospora microcarpa, Sabatia kennedyana, Sagittaria filiformis, Sagittaria weatherbiana, Scirpus divaricatus,* and *Scirpus lineatus*.

Nonvascular plants – *Cheilolejeunea discoidea. Cheilolejeunea rigidula, Fissidens amoenus* (*hallii*), *Fissidens hallianus, Lopholejeunea nigricans, Plagiochila patula,* and *Plagiochila raddiana.*

Vertebrate animals – *Anhinga anhinga, Elassoma boehlkei, Elanoides forficatus, Enneacanthus obesus, Liodytes rigida,* and *Rana heckscheri*. The fishes can inhabit the swamp when it is flooded.

Invertebrate animals – *Iridopsis cypressaria, Triodopsis soelneri,* and *Viviparus intertextus*.

CYPRESS—GUM SWAMP (BLACKWATER COVE SUBTYPE)

Concept: Cypress–Gum Swamps are wet forests dominated by combinations of *Nyssa* and *Taxodium*, flooded for long periods by overbank flow from rivers or streams. The Blackwater Cove Subtype encompasses distinctive examples in deeply flooded and somewhat lake-like abandoned channel segments that are connected to blackwater rivers (commonly named coves or backwaters). The vegetation has an open to closed canopy dominated by *Taxodium ascendens* or *Taxodium distichum* and a substantial understory of *Fraxinus caroliniana*, *Cephalanthus occidentalis*, or *Planera aquatica*. The known well-developed examples in North Carolina are all on the Waccamaw River.

Distinguishing Features: The distinctive vegetation and environment distinguishes the Blackwater Cove Subtype from the Blackwater Subtype. The canopy may be open to nearly closed, but the deep flooding and abundance of *Cephalanthus occidentalis* or *Planera aquatica* are distinguishing. Canopy trees are almost exclusively *Taxodium*, which have disproportionately broad and tall buttresses. Either *Taxodium ascendens* or *Taxodium distichum* may dominate. Some Oxbow Lake (Blackwater Subtype) occurrences may have zones of similar vegetation, but they are distinguished by lack of connection to the river (except in flood).

Crosswalks: *Taxodium ascendens / Fraxinus caroliniana - Cephalanthus occidentalis - (Planera aquatica)* Floodplain Woodland (CEGL004289).
G033 Bald-cypress - Tupelo Floodplain Forest.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).
Backwater (Schafale, Marty, and LeGrand 1985).

Sites: The Blackwater Cove Subtype occurs in elongate, triangular, or round low areas that project upstream from the river channel; they are exposed only at very low water. This community may fill the cove, or it may form a rim around treeless open water.

Soils: Soils in the Blackwater Cove Subtype are often mucky but may be sandy if current flows through them at high water. They are not specifically distinguished in soil mapping.

Hydrology: The Blackwater Cove Subtype is frequently flooded for long periods. Standing water may last for the entire growing season in wetter years. The flooding is often deeper than in other Cypress–Gum Swamps, with 2 meters of water not uncommon.

Vegetation: The Blackwater Cove Subtype canopy is dominated by either *Taxodium distichum* or *Taxodium ascendens*. The trees usually have a distinctive look, with very large, tall-buttressed bases, small trunks, and narrow crowns that produce limited shade. A well-developed understory is usually present, dominated by *Fraxinus caroliniana, Cephalanthus occidentalis*, or *Planera aquatica*. *Crataegus* sp. or *Ilex amelanchier* may also be present. When the water is down, herbaceous species typical of drawdown areas may be seen. *Eragrostis hypnoides, Eleocharis baldwinii,* or *Juncus repens* usually dominate. *Lindernia anagallidea*, *Hydrocotyle prolifera* (*verticillata* var. *triradiata*), and rare species such as *Sabatia kennedyana* or *Fimbristylis perpusilla* may be present.

Range and Abundance: Ranked G2G3 but likely rarer. The abundance and range of this community in North Carolina needs further clarification. Blackwater cove sites are present on the Black, Lumber, and Northeast Cape Fear rivers but are numerous and well developed only on the Waccamaw. It may be that distinctive examples of this community depend on the distinctive hydrological character of this river. This community was only recently recognized and was usually not distinguished in earlier site descriptions. Plot data too are limited because times when the water is low enough for sampling are uncommon. The synonymized NVC association also occurs in South Carolina and is questionably attributed to Georgia and Florida.

Associations and Patterns: The Blackwater Cove Subtype is a small patch community, with suitable sites scattered. It borders the river on one side. It often grades into the Blackwater Subtype in a slough upstream from the cove, where the canopy is dense, *Nyssa biflora* may be a major canopy component, and *Cephalanthus* and *Planera* are less abundant. It usually is bordered by Blackwater Bottomland Hardwoods, potentially any subtype, along the sides.

Variation: No variants have been recognized.

Dynamics: The specific dynamics of this subtype are not known. Given the inability of *Taxodium* seedlings and saplings to survive inundation of their crowns, tree regeneration must be a rare event dependent on prolonged drought. Most of the stands appear to be even-aged or two-aged. The distinctive herbaceous vegetation may grow vegetatively beneath the water or may persist as a seed bank until a dry year. Though water may flow through some of these areas during deeper floods, still water prevails, as they are not part of the river's regular current.

No sites comparable to the backwater coves have been noted on brownwater rivers. If such sites ever existed, they presumably were quickly filled with sediment. The persistence of deep water conditions seems to depend on the limited sediment deposition of blackwater rivers and may depend on the specific nature of the Waccamaw River.

Rare species:
Vascular plants – *Fimbristylis perpusilla, Rhynchospora decurrens,* and *Sabatia kennedyana*.

Vertebrate animals – *Elanoides forficatus, Liodytes rigida,* and *Rana heckscheri*.

Invertebrate animals – *Iridopsis cypressaria, Triodopsis soelneri,* and *Viviparus intertextus*.

SANDHILL STREAMHEAD SWAMP

Concept: The Sandhill Streamhead Swamp type covers very wet forests along mucky small streams in sandy terrain, which are dominated by combinations of *Nyssa biflora, Acer rubrum*, *Liriodendron tulipifera, Persea palustris*, and *Magnolia virginiana*, and have undergrowth of pocosin species. Either *Pinus taeda* or *Pinus serotina* may be present but are not dominant. These communities are conceptually intermediate between Cypress–Gum Swamp or Coastal Plain Small Stream Swamp, and Streamhead Pocosin, with the shrub and herb layers more related to the latter and the canopy more like the former.

Distinguishing Features: Sandhill Streamhead Swamps are distinguished from the closely associated Streamhead Pocosins by having canopy dominance by hardwoods, particularly including *Nyssa biflora*, rather than by *Pinus serotina*. The lower strata are often very similar.

Sandhill Streamhead Swamps are distinguished from Cypress–Gum Swamps by a more mixed canopy, which usually includes *Liriodendron tulipifera* and *Pinus serotina* as well as *Nyssa biflora*. *Taxodium ascendens* may be present in either but is rare in Sandhill Streamhead Swamp. Coastal Plain Small Stream Swamps have a mixed canopy that may contain many of the same species but usually contains additional species such as oaks. The well-developed shrub layer of Sandhill Streamhead Swamp, dominated by *Cyrilla racemiflora, Lyonia lucida, Ilex coriacea*, *Ilex glabra*, and other species shared with Streamhead Pocosin communities, is quite different from the open and more mixed shrub layer of Coastal Plain Small Stream Swamp and the sparse, more flood-tolerant shrub layer of Cypress–Gum Swamp.

Nonriverine Swamp Forests also have a substantial component of pocosin species but differ floristically. They are easily distinguishable by occurring in flat areas that lack seepage or overland flooding.

Crosswalks: *Nyssa biflora - Liriodendron tulipifera - Pinus (serotina, taeda) / Lyonia lucida* Swamp Forest (CEGL004734).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: Sandhill Streamhead Swamps occur along small to medium drainages in the Sandhills region, where seepage sustains saturated conditions. Because of their distinctive regime of steady flow, floodplain development is limited and fluvial landforms are not present. The sites are flat or may extend slightly up the bordering slopes, but they have little microtopography.

Soils: Soils are mucky sands or loams. They are usually mapped as Johnston (Cumulic Humaquept).

Hydrology: The hydrologic regime of streams in the Sandhills is distinctive because the porous sand around them leads to almost complete infiltration of rainfall and little surface runoff. Groundwater seepage maintains saturated conditions and supports stable stream flow. Overbank flooding is rare and sediment movement appears to be nonexistent away from the sandy channel itself.

Vegetation: Sandhill Streamhead Swamps may be closed or open forests. The canopy is a mix that includes *Nyssa biflora* in combination with *Liriodendron tulipifera, Acer rubrum* var. *trilobum*, *Pinus serotina, Pinus taeda*, *Persea palustris, Magnolia virginiana*, *Chamaecyparis thyoides*, and occasionally, *Liquidambar styraciflua* or *Taxodium ascendens*. The understory consists primarily of the same species but may also include *Ilex opaca* or *Oxydendrum arboreum*. The shrub layer is generally dense and is dominated by species shared with pocosins: *Cyrilla racemiflora, Lyonia lucida, Ilex coriacea, Ilex glabra, Persea palustris* and *Magnolia virginiana*. Less abundant but fairly frequent shrubs include *Aronia arbutifolia, Morella caroliniana, Vaccinium formosum, Rhododendron viscosum*, and *Arundinaria tecta*. *Xanthorhiza simplicissima* often is present near the channel. *Smilax laurifolia* may form tangles, and *Smilax rotundifolia, Smilax glauca*, or less commonly *Muscadinia rotundifolia* may be present but the diversity of other vines found in many swamp communities is usually absent. The herb layer usually is sparse, though it may be locally denser in open areas. *Lorinseria areolata*, *Osmundastrum cinnamomeum, Osmunda spectabilis*, and *Sphagnum* spp. are the most constant and usually most abundant species. Other herbs may include *Juncus effusus, Chasmanthium laxum, Viola primulifolia, Carex intumescens, Carex folliculata, Carex communis,* and other *Carex* spp.

Range and Abundance: Ranked G3?. Sandhills Streamhead Swamps are known only in the Sandhills region, though it is possible that similar conditions could exist locally elsewhere in the Coastal Plain. They are fairly abundant in the region in North Carolina. They also occur in South Carolina and possibly Georgia.

Associations and Patterns: Sandhill Streamhead Swamps are usually bordered by Pine/Scrub Oak Sandhill on adjacent upland slopes. Along drainages, Streamhead Pocosin usually occurs upstream. However, along a given drainage, Sandhill Streamhead Swamp, Streamhead Pocosin, Streamhead Atlantic White Cedar Forest, Streamhead Canebrake, and Coastal Plain Semipermanent Impoundment may occur in any order.

Variation: Examples vary in the amount of the various canopy trees, but it is unclear how much of this variation is natural and how much results from logging history or effects of fire exclusion.

Dynamics: The dynamics of Sandhill Streamhead Swamps appear to differ from most floodplain communities. Flooding is of marginal importance. Given the low nutrient status of soils and water, what flooding there is probably provides little nutrient subsidy. Because they occur along small streams that are closely bordered by longleaf pine communities, Sandhill Streamhead Swamps are frequently exposed to fire. The dense shrub layer makes them susceptible to burning, at least under some circumstances. Many examples show evidence of fire. Without a large component of pine with its flammable litter, they probably burn less intensely and less frequently than Streamhead Pocosins, but fire presumably is an important natural process in them.

The factors that lead to the occurrence of this community rather than others that may occur along Sandhills drainages are not entirely clear. Streamhead Pocosins probably occur where fire is more frequent, and Streamhead Canebrakes where it is most frequent. Streamhead Atlantic White Cedar Forests presumably need less frequent but occasional fire. It is possible these communities represent a shifting mosaic, where one may change into another over time. However, given that all may occur in the same present-day landscape with similar management regimes, such shifts must be uncommon. Given the limited mobility of *Arundinaria tecta* and *Chamaecyparis thyoides*, it seems unlikely that communities dominated by them could shift around very frequently. However, the presence of *Arundinaria* in many Sandhill Streamhead Swamps may allow for rapid development of canebrakes if fire frequency becomes high. It is also plausible that these different communities represent alternative stable states, where the flammability of the vegetation perpetuates a fire regime that allows it to persist after a rare establishing event. A further possibility is that unrecognized site differences affect the tendency to burn and lead to a stable mosaic of communities under natural conditions.

The dynamics of beaver ponds similarly are uncertain. If beavers create dams at random or systematically, their ponds and recovering vegetation may create a shifting mosaic under natural conditions. Alternatively, beavers may have preferred pond sites while other streamhead areas would never see impoundment. It is possible that the Sandhill Streamhead Swamp community would establish itself more readily than other communities in drained beaver ponds, so that past impoundment is the key to present occurrence of this community.

Comments: Sandhill Streamhead Swamp is newly recognized with the Fourth Approximation. Occurrences of it were variously treated as Cypress–Gum Swamp (Blackwater Subtype) and Coastal Plain Small Stream Swamp (Blackwater Subtype) in the 3rd Approximation. They resemble the latter in the intermittent flooding regime, location along small streams, and common admixture of pines in the canopy. They resemble the former in usual dominance by *Nyssa biflora* and long hydroperiod. They are distinct from either in being closely related to Streamhead Pocosins, floristically and spatially. Almost all of the understory, shrub, vine, and herb layer plants are shared with Streamhead Pocosin communities; only the canopy differs.

The placement of the crosswalked association in the Coastal Plain Hardwood Basin Swamp Group is problematic. This is a community of small streams, not basins or nonriverine flats, though it shares substantial flora with swamps in these settings.

Rare species:
Vascular plants – *Carex austrodeflexa, Eupatorium resinosum,* and *Schoenoplectus etuberculatus.*

Vertebrate animals – *Hyla andersonii.*

COASTAL PLAIN SMALL STREAM SWAMP

Concept: Coastal Plain Small Stream Swamp communities are forests of small floodplains that have microtopography such as ridges and sloughs on a scale too small to differentiate distinct communities. They usually support a mix of species with different moisture tolerances from very wet to mesic, because of fine-scale elevational variation. Uniformly wet small floodplains may support Cypress–Gum Swamp instead.

Distinguishing Features: Coastal Plain Small Stream Swamps are distinguished from all other floodplain communities by having a mixed composition of plants with very different flooding tolerance growing in close association along a stream with only small fluvial landforms. The canopy will usually include *Nyssa* or *Taxodium* along with substantial bottomland oaks, other bottomland hardwoods, and often pines. They are distinguished from Cypress–Gum Swamps in smaller floodplains by having a greater diversity in the canopy, and generally in all strata. They are distinguished from Mesic Mixed Hardwood Forests by having a significant component of wetland species and by occurring on a floodplain. They are distinguished from Sandhill Streamhead Swamps, which occur on similar size floodplains and also have a mixed composition, by having a broader mix of plants that is not limited to the most acid-tolerant "pocosin" species. Species such as *Quercus laurifolia, Quercus michauxii, Carpinus caroliniana*, and most of the vines and herbs listed below are not found in Sandhill Streamhead Swamps, while *Pinus serotina* is not found in Coastal Plain Small Stream Swamps.

Crosswalks: *Nyssa biflora - Quercus nigra - Quercus laurifolia - Pinus taeda / Carpinus caroliniana* Riparian Forest (CEGL007350).
G034 Oak - Sweetgum Floodplain Forest Group.
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: Coastal Plain Small Stream Swamps occur in the floodplains of small-to-medium size streams. They generally have microtopography created by sediment deposition and channel migration, such as slough, ridges, and small natural levees. These create a diversity of site conditions at a scale too small to support recognizable patches of Bottomland Hardwoods or Cypress–Gum Swamps.

Soils: Coastal Plain Small Stream Swamp soils are heterogeneous in drainage, texture, and organic content, both among sites and potentially at a fine scale within sites. A diversity of soil series are mapped, most frequently Muckalee and Bibb (Typic Fluvaquents), but also Johnston (Cumulic Humaquept). A significant minority are mapped as organic soils such as Dorovan (Typic Haplosaprist) or Croatan (Terric Haplosaprist).

Hydrology: Coastal Plain Small Stream Swamps are generally seasonally flooded but some may flood more or less often. Floods are usually of shorter duration than in larger floodplains, rising and falling more quickly because of the smaller watersheds. Many of the creeks have enough current during floods to scour local areas. While they carry little fine sediment compared to brownwater rivers, those in watersheds with clayey or loamy soils may carry some. Wetness when not in flood is heterogeneous. Low areas may remain saturated for long periods, and local areas may receive seepage from adjacent uplands.

Vegetation: Coastal Plain Small Stream Swamps are forests with extremely variable composition and generally a mix of species with different moisture tolerances. Most have no clear dominant tree. Highly constant species in CVS plot data, which may also codominate locally, include *Liquidambar styraciflua, Quercus nigra, Quercus laurifolia, Acer rubrum* var. *trilobum*, *Pinus taeda, Liriodendron tulipifera,* and *Nyssa biflora*. Also fairly frequent are *Quercus michauxii, Taxodium distichum, Quercus alba*, *Carya cordiformis*, and *Fagus grandifolia*. The understory may be dominated by *Carpinus caroliniana, Ilex opaca, Persea palustris*, or *Magnolia virginiana*, as well as canopy species. The shrub layer is usually moderate in density. The most constant shrubs include *Arundinaria tecta, Euonymus americanus, Cyrilla racemiflora*, and *Viburnum nudum*. Also fairly frequent are *Clethra alnifolia, Eubotrys racemosus, Morella cerifera, Lyonia lucida, Leucothoe axillaris*, and *Swida* (*Cornus*) *stricta*. Less frequent in plots but sometimes notably abundant are *Sabal minor, Vaccinium fuscatum, Vaccinium formosum, Hamamelis virginiana*, and *Lindera benzoin*. A wide range of woody vines may occur, including *Toxicodendron radicans, Smilax rotundifolia, Bignonia capreolata, Hydrangea (Decumaria) barbara*, *Muscadinia rotundifolia, Parthenocissus quinquefolia, Smilax glauca, Smilax bona-nox, Smilax walteri, Campsis radicans, Gelsemium sempervirens*, and *Berchemia scandens*. The herb layer may range from sparse to dense and may be quite variable among microsites within the community. The most constant species in plot data are *Mitchella repens, Lorinseria areolata*, and *Osmunda spectabilis*, but additional species that are fairly frequent include *Boehmeria cylindrica, Osmundastrum cinnamomeum, Athyrium asplenioides, Dioscorea villosa, Carex debilis, Carex gigantea, Leersia virginica, Chasmanthium laxum, Dichanthelium boscii, Triadenum walteri, Hexastylis arifolia, Impatiens capensis*, and *Lycopus virginicus*. Clumps of *Sphagnum* spp. may be present locally.

Range and Abundance: Ranked G4? Coastal Plain Small Stream Swamps are common throughout the parts of the Coastal Plain beyond tidal influence. They are often left in recognizable condition even when the surrounding uplands have been heavily altered, though they are often young or altered because their narrowness makes them easy to log. The synonymized NVC association is attributed to states from North Carolina to Alabama, including Florida.

Associations and Patterns: Coastal Plain Small Stream Swamps are a regular part of the landscape mosaic in dissected areas other than the Sandhills region. Some are bordered by Mesic Mixed Hardwood Forest, Dry-Mesic Oak–Hickory Forest, or Basic Mesic Forest on steep bluffs. Those in less steep terrain are naturally bordered by longleaf pine communities. Those near enough to the coast may grade to Tidal Swamps downstream, while others will end at a large blackwater or brownwater river floodplain.

Variation: Coastal Plain Small Stream Swamp is one of the most variable communities in the Fourth Approximation. Recognition of variants or subtypes is needed; however, the variation has not been sorted out enough to do so. Several associations in NVC appear to overlap this concept, but they do not fit the occurrences in North Carolina well and do not appear to represent a good division of subtypes for North Carolina occurrences. Instead, there may be variation between those in sandy areas and those in loamy or clay-rich areas, analogous to the difference between the Blackwater and Intermediate subtypes of Cypress–Gum Swamp. There may be differences based on stream gradient.

Dynamics: Most of the dynamics of Coastal Plain Small Stream Swamps are similar to those of blackwater floodplain communities. Flooding brings little sediment but likely provides some nutrient subsidy.

The role of fire is not well known but likely is limited under natural conditions. Those at the bottom of steeper slopes or bordered by mesophytic vegetation are naturally sheltered from fire. Those bordered by longleaf pine communities were naturally exposed to fire frequently. However, the predominantly forb and fern herb layers are not highly flammable during the growing season and wetness limits fire penetration in much of the winter. Floods which redistribute litter also reduce the ability of these communities to carry fire.

More than most other floodplain communities, Coastal Plain Small Stream Swamps are subject to the dynamics of beaver behavior. Beaver dams may turn them quickly into Coastal Plain Semipermanent Impoundment communities. Once ponds drain, it may take many years for the typical forest to return. It is not known how much of the landscape's small stream floodplains were impounded by beavers under more natural conditions, nor whether ponds shifted frequently or were relatively stable. In the last two to three decades, beavers have impounded many of the small streams in some parts of the Coastal Plain.

Comments: This community type has been narrowed from the definition in the 3rd Approximation. Pocosin-like small stream bottoms in sandhill terrain have been put into the Sandhill Streamhead Swamp type, and those strongly dominated by *Nyssa* or *Taxodium* have been put into Cypress–Gum Swamp. Coastal Plain Small Stream Swamp remains for small streams that have more mixed canopies due to variable flooding and fine-scale microtopography. The Brownwater Subtype in the 3rd Approximation has been dropped, as no well-developed examples were found.

This community has had relatively little study. Bledsoe (1993) described the microsite variability of vegetation along one stream, including an interesting mix of species typical of blackwater and brownwater rivers in different microsites. A moderate number of CVS plots have been collected.

Rare species:
Vascular plants – *Baccharis glomeruliflora, Carex austrodeflexa, Carex godfreyi, Carex lupuliformis, Carex lutea, Chasmanthium nitidum, Cyperus virens, Eupatorium resinosum, Gelsemium rankinii, Hottonia inflata, Isoetes microvela, Lindera subcoriacea, Luziola fluitans, Macbridea caroliniana, Malaxis spicata, Ponthieva racemosa, Scirpus lineatus,* and *Trillium pusillum sensu lato*.

Nonvascular plants – *Fissidens hallii, Lejeunea bermudiana,* and *Plagiochila raddiana*.

Vertebrate animals – *Liodytes rigida.*

Invertebrate animals – *Ptichodis bistrigata*.

OXBOW LAKE (BROWNWATER SUBTYPE)

Concept: Oxbow Lakes are permanently flooded open water depressions in large floodplains, isolated from the river by channel shifts. Most are largely unvegetated, but they may contain sparse vegetation, a more vegetated edge, or patches of woody or herbaceous wetland plants of various kinds. The Brownwater Subtype covers those along brownwater rivers, which receive substantial mineral sediment input. They typically have an edge zone containing *Taxodium distichum, Nyssa aquatica*, *Platanus occidentalis,* or *Betula nigra*.

Distinguishing Features: Oxbow Lake communities are distinguished from Cypress–Gum Swamps by being wet enough to lack a closed tree canopy. They are distinguished from Semipermanent Impoundment communities by occurring in closed, undammed basins created by an abandoned river channel. This setting produces an aquatic community that is isolated from both the river and from flowing water input except in floods.

The Brownwater Subtype can usually easily be distinguished by the character of the river and the occurrence of brownwater communities adjacent to it. It typically has an edge zone containing brownwater species such as *Platanus occidentalis* or *Fraxinus pennsylvanica* as well as the more widespread *Taxodium distichum* and *Betula nigra*.

Crosswalks: Not covered in NVC.
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Oxbow Lake communities occur in large floodplains in segments of former river channels that have become isolated from the river by channel shifts. Deposition along the new river course has closed them off, turning them into basins that hold permanent water and are not connected to the river except during floods.

Soils: Oxbow Lake soils are treated as inclusions or mapped as water in soil surveys. The substrate is alluvial material. The bed presumably is initially sandy, but over time clay is deposited.

Hydrology: Oxbow Lakes are permanently flooded, drying, if ever, only in extreme drought. Except during floods, the water is stagnant and any suspended clay can settle out. In the Brownwater Subtype, floods bring pulses of sediment-laden water.

Vegetation: The interior of Oxbow Lake communities is open water, generally without any emergent vegetation. The aquatic vegetation is poorly known. The edges generally are lined with trees, which most often include *Platanus occidentalis, Salix nigra, Taxodium distichum, Nyssa aquatica,* or *Nyssa biflora,* less often *Populus heterophylla, Ulmus americana, Quercus lyrata, Carya aquatica*, or other species of brownwater floodplains. *Cephalanthus occidentalis* or *Swida (Cornus) stricta* may form a shrubby edge in places. Herbs on the edges may include *Persicaria* spp., *Echinodorus cordifolius, Carex* spp. (*lurida, typhina, gigantea,* and potentially many other species), *Boehmeria cylindrica, Proserpinaca pectinata, Sagittaria latifolia, Hydrocotyle prolifera*, *Onoclea sensibilis, Bidens frondosa,* and *Pluchea camphorata*.

Range and Abundance: No G-rank is assigned. In North Carolina, the Brownwater Subtype is extremely rare, with only a handful of examples known. Oxbow Lakes are not recognized in the NVC but they potentially could occur throughout the Southeast.

Associations and Patterns: Oxbow Lakes are small patch communities. They may occur as isolated lakes or several may occur in close proximity. They are embedded in the floodplain community mosaic of Cypress–Gum Swamp, Brownwater Bottomland Hardwoods, and Brownwater Levee Forest of various subtypes.

Variation: No patterns of variation have been identified. Each of the handful of examples is different in its bordering vegetation.

Dynamics: Oxbow Lakes are geologically driven communities. They are created by channel shifts, which appear to be rare events in North Carolina's floodplains. When a meander is cut off, it initially remains connected to the river as a backwater, but sediment deposition on the riverbank fairly quickly isolates it from the river. It will then gradually fill with sediment carried in by floods. It is unclear how long this process takes, but the rarity of oxbow lakes on brownwater rivers suggests they are not geologically long-lived.

Vegetation dynamics may resemble a form of primary succession. The trees on the edge include species that readily establish on newly deposited material, such as *Salix nigra*, species common on riverbanks, such as *Platanus occidentalis*, and species of very wet areas, such as *Taxodium distichum* and *Nyssa aquatica*. As the water becomes shallower with ongoing sediment deposition, these species may spread toward the center. Ultimately the open water will be eliminated, and the depression will succeed to Cypress–Gum Swamp, with the long-lived dominants of that community accumulating over time. A similar process of primary succession was described by Shankman (1991, 1993) for rivers in western Tennessee.

Comments: These communities are not well known. The vegetated portions of them, if any, somewhat resemble the primary successional communities of bars or backwaters along the rivers, but water levels fluctuate less and they have less disturbance. The aquatic animal and planktonic communities can be expected to be more distinctive, because they are free from interaction with the river community for long periods. These communities are substantially aquatic rather than terrestrial but are part of the Palustrine System of Cowardin because of their small size.

Rare species:
Vascular plants – *Didiplis diandra* and *Hottonia inflata.*

Vertebrate animals – *Rana heckscheri*.

OXBOW LAKE (BLACKWATER SUBTYPE)

Concept: Oxbow Lakes are permanently flooded open water depressions in large floodplains, isolated from the river by channel shifts. Most are largely unvegetated, but they may contain sparse vegetation or patches of woody or herbaceous wetland plants of various kinds. The Blackwater Subtype covers examples on blackwater rivers. They typically have an edge zone containing *Taxodium distichum, Nyssa biflora, Liquidambar styraciflua, Planera aquatica*, or *Cephalanthus occidentalis*.

Distinguishing Features: Oxbow Lake communities are distinguished from Cypress–Gum Swamps by being wet enough to lack a closed tree canopy. They are distinguished from Semipermanent Impoundment communities by occurring in closed, undammed basins created by an abandoned river channel. This setting produces an aquatic community that is isolated from both the river and from flowing water except in floods. The Blackwater Subtype can usually be distinguished easily by the character of the river and the occurrence of blackwater communities adjacent to it. The edge zone will lack brownwater species such as *Platanus occidentalis* and will probably contain only more broadly tolerant species such as *Taxodium distichum* and *Betula nigra*. On the Waccamaw and Lumber Rivers, as well as in states to the south, *Planera aquatica* may be abundant.

Crosswalks: Not covered in NVC.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Oxbow Lake communities occur in large floodplains in segments of former river channels that have become isolated from the river by channel shifts. Deposition along the new river course has closed them off, turning them into basins that hold permanent water and are not connected to the river except during floods.

Soils: Oxbow Lake soils are treated as inclusions or mapped as water in soil surveys. The substrate is alluvial material. The bed presumably is initially sandy, and given the lack of clay in blackwater rivers, it may stay sandy or may fill with organic matter.

Hydrology: Oxbow Lakes are permanently flooded, drying, if ever, only in extreme drought. Except during floods, the water is stagnant. In the Blackwater Subtype, floods bring little in the way of sediment or nutrients.

Vegetation: The interior of Oxbow Lake communities is open water, generally without any emergent vegetation. The aquatic vegetation is poorly known. The edges generally are lined with trees, which in the Blackwater Subtype most often are *Taxodium distichum, Taxodium ascendens*, and on the Waccamaw River, *Planera aquatica*. *Quercus lyrata, Quercus laurifolia*, or *Liquidambar styraciflua* may line them where the edges are steeper. Most descriptions do not note any emergent herbs.

Range and Abundance: No G-rank is assigned yet. In North Carolina, the Blackwater Subtype is known on all the large blackwater rivers but only the Waccamaw River has more than one or two.

They are more abundant in South Carolina, with several dozen occurring on the Little Pee Dee River a short way south of the state line. Oxbow Lakes are not recognized in the NVC but this subtype potentially could occur wherever there are blackwater rivers.

Associations and Patterns: Oxbow Lakes are small patch communities. They may occur as isolated lakes or several may occur in close proximity. They are embedded in the floodplain community mosaic of Cypress–Gum Swamp and Blackwater Bottomland Hardwoods of various subtypes.

Variation: No patterns of variation have been identified.

Dynamics: Oxbow Lakes are geologically driven communities. They are created by channel shifts, which appear to be rare events in North Carolina's floodplains. When a meander is cut off, it initially remains connected to the river as a backwater. It becomes an oxbow lake only if sediment deposition blocks the connection or the channel migrates farther away. The abundance of backwaters, greater than of oxbow lakes, suggests that is not inevitable. On blackwater rivers, the lack of fine sediment means that lakes do not fill as rapidly as on brownwater rivers, persisting until the much slower accumulation of organic matter fills them.

Comments: These communities are not well known. The vegetated portions of them, if any, resemble the primary successional communities of bars or backwaters along the rivers, but water levels fluctuate less and they have less disturbance. The aquatic animal and planktonic communities can be expected to be more distinctive because the environment is free from interaction with the river community for long periods. These communities are substantially aquatic rather than terrestrial but are part of the Palustrine System because of their small size.

Rare species:
Vascular plants – *Didiplis diandra* and *Torreyochloa pallida*.

Vertebrate animals – *Rana heckscheri*.

SAND AND MUD BAR (BROWNWATER SUBTYPE)

Concept: Sand and Mud Bars are communities of soft sediment deposits along rivers, nonforested because of recent deposition, frequent reworking, or frequent scouring. Vegetation generally is sparse or patchy. The Brownwater Subtype occurs along brownwater rivers, where clay deposition and circumneutral water chemistry influence the community.

Distinguishing Features: The Sand and Mud Bar type is distinguished by the combination of occurrence on soft sediments along a low-lying river shoreline and lack of a well-developed tree canopy. Vegetation ranges from herbs to shrubs, often at low density; tree cover is low to nonexistent, though more cover may be created by trees leaning in from adjacent forests. Sand and Mud Bars should be recognized only where the patch is wider than the narrow band of shrubs present on most riverbanks. The Brownwater Subtype is distinguished by occurring on brownwater rivers. It contains species typical of brownwater systems that don't occur on blackwater rivers, such as *Platanus occidentalis, Acer negundo*, and *Fraxinus pennsylvanica*.

Crosswalks: No NVC association appears to cover this community.
G978 Eastern North American Riverine Sand-Gravel Bar Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).

Sites: Sand and Mud Bar (Brownwater Subtype) communities occur wherever well-developed bars are present along brownwater rivers. Most are point bars on the insides of meanders, but they may occur on bars along straight reaches as well. Bars vary in slope and in elevation above the river but are lower than the riverbanks.

Soils: No well-developed soil is present on the bars. The substrate consists of newly deposited or reworked sand, silt, or clay, sometimes with layers of leaf litter or debris buried by later sediment deposition. Often in the Brownwater Subtype the bulk of the bar appears to consist of sand but there is a thin layer of silt and clay deposited as the most recent flood flow waned. These surface layers may be removed by rain over time.

Hydrology: Sand and Mud Bars are frequently flooded. Natural flood regimes on brownwater rivers tend to include long duration floods and some very low flows. On rivers controlled by dams, the very high flows and the low flows are eliminated, but low-level floods often last longer. This may have effects on the morphology of bars as well as on the vegetation. Though bars are deposited where the river current is the slowest along its course, during high flows currents are sometimes swift enough to scour or rework the surface. Sediment deposition may be heavy enough in some parts to be an important disturbance to the vegetation.

Vegetation: Sand and Mud Bar communities have sparse to moderately dense herbaceous vegetation with variable cover of small woody plants. In the Brownwater Subtype the typical woody species are young *Salix nigra, Betula nigra, Fraxinus pennsylvanica, Platanus occidentalis*, and on the Roanoke River, often *Acer saccharinum*. *Hibiscus laevis* or *Hibiscus moscheutos* often is present though rarely very dense. The herbs are tremendously variable.

Coleataenia rigidula and *Echinochloa crusgalli* are perhaps the most frequent species. On the Roanoke River, *Leersia oryzoides* is frequent (Rice et al. 2001). On the Tar River, species at least fairly frequent include *Carex louisianica, Carex tribuloides, Carex typhina, Leersia virginica, Rumex conglomeratus, Erechtites hieracifolia, Mikania scandens, Commelina virginica, Commelina communis, Eclipta prostrata, Elymus virginicus, Persicaria punctata, Persicaria hydropiperoides, Persicaria sagittata, Rumex crispus, Peltandra virginica, Viola* spp., and the exotic species *Murdannia keisak, Microstegium vimineum, Alternanthera philoxeroides*, and *Humulus japonicus* (Faestal 2012).

Range and Abundance: No G-rank has been assigned. The Brownwater Subtype appears to be irregularly distributed among brownwater rivers. Faestal (2012) noted that there were few bars on the Cape Fear River and there are few on the Roanoke. Both of these rivers meander relatively little. Bars are more numerous on the Neuse River and perhaps on the Tar. Similar bar communities presumably occur along brownwater rivers throughout the Southeast, though it is uncertain how widely they would be regarded as the same NVC association.

Associations and Patterns: Sand and Mud Bars occur along river channels, generally on the inside of active meanders. They generally grade to Brownwater Levee Forest of some subtype on the landward side.

Variation: Variation in communities has not been clarified but may be sufficient to recognize a different variant for the Roanoke than for North Carolina's other brownwater rivers. Extreme heterogeneity at fine scales within patches, along with potential for drastic changes in vegetation with time makes recognition of consistent variants difficult. There presumably are significant differences between areas that have stabilized and are undergoing directional succession compared to those that are regularly reworked or scoured.

Dynamics: Sand and Mud Bars are among the most dynamic natural communities in North Carolina. Their location is tied to river channel patterns and is predictable but the vegetation and even the configuration of the site may potentially be changed drastically by a single flood. Slower changes, over periods of years or dozens of years, also occur as river meanders migrate and older portions of bars become more sheltered or stabilize. Long-lived plant species may be present but much of the vegetation is newly established and much may be ruderal or short-lived. Regular input of propagules collected over a large area may be an important determinant of plants present. The species present and their abundance may be very different at different times.

Though not well known, it is likely that bar configuration and vegetation are in short-term equilibrium with river behavior but that they respond to changes in river flood regimes caused by climatic cycles. The cycles of wetter or drier weather on the scale of 30 years documented by Stahle et al. (1988) may be important to them. The changes caused by upstream dams may be crucial. Hupp, et al. (2009a, 2009b) noted that point bars are no longer forming on the Roanoke River. At the same time, the bank erosion by slumping that they describe as abundant on the middle part of the river creates new habitat for bar communities. The author has observed amphitheater-like slump scars with beds of slumped material at riverbank level and supporting bar-like vegetation. However, these areas are more sheltered from the river current and also receive groundwater input.

Comments: Study of this community is limited. Though both Faestal (2012) and Rice (et al. 2001) included it in their classifications, the number of plots was limited. Site observations are extremely limited.

Rare species: No rare species are known to be specifically associated with this community.

SAND AND MUD BAR (BLACKWATER SAND BAR SUBTYPE)

Concept: Sand and Mud Bars are communities of soft sediment deposits along rivers, non-forested because of recent deposition, frequent reworking, or frequent scouring. Vegetation generally is sparse or patchy. The Blackwater Sand Bar Subtype covers examples on higher sandy bars along blackwater rivers.

Distinguishing Features: The Sand and Mud Bar type is distinguished by the combination of occurrence on soft sediments along a river shoreline and lack of a well-developed tree canopy. Vegetation ranges from herbs to shrubs, often at low density, and tree cover is low to nonexistent. Sand and Mud Bars should be recognized only where the patch is wider than the narrow band of shrubs present on most riverbanks. The Blackwater Sand Bar Subtype is distinguished from the Blackwater Drawdown Bar Subtype by being higher, generally exposed when the river is not in flood. It usually has a clean sand substrate, though there may be piles or layers of organic debris. The vegetation may be sparse or locally dense but usually includes abundant medium to tall forbs and grasses, such as *Coleataenia rigidula* ssp. *rigidula*. Tree seedlings may be present, as may a number of native or invasive ruderal herbaceous species.

Crosswalks: *Panicum rigidulum - Hibiscus moscheutos* Wet Meadow (CEGL004273).
G978 Eastern North American Riverine Sand-Gravel Bar Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Sand and Mud Bar (Blackwater Subtype) communities occur wherever well-developed bars are present along blackwater rivers. Most examples are on point bars on the insides of meanders but they may occur on bars along straight reaches as well. Bars vary in slope and in elevation above the river, but all are lower than the riverbanks. The substrate is well-sorted sand in most parts.

Soils: No well-developed soil is present on the bars. The substrate consists of newly deposited or reworked sand, sometimes with layers of leaf litter or debris buried by later sediment deposition.

Hydrology: Sand and Mud Bars are frequently flooded. Natural flood regimes on blackwater rivers tend to be variable, with flooding caused by storms possible at any time of year. Though bars are deposited where the river current is the slowest along its course, during high flows currents are sometimes swift enough to scour or rework the surface. Sediment deposition may be heavy enough in some parts to be an important disturbance to the vegetation. When the river is low, the sand substrate of these bars may lead to excess drainage and dry conditions.

Vegetation: Sand and Mud Bar communities have sparse to moderately dense herbaceous vegetation with variable cover of small woody plants. The most typical woody species in the Blackwater Subtype are *Betula nigra, Salix nigra, Taxodium distichum*, and on the Waccamaw and Lumber River, *Planera aquatica*, occurring as seedlings, saplings, or stunted older individuals. Frequent herbs are *Coleataenia rigidula*, *Lindernia dubia, Hydrocotyle prolifera, Hydrocotyle verticillata, Pluchea camphorata, Persicaria punctata*, other *Persicaria* spp., *Boehmeria cylindrica*, *Cyperus polystachyos, Mikania scandens, Lobelia elongata,* and various *Dichanthelium* spp. Less frequent but apparently characteristic species include *Fimbristylis* *autumnalis, Eupatorium capillifolium, Ludwigia alternifolia, Hypericum mutilum, Chasmanthium laxum, Erianthus* spp., *Leersia oryzoides, Agrostis perennans*, and on the Waccamaw River, *Sabatia kennedyana, Hymenocallis pygmaea*, and *Helenium flexuosum*.

Range and Abundance: Ranked G2G3 but more likely G3. This community is present in numerous patches on the upper and middle reaches of the larger blackwater rivers in North Carolina, though the aggregate acreage is small. It occurs in South Carolina and possibly Georgia, but the NVC association is not attributed more widely.

Associations and Patterns: Sand and Mud Bars occur along river channels, generally on the inside of active meanders. They grade to Blackwater Levee/Bar Forest, Blackwater Bottomland Hardwoods, or Cypress–Gum Swamp away from the river.

Variation: Two variants are recognized:

1. Typic Variant occurs on most blackwater rivers.

2. Waccamaw Variant occurs on the Waccamaw River and potentially on lower Juniper Creek. It is marked by distinctive floristic elements, such as *Sabatia kennedyana*. The hydrologic regime of the Waccamaw River may also be important to its different character.

Extreme heterogeneity at fine scales within patches, along with potential for drastic changes in vegetation with time, makes recognition of consistent variants difficult. There presumably also are significant differences between areas that have stabilized and are undergoing directional succession compared to those that are regularly reworked or scoured.

Dynamics: Sand and Mud Bars are among the most dynamic natural communities in North Carolina. Their location is tied to river channel patterns and is predictable but the vegetation and even the configuration of the site may potentially be changed drastically by a single flood. Slower changes, over periods of years or dozens of years, also occur as river meanders migrate and older portions of bars become more sheltered or stabilize. The relatively pure sand of most blackwater bars makes them more easily eroded than brownwater bars and may contribute to lesser stability. At the same time, the lack of clay and silt deposition leads to lower soil fertility and greater potential for dry conditions.

Comments: Study of this community is limited. Plot data are scarce. Examples have been described for multiple sites on the Waccamaw and Lumber River but there is little description for the Black, Northeast Cape Fear, or other rivers.

Rare species:
Vascular plants – *Cyperus subsquarrosus, Eriocaulon aquaticum, Gratiola lutea, Hymenocallis pygmaea, Isoetes microvela, Paspalum fluitans, Potamogeton amplifolius, Pycnanthemum setosum, Rhynchospora crinipes, Sabatia kennedyana,* and *Sclerolepis uniflora.*

SAND AND MUD BAR (BLACKWATER DRAWDOWN BAR SUBTYPE)

Concept: Sand and Mud Bars are communities of soft sediment deposits along rivers, nonforested because of recent deposition, frequent reworking, or frequent scouring. Vegetation generally is sparse or patchy. The Blackwater Drawdown Bar Subtype covers examples on lower shorelines of blackwater rivers, typically dominated by small plants tolerant of prolonged flooding such as *Eragrostis hypnoides, Micranthemum umbrosum, Juncus repens*, or *Cyperus subsquarrosus* (*Lipocarpha micrantha*).

Distinguishing Features: The Sand and Mud Bar type is distinguished by the combination of occurrence on soft sediments along a river shoreline and lack of a well-developed tree canopy. The Blackwater Drawdown Bar Subtype is distinguished from the Blackwater Sand Bar Subtype by being lower, generally exposed only at very low river levels. The substrate often is finer textured, with appreciable silt or organic matter as well as sand. The vegetation may be sparse but may also consist of dense mats of small herbs.

Crosswalks: *Eragrostis hypnoides - Micranthemum umbrosum - Lipocarpha micrantha - (Juncus repens)* Wet Meadow (CEGL004341).
G188 South Atlantic & Gulf Coastal Plain River & Basin Freshwater Marsh & Wet Meadow Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: The Blackwater Drawdown Bar Subtype occurs on lower riverbank areas that are exposed only at the lowest water levels. It is well developed only intermittently along the river, where a wide bench or flat exists at the appropriate level. It is not necessarily associated with point bars. It may also occur in backwaters.

Soils: No well-developed soil is present on the bars. The substrate consists of newly deposited or reworked sand or silt.

Hydrology: The Blackwater Drawdown Bar Subtype is intermittently exposed. It may be flooded for long periods during the growing season and may not be exposed at all in wetter years.

Vegetation: The vegetation may be sparse but often is a dense bed of small herbs, many of them annual. Abundant and frequent species include *Eragrostis hypnoides, Cyperus subsquarrosus (Lipocarpha micrantha), Fimbristylis autumnalis, Micranthemum umbrosum, Lindernia dubia, Juncus repens*, *Eleocharis baldwinii*, and on the Waccamaw River, *Sabatia kennedyana*. Other characteristic species include *Fimbristylis perpusilla*, *Helenium flexuosum, Gratiola aurea*, *Helanthium tenellum (Echinodorus parvulus*), *Oldenlandia boscii*, and *Edrastima (Oldenlandia) uniflora*. Species of the Blackwater Sand Bar Subtype, such as *Cyperus polystachyos, Hypericum walteri, Persicaria* spp., *Pluchea camphorata, Hypericum mutilum,* and *Hydrocotyle verticillata*, and ruderal species such as *Erechtites hieracifolia* and *Digitaria sanguinalis* may be present in small numbers. A wide variety of other species may be present with low frequency.

Range and Abundance: Ranked G2. The abundance of this community is not well known. In North Carolina, well-developed examples are documented only on the Waccamaw River. Other rivers have not been studied in as much detail and it is unclear if similar communities, perhaps minus many of the rare species, will be found there. The synonymized NVC association is attributed to Virginia, South Carolina, and possibly Georgia but it is unclear how well understood the community is in those areas either.

Associations and Patterns: The Blackwater Drawdown Bar Subtype occurs as small patches within the banks of the river or on the floor of deep backwater coves. It may be bordered by the Blackwater Sand Bar Subtype but otherwise is bordered by Blackwater Bottomland Hardwoods or Cypress–Gum Swamp.

Variation: Variation is not well studied. Patches are heterogeneous at a fine scale and vary substantially from time to time. In early studies on the Waccamaw River, many patches were dominated either by *Eleocharis baldwinii* or *Juncus repens,* but it is unclear if this dominance persists in the same locations. If this subtype is found on other rivers, it may be that the flora on the Waccamaw River would be distinct enough warrant recognition of variants.

Dynamics: The dynamics of the Blackwater Drawdown Bar Subtype are not well known. The large number of annual plants may only geminate when the water is low, and they presumably persist in a seed bank the rest of the time. Being located beneath the river, these areas are subject to the river's current and may be affected by scouring and deposition of new sediment. However, they appear to occur in low-energy flow regimes.

Comments: The boundary between the concept of this subtype, the Blackwater Sand Bar Subtype, and Cypress–Gum Swamp (Blackwater Cove Subtype) needs further clarification.

Rare species:
Vascular plants – *Cyperus subsquarrosus, Fimbristylis perpusilla, Gratiola lutea, Helanthium tenellum, Ludwigia brevipes, Oldenlandia boscii*, *Paspalum fluitans, Potamogeton amplifolius,* and *Sabatia kennedyana*.

SAND AND MUD BAR (NARROWLEAF POND-LILY SUBTYPE)

Concept: The Narrowleaf Pond-Lily Subtype of Sand and Mud Bar encompasses areas on edges or within blackwater river channels that are dominated by *Nuphar sagittifolia*. These areas are permanently or nearly permanently flooded.

Distinguishing Features: This community is distinguished from all others by dominance of *Nuphar sagittifolia* in a nontidal, blackwater river setting. The Narrowleaf Pond-Lily Subtype of Tidal Freshwater Marsh may occur in downstream portions of blackwater rivers and is similar except for having tidal water level fluctuations. *Zizaniopsis miliacea* or other species of Tidal Freshwater Marsh may be present in it but are absent in the Sand and Mud Bar subtype.

Crosswalks: *Nuphar sagittifolia* Aquatic Vegetation (CEGL004328).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: The Narrowleaf Pond-Lily Subtype occurs on edges of river channels with minimal current or in backwaters.

Soils: Soils are soft sediment, probably of silt or muck.

Hydrology: The Narrowleaf Pond-Lily Subtype is essentially permanently flooded.

Vegetation: The vegetation consists of a dense-to-moderate bed of *Nuphar sagittifolia*. Usually no other vascular plants are present.

Range and Abundance: Ranked G3? but probably G1. In North Carolina it is known in well-developed form only on the Waccamaw River. Though still rare, Tidal Freshwater Marsh (Narrowleaf Pond-Lily), on tidally influenced rivers, is more abundant. The association is also attributed to South Carolina, where it may occur only on the Waccamaw River.

Associations and Patterns: This community occurs in the river channel. It may border Cypress–Gum Swamp or Blackwater Bottomland Hardwoods, possibly Sand and Mud Bar.

Variation: Nothing is known of variation.

Dynamics: Nothing specific is known about the dynamics of this community.

Comments: The existence of three very similar communities dominated by *Nuphar sagittifolia* is perhaps only marginally acceptable, but the distinctive hydrologic environment of each appears to justify it. All three occur in North and South Carolina, in the narrow range of this species. A comparable *Nuphar advena* subtype may also exist on other blackwater rivers outside of the range of *Nuphar sagittifolia* but has not been documented.

Rare species: No rare species are known to be specifically associated with this community.

Though not documented, rare aquatic species of the Waccamaw River such as *Procambarus braswelli* and *Enneacanthus chaetodon* may use it.

RIVERINE FLOATING MAT

Concept: Riverine Floating Mats are beds of free-floating vegetation in still waters on the edges of rivers. This community is currently defined conceptually to include any vegetation of large free-floating plants along Coastal Plain flowing or tidal rivers but examples are known only along blackwater rivers in the lower flowing reaches and upper tidal reaches. They are typically dominated or codominated by *Hydrocotyle ranunculoides* or the exotic *Alternanthera philoxeroides* but could be dominated by other native species. Beds consisting solely of diminutive floating plants such as *Lemna* spp. are not included.

Distinguishing Features: The Riverine Floating Mat community is distinguished by floating vegetation of *Hydrocotyle ranunculoides* or similar plants in river channels or waters connected to a river. Beds consisting solely of exotic species such as *Alternanthera philoxeroides* or floating *Murdannia keisak* should not be treated as this community unless there is evidence they once were dominated by native floating species. However, beds with native species that are overgrown by these exotic species should be treated as degraded examples. Beds dominated by rooted floating-leaf plants such as *Nuphar advena* or *Nuphar sagittifolia* are treated as Sand and Mud Bar. Water with only diminutive floating plants such as *Lemna*, *Wolffia*, *Wolffiella*, or *Azolla* is treated as an unclassified aquatic community.

Crosswalks: *Hydrocotyle ranunculoides* - (*Sacciolepis striata*) Floating Aquatic Vegetation (CEGL004305).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).

Sites: Riverine Floating Mats occur in backwaters or still edges of channels in the lower flowing reaches or upper tidal reaches of rivers. Water is generally several feet deep but may be shallower.

Soils: No soil is present. The mat does not typically interact with the riverbed, but forms a dense mat of interlaced stems, rhizomes, and fibrous roots.

Hydrology: The sites of Riverine Floating Mats are permanently flooded. The vegetation floats on the surface of the water.

Vegetation: Riverine Floating Mats are most typically dominated by *Hydrocotyle ranunculoides* in their natural condition, but the exotic *Alternanthera philoxeroides* has often become dominant or codominant. In the center of mats, *Sacciolepis striata* will often dominate. Small numbers of other plants such as *Limnobium spongia, Pontederia cordata, Dichanthelium scabriusculum, Decodon verticillatus*, or *Iris virginica* may be present. Diminutive floating plants such as *Lemna* spp., *Wolffia* spp., *or Wolffiella gladiata* may be present in small openings with uncovered water. Unusual examples dominated by different species, such as *Hymenachne (Panicum) hemitomon, Ludwigia repens*, or *Eleocharis* sp. are known.

Range and Abundance: Ranked G3G4. The abundance of this community is not well known. It is present on many blackwater and upper tidal rivers throughout the lower Coastal Plain in North

Carolina but the overall acreage is small. Few examples remain that are not heavily altered by exotic plants. This community also occurs in South Carolina. The synonymized NVC association is questionably attributed to Georgia, Florida, and Alabama, and attributed without question to Missssissippi.

Associations and Patterns: River Floating Mats occur as small patches within river channels. They may be attached to the shore or separated by a few meters from it. In tidal rivers, they may occur close to Tidal Freshwater Marsh (Narrowleaf Pond-Lily, Broadleaf Pond-Lily, or Southern Wild Rice subtypes). They usually border Cypress–Gum Swamp or Tidal Swamp, less often Blackwater Bottomland Hardwoods.

Variation: Variation has not been well defined. Several examples appear to have unique composition. It is not always clear if they are enduring communities or if they should be considered Riverine Floating Mat communities at all. If they are, several variants or subtypes could be defined.

Dynamics: The dynamics of these communities likely are unique, but they are not well known. The stability and long-term nature of them is uncertain. The mats are somewhat fragile and can be disturbed by unusual flood flows or storm surges. Mats may occasionally break loose and drift to new locations, and fragments of plants may lodge to start new mats. Mat dynamics may be altered by alterations in flow regimes, and they may also be affected by water pollution. It is possible that mats have become more extensive or vigorous because of nutrient enrichment. They may also have been altered by powered boats, with frequent wakes disturbing them in areas with heavy traffic.

Mats often appear zoned in a way the suggests succession, with *Hydrocotyle* dominant around the edges and extending outward but with *Sacciolepis* overtopping it in the middle of a mat. Additional species, if present at all, will generally be in the center of mats, in areas that appear to be the oldest, thickest, and most stable. There appears to be a seasonal succession, with *Hydrocotyle* active and dominant in the spring, *Alternanthera* overtopping it in summer, and *Sacciolepis* overtopping both later in the summer.

The widespread invasion of *Alternanthera philoxeroides* has severely altered most examples. In a few places, *Murdannia keisak*, usually a rooted or draping invasive plant of swamps, extends outward from shore as floating mats and can overrun natural Riverine Floating Mats.

Comments: These communities are intermittent along most larger blackwater rivers. It is unclear that well-developed examples occur along any brownwater rivers. They seldom occur on smaller streams.

Hydrocotyle ranunculoides was considered uncommon several decades ago. It is unclear if this suggests floating mats have become more common or if survey of rivers was limited at that time. It is possible that Riverine Floating Mats have increased as a result of nutrient enrichment.

Rare species:
Vascular plants – *Acmella repens* and *Potamogeton amplifolius*.

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (OPEN WATER SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands created by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Open Water Subtype covers the deeper portions of pond complexes, dominated by open water or by submersed, floating, or floating-leaved aquatic plants, with limited emergent vegetation. It is generally a zonal community, occurring in a complex with other subtypes.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. Good mimics are usually old mill ponds that have long been unused. Larger reservoirs and smaller farm ponds do not seem to develop similar communities and have no natural community analogue. Other permanently or semipermanently flooded communities such as Oxbow Lake and the various Coastal Plain Depression Communities are generally readily distinguishable by occurring in closed basins without dams. Their vegetation usually is quite different, though recently formed Oxbow Lakes may look similar.

The Open Water Subtype is distinguished by the absence of substantial emergent vegetation or tree cover. Some examples have no significant vascular plant cover. *Nymphaea odorata* is the most typical plant, but *Utricularia* spp., *Lemna* spp., *Myriophyllum* spp., and others may dominate instead.

Crosswalks: *Nuphar advena - Nymphaea odorata* Aquatic Vegetation (CEGL002386)
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: Coastal Plain Semipermanent Impoundments occur on the floodplains of blackwater or brownwater streams or rivers. A few examples have been found on tidal creeks, though the damming blocks tidal exchange. Beavers prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. On large river floodplains, beavers dam sloughs, tributary streams, or channels draining backswamps. Old mill ponds that mimic beaver ponds tend to be on relatively small streams. While beavers strongly prefer low gradient streams, very few streams in the Coastal Plain have high enough gradients to deter them.

Soils: Coastal Plain Semipermanent Impoundments can occur on any floodplain soil, though impoundment presumably modifies the preexisting soil if the pond lasts very long. Besides water saturation, depletion of oxygen, and development of a strongly reducing chemical environment, the still water of ponds traps sediment. It may allow clay or muck deposition where it would not otherwise occur. An accumulated clay layer may persist even after the pond drains and is revegetated. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam is breached, sediment stored in floodplains might remain in place for centuries.

Hydrology: The Open Water Subtype has deeper water than the other subtypes and is permanently flooded as long as the dam is maintained. Brief dam breaches may occur, but if they are not repaired, the Open Water Subtype quickly develops into other subtypes.

Vegetation: The vegetation of the Open Water Subtype consists of aquatic plants. Dominant plants may include free-floating plants such as *Lemna* spp., *Wolffia*, *Wolffiella gladiata*, or *Azolla caroliniana*; floating leaf aquatics such as *Nymphaea odorata*, *Nuphar advena*, or *Brasenia schreberi*; or submersed aquatic plants such as *Potamogeton* spp., *Cabomba caroliniana*, or *Utricularia* spp. Mat-forming floating plants such as *Hydrocotyle ranunculoides* or the introduced *Alternanthera philoxeroides* can occur but are less typical. Other, less common plants may include *Hottonia inflata*. Nonaquatic plants may be present as minor components, with a number of species potentially inhabiting any remaining stumps, logs, tree bases, or old tip-up mounds. Sparse *Taxodium distichum*, *Nyssa aquatica*, *Nyssa biflora*, *Acer rubrum* var. *trilobum*, or *Fraxinus pennsylvanica* may persist. A diverse community of animals may use the ponds, including frogs and toads, lizards, turtles, snakes, and birds which are not common in the surrounding forest (Metts et al. 2001).

Range and Abundance: Ranked G4G5. This community may be found wherever streams or rivers occur on the Coastal Plain. Beaver ponds are abundant in the Sandhills region, which has a high stream density, but is also the site of first reintroduction of beavers. They are scarce in the outer Coastal Plain. Similar communities may occur in all the Coastal Plain states.

Associations and Patterns: The Open Water Subtype usually occurs with other subtypes, though sometimes it may occupy most of a given impoundment. It usually occupies the middle of the impoundment and near the dam, where water tends to be the deepest. In shallow ponds, it may occur as a narrow sinuous body following the stream channel. On large river floodplains, such as the Roanoke River, beavers tend to build ponds in sloughs or in backswamps (Townsend and Butler 1996). In these settings, the middle of impoundments may be the Cypress–Gum Subtype, the trees persisting from a previous Cypress–Gum Swamp. There, the outer portions of the slough or backswamp, having been occupied by the less flood-tolerant trees of Bottomland Hardwoods communities, may be the location of the Open Water Subtype.

Coastal Plain Semipermanent Impoundments in general are bordered by floodplain communities. In the Sandhills, Streamhead Pocosin or Streamhead Canebrake may occur adjacent to them. A variety of upland communities may border them on the edges, though the Open Water Subtype more often grades to other Coastal Plain Semipermanent Impoundment communities.

Variation: The vegetation is extremely variable among examples and can be patchy and heterogeneous within individual ponds. The dominant plants may occur in any combination, and vegetation density can range from dense to sparse or nearly absent.

Differences between brownwater and blackwater examples should be examined; none have been identified to date, but detailed data are lacking. There must necessarily be differences among those of small and large stream systems, given the differences in flood regime.

Krues and Bason (2015) described a physical typology of beaver ponds that may be useful in describing their variation. The main pond forms, inundating (filling the floodplain), channel (flooding the channel only), and discontinuous (flooding part of floodplain and channel but with high ground on levees or rises) may be helpful, though additional types for sloughs and for backswamps in large floodplains would need to be added to these categories. The cluster configuration types they described also appear useful: pioneer (single pond), disjunct serial (several ponds nearby), and stair step serial (ponds running together).

Dynamics: Beaver pond dynamics are unique among North Carolina's natural communities, contrasting with the stable site-driven mosaic that makes up most of the natural community landscape. They are among the most dynamic of communities, appearing and potentially disappearing rapidly, and occurring on sites that previously supported very different communities.

Pond dynamics are dependent on the behavior of individual beaver families and on the dynamics of beaver populations. Each beaver colony consists of one breeding pair, along with subadult offspring and young. A given colony may maintain several ponds and several lodges or bank burrows. They are territorial, with a family excluding other beavers, so colonies are nonoverlapping. New beavers will not move into a site if adult beavers are present (Allen 1982). Snodgrass (1997), at Savanna River Site in South Carolina and Georgia, found colonies to be separated by more than 100 meters.

Individual ponds can form rapidly when beavers build a dam large and high enough to impound deep water. Most trees die quickly, though ponds in Cypress–Gum Swamps may retain their tree canopy and not become the Open Water Subtype quickly, or at all. Young examples of the Open Water Subtype have recently dead trees, which gradually fall and decompose, eventually leaving a largely open water pond. Stumps may persist for many years, providing microhabitats for nonaquatic plants as well as for animals.

Colonization by aquatic plants takes some time, though it is not known how long. Presumably this depends on proximity of populations and the abundance of dispersal vectors such as waterfowl. Beavers themselves could contribute to dispersal from nearby ponds as well. More mature ponds are generally believed to be more diverse, as aquatic species accumulate over time. Many old mill ponds predate the reintroduction of beavers, and their more diverse aquatic communities are believed to represent the vegetation that once would have occurred in the more persistent beaver ponds.

When a dam is abandoned, the deep pond usually drains quickly, and the Open Water Subtype succeeds to one of the other subtypes, eventually returning to a floodplain forest community if not impounded again. While drained ponds in the North may persist as wet meadows for 50 years or more (Wright et al. 2002), forest return generally appears much more rapid in most of North Carolina.

Beavers may directly affect the vegetation in and around ponds, though this is particularly poorly known in the Open Water Subtype. Beavers are generalist herbivores but have strong food preferences (Allen 1982, Rossell, et al. 2014). Though they are most widely known for eating trees and shrubs, they prefer herbaceous vegetation if it is available, including most of the aquatic species named above. While it has been suggested that their preferences among woody plants may influence forest succession in adjacent areas, a similar effect of selective feeding on herbaceous plants has not been suggested. However, it is at least conceivable.

The natural population dynamics of beavers and beaver ponds remain poorly known. No record remains of beaver populations and behavior in early European times in most of the country. Indeed, in many places, heavy exploitation by Native Americans for trade preceded the arrival of colonists. Populations almost everywhere throughout the huge range of North American beavers are recovering from the heavy exploitation and often complete extirpation of the past. There is extensive literature on beavers, but relatively little specific to the South. Population dynamics may well be different where ponds do not freeze over in winter, where herbaceous food is often available year-round, and where landscapes and potential predators are different. Beavers were extirpated from North Carolina long ago and were reintroduced in 1939. They have now returned throughout most of the state, but at different times and rates. In addition, trapping and management to reduce their effect on forests, agriculture, and human infrastructure are widespread. Few ponds and no populations can be assumed to be free of such influences. An important question is how much populations naturally were controlled by predation, and how this affected the life span of colonies.

Beaver ponds are widely believed to create a shifting mosaic, functioning as a metapopulation, with creation of individual ponds followed by abandonment and succession, and new ponds created elsewhere as beavers move. While the situation is usually portrayed as random colonization followed by abandonment when woody food resources are consumed, the scenario is no doubt more complicated, with preferred sites occupied much of the time, marginal sites abandoned more frequently, and some areas unsuitable and rarely or never ponded. In the Roanoke River floodplain, Townsend and Butler (1996) found that most ponds were created in sloughs, and a fair number were on the edges of backswamps next to natural levees where woody food other than the undesired *Taxodium* and *Nyssa* are more available. However, ponds in backswamps were larger, and amounted to slightly larger acreage. Fryxell (2001), working in boreal forest, found beaver occupancy to be complex, with a small number of ponds being source populations and a larger number being sinks that did not reproduce at replacement levels. About 20% of the ponds persisted through the 11-year study, but many pond sites were abandoned and recolonized repeatedly within the period. Rather than a shifting mosaic, the landscape appeared to consist of sites that were repeatedly reoccupied long before succession occurred, and abandonment appeared to have less to do with depletion of food than with marginal habitat that did not support consistent reproduction. The stable colonies had ponds with abundant aquatic plants, which might mean better food supply; however, it is unclear if those ponds were stable because they had more aquatic plants or if they had more aquatic plants because they are more stably maintained by beavers.

Crucial parameters that remain unknown are how much of a natural landscape would be occupied by which stages of beaver ponds at a given time, and how much of the landscape would ever be affected by them. Snodgrass (1997) found up to 27% of stream length affected by impoundments in some small watersheds, but much less in larger watersheds. Forty-one years after reintroduction, without management during most of that time, they had affected only 9% of stream length and 0.5% of the land area. He also found 0.1 square meter/ha/year newly impounded. Brzyski (2005), in the Georgia Coastal Plain, found only 0.07 colonies/km of stream, a very low density. Kroes and Bason (2015), in the Virginia and North Carolina Coastal Plain, found about 1 pond/100 sq. km. In the Adirondacks, Wright et al. (2002) found 26.7% of stream length affected, and 3.32% of the landscape. In all cases, it is unclear how fully beaver populations had recovered, nor how much ongoing trapping and other management was occurring. Some referred to human destruction of ponds.

In the modern landscape, beavers sometimes take advantage of man-made structures such as road fills, bridges, and culverts. This probably is caused simply by these structure constricting flow and increasing current, trigging the beavers' instinct to place dams there, but at such constrictions, a small dam can create a large and deep pond. Thus, some beaver ponds may be larger than individual ponds in the past, even while ponds overall are less extensive.

Comments: Beaver ponds are potentially important in larger landscapes. They have been called "ecosystem engineers," because they cause physical habitat change and create habitat that would not otherwise be present (Wright et al. 2002). Though the open water and marshy vegetation they create often contrasts less with the other Coastal Plain vegetation than it does with Piedmont and Mountain forests, they provide distinctive habitat that allows different animals and plants to persist in the landscape. Several studies have noted that, though species richness of plants is lower in beaver ponds than in the forests they replace, the presence of beaver ponds increases the species richness of the landscape as a whole (Bartel 2008, Bonner 2005, Metts, et al. 2001, Wright, et al. 2002). Modeling exercises in some of these studies have calculated what abundance of beaver ponds should provide maximum diversity. There is no reason to believe that this particular abundance is what would specifically be present naturally, but the presence of multiple species that depend on beaver pond habitat or artificial analogues shows that it was present in important amounts.

Beaver ponds also apparently provide important ecosystem services and may be important to local geomorphologic processes. They may help buffer stream flows, enhance ground water recharge, and reduce stream velocity. Snodgrass (1997), working in the Savanna River Plant of South Carolina, found that ponds on intermittent streams caused perennial flow in them downstream of the dam. Most importantly, they trap sediment. Kroes and Bason (2015) reported sediment accumulations of 15-20 mm/year in Piedmont streams, compared to 1.6-5.4 mm in unponded streams. Coastal Plain ponds trapped shallower sediment, but the larger surface area of the ponds led to similar total amounts. They noted that, while sediment trapped in channels is often lost quickly when a dam breaks, that deposited in the floodplain can persist. Even in the mountainous landscape of Glacier National Park, Butler and Malanson (2005) found that most ponds that catastrophically drained in severe thunderstorms lost little of their sediment before grass and shrubs stabilized the exposed pond bed.

Nelumbo lutea Aquatic Vegetation (CEGL004323) is another NVC association that might potentially describe some of our examples. The NVC associations do not distinguish natural and pseudo-natural impoundments from artificial lakes and from other natural basins, apparently even from tidal rivers; hence the correspondence is only partial.

Rare species:
Vascular plants – *Carex decomposita, Carex disjuncta, Ceratophyllum australe, Didiplis diandra, Eleocharis robbinsii, Eleocharis vivipara, Heteranthera pauciflora (multiflora*), *Hottonia inflata, Lilaeopsis caroliniensis, Ludwigia brevipes, Myriophyllum laxum, Potamogeton confervoides, Sagittaria macrocarpa, Utricularia geminiscapa,* and *Utricularia olivacea*.

Vertebrate animals – *Liodytes rigida, Mycteria americana,* and *Porphyrio martinicus.*

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (TYPIC MARSH SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands created by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Typic Marsh Subtype encompasses shallow water and saturated portions of ponds dominated by emergent herbaceous marsh vegetation in the Coastal Plain outside of the Sandhills. It is both a zonal community in active ponds and a successional community in drained ponds.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. Drained beaver ponds are treated as Semipermanent Impoundments until they become more similar to another floodplain community. Young shrub and sapling stands are treated as the Typic Marsh Subtype until they form a recognizable forested community.

The Typic Marsh Subtype is distinguished from other subtypes by the dominance of emergent herbaceous or shrub vegetation and the lack of a substantial tree canopy. *Salix* or other early successional small trees may be present, and *Taxodium distichum, Nyssa biflora*, or *Nyssa aquatica* may be present as scattered trees. The Typic Marsh Subtype is distinguished from the Sandhills Marsh Subtype by floristic differences that indicate the lower nutrient status in the Sandhills. Species indicative of the Typic Marsh Subtype and not typical in the Sandhills Marsh Subtype include most *Persicaria* spp., *Typha latifolia*, *Leersia hexandra*, *Saururus cernuus*, *Cladium jamaicense*, *Sacciolepis striata, Scleria muhlenbergii*, and *Rhynchospora macrostachya*. Species indicative of the Sandhills Marsh Subtype include *Schoenoplectus subterminalis*, *Eriocaulon decangulare*, *Carex glaucescens*, *Carex striata*, most *Eleocharis* spp., *Schoenoplectus etuberculatus*, *Orontium aquaticum*, and *Sphagnum* spp.

Crosswalks: *Polygonum (hydropiperoides, punctatum) - Leersia* spp. Wet Meadow (CEGL004290).
G756 Eastern North American Wet Shoreline Vegetation Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: The Typic Marsh Subtype occurs on floodplains of blackwater or brownwater streams or rivers, rarely on tidal creeks. Beavers prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. On larger river floodplains, beavers dam sloughs or outlets of backswamps. While they strongly prefer low gradient streams, very few streams in the Coastal Plain have high enough gradients to deter them. The Typic Marsh Subtype usually occurs on the edges of beaver ponds or in beds of recently drained ponds, but it may occasionally occupy most of an active pond.

Soils: Coastal Plain Semipermanent Impoundments can occur on any floodplain soil, though impoundment presumably modifies the preexisting soil if the pond lasts very long. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tended to wash out quickly if the dam was breached, sediment stored in floodplains might remain in place for centuries. If enough sediment accumulates, the soil left behind when the pond drains may be higher and drier than what existed on the site before.

Hydrology: The Typic Marsh Subtype may be permanently or nearly permanently flooded to shallow depths, may draw down during dry seasons, or may be unflooded but permanently saturated. Drained or partially drained ponds may have no standing water.

Vegetation: The vegetation of the Typic Marsh Subtype is dominated by herbaceous plants or shrubs. The species composition is extremely variable and is not well documented. Species that have been noted as patch dominants or as abundant in some sites include *Sparganium americanum*, *Persicaria hydropiperoides*, *Persicaria densiflora*, *Persicaria punctata*, *Persicaria sagittata*, *Leersia hexandra*, *Hymenachne* (*Panicum*) *hemitoma, Saururus cernuus, Typha latifolia*, *Rhynchospora macrostachya*, *Scleria muehlenbergii*, *Sacciolepis striata*, *Cladium jamaicense*, and the exotic species *Murdannia keisak* and *Microstegium vimineum*. Other species noted as present in as many as three of the 11 recorded species lists in Natural Heritage Program files include *Peltandra virginica*, *Juncus effusus*, *Boehmeria cylindrica*, and *Decodon verticillatus*. Other herbaceous species include *Triadenum walteri*, *Impatiens capensis*, *Glyceria striata*, *Persicaria hastata*, *Lycopus virginicus*, *Carex gynandra*, *Rhexia virginica*, *Rhynchospora scirpoides*, *Galium aparine*, *Dulichium arundinaceum*, and *Ludwigia leptocarpa*. Aquatic species such as *Nymphaea odorata* may be present in small numbers amid the emergent vegetation or in small pools. Woody plants may be absent, may consist of sparse trees and shrubs remaining from before impoundment, or may consist of sparse-to-dense young individuals invading the marsh. They usually are generalist species of open wetlands, such as *Alnus serrulata, Swida* (*Cornus*) *stricta*, *Cephalanthus occidentalis, Salix nigra*, *Salix caroliniana*, and *Rosa palustris*, or water-tolerant trees such as *Acer rubrum* var. *trilobum* and *Nyssa biflora*.

Range and Abundance: Ranked G4?. This community may be found wherever streams or rivers occur in the Coastal Plain, though this subtype is scarce or absent in the Sandhills Region. Similar communities may occur in all the southeastern states. Beaver ponds are scarce in the outer Coastal Plain and are more abundant in the northern inner and middle Coastal Plain. This may simply reflect stream density but could also reflect locations of reintroduction and recent spread.

Associations and Patterns: The Typic Marsh Subtype usually occurs with other subtypes, as an edge zone or at the shallower upstream end. In channel ponds (see Krues and Bason 2015), open water may be limited to a narrow band and marsh may make up most of the pond outside the channel. Coastal Plain Semipermanent Impoundments in general are bordered by floodplain communities. The Typic Marsh Subtype often also borders upland communities of various types.

Variation: This subtype, as currently defined, is one of the most variable in the state, both in differences among sites and in heterogeneity within sites. However, patterns have not been identified in the vegetational variation. Vegetation often appears to consist of patches or zones dominated by a single species, but other areas may have the same species intermixed. True monocultures are not common, and most are not a large proportion of the marsh area. Two variants are tentatively recognized based on presumed functional differences:

1. Active Pond Variant occurs in ponds where beavers are present and maintaining the dam.

2. Successional Pond Variant occurs in abandoned ponds that have drained. Vegetation often is newly established in what was the Open Water Subtype or, in older examples, invading shrub and tree saplings are present. Other vegetational differences between these variants are not well known, but *Leersia virginica*, *Kellochloa* (*Panicum*) *verrucosa*, *Persicaria sagittata*, and the exotic species are some that are more likely to be abundant in successional examples.

Other likely sources of variation that could lead to variants or subtypes include blackwater versus brownwater, small versus large floodplains, association with organic soils, and distance from the coast. Water depth or wetness clearly is an important driver of local variation in vegetation but does not appear to be a useful basis for division given its wide range within sites. However, deeper water patches associated with old channels tend to be dominated by *Sparganium americanum*.

The physical typology of beaver ponds and pond clusters described by Krues and Bason (2015) and summarized under the Open Water Subtype may be useful.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

These communities can form fairly rapidly when a pond is built, but they may be slower to develop than the Open Water Subtype because the shallower water may take longer to kill the existing trees. Some live trees, generally showing signs of stress, are present for some time, before they eventually succumb to the flooding or are girdled or cut by the beavers. Snags may be abundant for several years. The role of stumps and fallen logs in providing microsites for plants of drier sites is even more important in this subtype than in the deeper water. Tops of logs may remain above the surface of the shallower water in this subtype. Establishment of some herbaceous vegetation can be rapid, but the community continues to develop and change in composition and diversity with time. There may be a repeatable successional trajectory in the development of these communities, but it has not been described. It is unknown how much of the tremendous variability observed is related to duration of impoundment in addition to variation in flooding conditions.

The Typic Marsh Subtype may also rapidly spread into deeper parts of the pond when the dam is abandoned. While drained ponds in the North may persist as wet meadows for 50 years or more (Wright et al. 2002), forest return is much more rapid in most of North Carolina. However, if part of the dam remains, it may retain enough water to prevent woody invasion and to allow the marsh to persist for some years.

In addition to limited knowledge of the natural abundance and duration of beaver ponds in North Carolina, and in general, there is limited knowledge of the number of examples, extent, and duration of the different subtypes. Most drained ponds probably go through a stage of marsh vegetation, but it may be short-lived. In long-lasting ponds, the marsh may be a stable zone, or may slowly succeed to the Cypress–Gum Subtype.

Comments: See the discussion on ecosystem services and landscape roles of beaver ponds, under the Open Water Subtype.

No Coastal Plain Semipermanent Impoundment subtypes have had extensive study. Very few CVS plots exist. Sites descriptions often do not document their vegetation in great detail. In addition, many examples are relatively new and were not present at the time of older site descriptions.

The NVC associations related to the Typic Marsh Subtype are confusing and problematic, and they have changed over the development of the 4th Approximation. The association currently crosswalked is also crosswalked to Piedmont/Mountain Semipermanent Impoundment (Piedmont Marsh Subtype), as there is no closer fit for either. It is attributed to the Blue Ridge region as well, though a different association covers beaver pond marshes there. Several additional associations were listed as potential crosswalks to the Typic Marsh Subtype in earlier drafts, each dominated by one to three species that can dominate patches in the community, but each association is also described as broader than beaver pond marshes. Most of these associations have been dropped or have been clarified as being narrower and not occurring in North Carolina. The one potential overlapping association remaining is *Juncus effusus* Marsh (CEGL004112). The Typic Marsh Subtype is heterogeneous and may warrant splitting. However, division based on the poorly marked zones within the marsh does not appear beneficial. Variations correlating with size of impounded stream, amount of mineral sediment vs. muck, presence of seepage, and biogeography may be a good basis for classifying these communities but are virtually undocumented. Even within a region and stream type, beaver ponds vary substantially. An additional axis of variation is the cycle from new creation to maturity to abandonment and succession back to unimpounded community types.

Rare species:
Vascular plants – *Lilaeopsis caroliniensis, Luziola fluitans var. fluitans, Lycopus angustifolius, Persicaria hirsuta, Scirpus etuberculatus, Spiranthes longilabris,* and *Torreyochloa pallida* var. *pallida.*

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (SANDHILLS MARSH SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands created by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Sandhills Marsh Subtype covers herbaceous-dominated zones or ponds of the Sandhills Region, where sediment input is minimal and muck substrate predominates. It includes both shallow water edges of active ponds and marshy vegetation in drained ponds.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. Drained beaver ponds are treated as Semipermanent Impoundments until they become more similar to another floodplain or streamhead community.

The Sandhills Marsh Subtype is distinguished from the Cypress–Gum Subtype by dominance of emergent herbaceous vegetation and by the lack of a substantial tree or shrub canopy. However, *Nyssa biflora* trees remaining from before impoundment may be present with limited cover, and shrubs generally establish around the edges. The Typic Marsh Subtype is distinguished from the Sandhills Marsh Subtype by floristic differences that indicate the lower nutrient status in the Sandhills. Species indicative of the Typic Marsh Subtype and not known in the Sandhills Marsh include most *Persicaria* spp., *Typha latifolia*, *Leersia hexandra*, *Saururus cernuus*, *Cladium jamaicense*, *Sacciolepis striata, Scleria muhlenbergii*, and *Rhynchospora macrostachya*. Species indicative of the Sandhills Marsh Subtype include *Schoenoplectus subterminalis*, *Eriocaulon decangulare*, *Carex glaucescens*, *Carex striata*, most *Eleocharis* spp., *Schoenoplectus etuberculatus*, *Orontium aquaticum*, and *Sphagnum* spp.

The Sandhills Marsh Subtype is distinguished from the Sandhills Mire Subtype by having a broader mix of plant species that is not limited to those of the most extreme acidic conditions. Earlier drafts of the 4th Approximation listed a suite of species as indicative of the Sandhills Mire Subtype: *Carex mitchelliana*, *Carex howei, Carex stricta, Glyceria obtusa, Leersia oryzoides, Dichanthelium scabriusculum, Peltandra virginica*, *Dichanthelium dichotomum*, *Dulichium arundinaceum, Triadenum virginicum, Lycopus cokeri, Eupatorium resinosum, Carex atlantica* and *Lorinseria areolata*. Most of these can also be found in the Sandhills Marsh Subtype but an additional mix of species shared with the Coastal Plain Marsh Subtype or with more mineral-rich marshes may also be found. Species such as *Scirpus cyperinus, Sparganium americanum*, *Dulichium arundinaceum*, *Leersia* spp., and *Juncus* spp. are more typical of the Sandhills Marsh Subtype. The Sandhills Mire Subtype also often has a greater presence of shrubs.

Crosswalks: *Orontium aquaticum* - *Schoenoplectus (etuberculatus, subterminalis) - Eriocaulon decangulare - Juncus trigonocarpus* Marsh (CEGL007860).
G188 South Atlantic & Gulf Coast Marsh & Wet Meadow Group.
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: The Sandhills Marsh Subtype occurs along streams in the Sandhills Region. This subtype typically occurs on the edges of active beaver ponds or in beds of recently drained ponds.

Soils: Typical soils of Sandhills Region streams are Bibb and Johnston (Typic Fluvaquents and Cumulic Humaquepts). These soils are generally high in organic matter and are kept constantly saturated by the seepage of water from the adjacent porous soils. As such, they may be changed less by impoundment than most, but presumably become more anoxic. Over time, accumulated organic matter rather than transported mineral sediment tends to fill the Sandhills ponds.

Hydrology: The Sandhills Marsh Subtype may be permanently or nearly permanently flooded to shallow depths or may be unflooded but permanently saturated. Drained or partially drained ponds may have no standing water. While beavers generally prefer second order streams (Snodgrass 1997), the stable stream flow characteristic of Sandhills creeks may make smaller creeks attractive while also making higher order streams stable enough for dams.

Vegetation: The vegetation of the Sandhills Marsh Subtype is dominated by emergent herbaceous plants. The species composition is extremely variable and is not well documented. Species that have been noted as patch dominants or as abundant in some sites include *Sparganium americanum*, *Dulichium arundinaceum*, *Rhynchospora* spp., *Schoenoplectus subterminalis*, *Carex striata*, *Glyceria obtusata*, *Eleocharis robbinsii*, *Eleocharis quadrangulata*, *Orontium aquaticum*, and *Iris virginica*. Species that were noted relatively frequently include *Scirpus cyperinus*, *Andropogon glomeratus*, and *Carex glaucescens*. Other species include *Juncus abortivus*, *Juncus canadensis*, *Juncus effusus*, *Juncus coriaceus*, *Juncus repens*, *Carex intumescens*, *Carex atlantica*, *Carex lonchocarpa*, other *Carex* spp., *Dichanthelium scabriusculum*, *Eleocharis tuberculosa*, *Eleocharis equisetoides*, *Rhynchospora chalarocephala*, *Rhynchospora macra*, *Xyris fimbriata*, *Xyris caroliniana*, *Xyris smalliana*, *Sagittaria engelmannii*, *Sagittaria graminea*, *Eupatorium resinosum*, *Lycopus cokeri*, *Rhexia mariana*, *Proserpinaca pectinata*, *Hydrocotyle umbellata*, *Triadenum virginianum*, and *Solidago salicina (patula* var. *strictula)*. *Sphagnum* is sometimes abundant. Aquatic species such as *Nymphaea odorata* or *Brasenia schreberi* may be present in small numbers amid the emergent vegetation or in small deeper spots. Woody plants may be absent, may consist of sparse trees and shrubs remaining from before impoundment, or may consist of sparse-to-dense young individuals invading the marsh after pond drainage. While woody species typical of many open wetlands may be present, such as *Viburnum nudum, Vaccinium formosum*, or *Acer rubrum,* pocosin species such as *Lyonia lucida*, *Cyrilla racemiflora*, *Magnolia virginiana*, *Clethra alnifolia*, and *Smilax laurifolia* are more typical.

Range and Abundance: Ranked G2?. This community may potentially be found anywhere in the Sandhills Region, but examples have been documented primarily from the large public lands of the region and few are known. Similar communities presumably occur in South Carolina but it is unclear if they range any more widely. It is possible that ponds of this character could occur elsewhere in the Coastal Plain on blackwater streams, but no examples have been found. The combination of low mineral sediment input and long-term saturation by seepage is scarce outside the Sandhills.

Associations and Patterns: It is common for beaver ponds of the Open Water Subtype and Sandhills Marsh Subtype to occur interspersed with reaches of Sandhills Streamhead Swamp and

Streamhead Pocosin along the streams. Ponds sometimes are single and sometimes are in complexes with multiple active and abandoned dams, with multiple patches of Open Water and Sandhills Marsh Subtype; other ponds or complexes may consist entirely of the Sandhills Marsh Subtype. They are often bordered by Streamhead Pocosin but can be bordered by upland communities.

Variation: This subtype is currently defined more narrowly than other marsh subtypes, but nevertheless is extremely variable. A very wide range of species may dominate patches. Among species lists available for this community, virtually no species has as much as 50% constancy and, more than in most communities, a large proportion of species has been noted in only one or two examples.

The physical typology of beaver ponds and pond clusters described by Krues and Bason (2015) and summarized under the Open Water Subtype may be useful.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

These communities can form fairly rapidly when a pond is built, but they may be slower to develop than the Open Water Subtype because the shallower water may take longer to kill the existing trees. Some live trees, generally showing signs of stress, are present for some time, before they eventually succumb to the flooding or are cut by the beavers. Snags may be abundant for several years. The role of stumps and fallen logs in providing microsites for plants of drier sites is even more important in this subtype than in the deeper water. Tops of logs may stay above the surface of the shallower water. Establishment of some herbaceous vegetation can be rapid, but the community continues to develop and change in composition and diversity with time. It is unknown how much of the tremendous variability observed is related to duration of impoundment in addition to variation in flooding conditions.

The Sandhills Marsh Subtype may also spread rapidly into deeper parts of the pond when a dam is abandoned. It may be invaded by woody vegetation rapidly or slowly. It may potentially succeed to the Sandhills Mire Subtype, Cypress–Gum Subtype, or return to a Sandhills Streamhead Swamp. However, if part of the dam remains, it may retain enough water to prevent woody invasion and to allow the marsh to persist for some years. It appears that this phenomenon may be more common in the Sandhills than in other regions.

The relationship between the Sandhills Mire Subtype and Sandhills Marsh Subtype is particularly unclear. The most readily observable ponds on public lands are of the Sandhills Marsh Subtype, while all known Sandhills Mire Subtype ponds are known on Fort Liberty and were described longer in the past. It is possible the Sandhills Mire Subtype represents a later stage of succession, perhaps one that doesn't always occur before trees invade. However, Lee Gerald (personal comm. 1990s) described a successional trend of Sandhills beaver ponds that appears to suggest early development of mires: Sphagnum comes in quickly in drained ponds, and sedge-grass vegetation develops on this. Shrubs and trees, especially *Acer rubrum, Alnus serrulata*, and *Cyrilla racemiflora* invade the marsh over the space of 10-20 years, starting from the head of the pond and the edges. *Nyssa biflora*, persisting through the impoundment or newly established, along with

Acer rubrum, tends to dominate the drained pond bed, with herbaceous cover beneath. Former ponds remained hardwood dominated and did not return to Streamhead Pocosin after 40 years. This appears to represent the Sandhills Mire Subtype and does not sound like it involves the Sandhills Marsh Subtype. It thus suggests that the two subtypes could represent different trajectories from the beginning, either because of different early stages or because of different environments. The Sandhills Mire Subtype could potentially occur where seepage is more abundant.

Comments: The vegetation of Coastal Plain Semipermanent Impoundment subtypes is not well studied. Very few CVS plots exist. Sites descriptions often do not document their vegetation in great detail. In addition, many examples are relatively new and were not present at the time of older site descriptions.

The classification of the Sandhills Marsh and Sandhills Mire subtypes needs further consideration and possible revision. The Sandhills Mire Subtype was based on quantitative data on drained ponds on Fort Liberty (Hall 2005), but comparable data are not available elsewhere in the Sandhills. There are believed to be significant floristic differences between the mires of Fort Liberty and ponds elsewhere, but the relationship between those floristic differences and the successional stages of drained ponds remains unclear. Accumulation of species lists for ponds in the Sandhills Game Land indicates that the floristic differences among these areas are not strong as initially believed, and now appear to be less than the variation among ponds within each area. Since both early and late successional stages must occur in both places, the distinction needs to be clarified to be either a structural/successional one, or a more useful floristic split needs to be identified.

See the descriptions of the Open Water and Typic Marsh Subtype for general discussion and references on beaver ponds, landscape diversity, and ecosystem services. Because Sandhills beaver ponds accumulate more organic matter, and are less subject to erosion by severe floods, they may be even more important in sequestering carbon.

Rare species:
Vascular plants – *Hypericum fasciculatum, Ludwigia sphaerocarpa, Rhynchospora macra,* and *Xyris chapmanii*.

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (SANDHILLS MIRE SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands created by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Sandhills Mire Subtype covers drained impoundments of the Sandhills Region, where woody vegetation has become abundant over the herbaceous layer in a deep muck substrate.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. Drained beaver ponds are treated as Semipermanent Impoundments until they become more similar to another floodplain or streamhead community.

The Sandhills Marsh Subtype is distinguished from the Sandhills Mire Subtype by having a broader mix of plant species that is not limited to those of the most extreme acidic conditions. Earlier drafts of the 4th Approximation listed a suite of species as indicative of the Sandhills Mire Subtype: *Carex mitchelliana*, *Carex howei, Carex stricta, Glyceria obtusa, Leersia oryzoides, Dichanthelium scabriusculum, Peltandra virginica*, *Dichanthelium dichotomum*, *Dulichium arundinaceum, Triadenum virginicum, Lycopus cokeri, Eupatorium resinosum, Carex atlantica* and *Lorinseria areolata*. Most of these can also be found in the Sandhills Marsh Subtype but an additional mix of species shared with the Coastal Plain Marsh Subtype or with more mineral-rich marshes may also be found. Species such as *Scirpus cyperinus, Sparganium americanum*, *Dulichium arundinaceum*, *Leersia* spp., and *Juncus* spp. are more typical of the Sandhills Marsh Subtype. The Sandhills Mire Subtype also often has a greater presence of shrubs. Species indicative of the Sandhills Mire Subtype include *Eriocaulon decangulare*, *Carex glaucescens*, *Carex howei*, *Carex atlantica*, numerous other *Carex* species, *Orontium aquaticum*, *Eupatorium resinosum*, *Lycopus cokeri*, *Xyris* spp., *Sphagnum* spp., and numerous others.

Both the Sandhills Marsh and Sandhills Mire Subtypes have substantial floristic differences distinguishing them from the Typic Marsh Subtype. Species indicative of the Typic Marsh Subtype and not known in the Sandhills Marsh include most *Persicaria* spp., *Typha latifolia*, *Leersia hexandra*, *Saururus cernuus*, *Cladium jamaicense*, *Sacciolepis striata, Scleria muhlenbergii*, and *Rhynchospora macrostachya*. Most of the species listed in the previous paragraph, especially those of highly acidic, bog-like environments, do not occur in the Typic Marsh Subtype.

Crosswalks: *Nyssa biflora - Alnus serrulata / Carex (mitchelliana, atlantica* ssp. *capillacea - Glyceria obtusa* Floodplain Shrub (CEGL004800).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: The Sandhills Mire Subtype occurs on floodplains of streams in the Sandhills Region. This subtype typically occurs in the beds of ponds that have been drained for some years.

Soils: Typical soils of Sandhills streams are Bibb and Johnston (Typic Fluvaquent and Cumulic Humaquept). These soils are generally high in organic matter and are kept constantly saturated by the seepage of water from the adjacent porous soils. As such, they may be changed less by impoundment than most, but presumably become more anoxic. Over time, accumulated organic matter rather than transported mineral sediment tends to fill the Sandhills ponds.

Hydrology: The Sandhills Mire Subtype tends to be unflooded but permanently saturated. Minor stream flooding may occur but is rare.

Vegetation: Vegetation of the Sandhills Mire Subtype is an open woodland or shrubland with a well-developed herbaceous layer beneath. *Acer rubrum* and *Nyssa biflora* are the dominant trees, which may be young or may have survived through the life of the pond. Shrubs typically are *Alnus serrulata*, *Viburnum nudum*, *Cyrilla racemiflora*, and *Arundinaria tecta* but may also include *Clethra alnifolia*, *Lyonia lucida*, *Morella caroliniana*, and *Ilex glabra*. *Smilax laurifolia* and *Smilax walteri* are often present. The herb layer is dense to moderate. *Sphagnum* is often extensive. Herbs that are dominant or abundant (Hall 2005) include *Leersia oryzoides*, *Carex howei*, *Carex atlantica*, *Carex mitchelliana*, *Carex glaucescens*, *Carex lonchocarpa*, *Scirpus cyperinus*, *Glyceria obtusa*, *Dichanthelium scabriusculum*, and *Dichanthelium dichotomum* var. *dichotomum*. Other species less frequently abundant include *Dulichium arundinaceum*, *Carex stricta*, *Andropogon glomeratus*, *Rhynchospora stenophylla*, other *Rhynchospora* spp., *Peltandra virginica*, *Xyris fimbriata*, *Xyris iridifolia*, *Eriocaulon decangulare*, *Iris virginica*, and *Sparganium americanum*. Other fairly frequent species include *Orontium aquaticum*, *Eupatorium resinosum*, *Lycopus cokeri*, *Sarracenia flava*, *Drosera* spp., *Carex debilis*, and *Woodwardia virginica*. A great number of additional species occur in at least a few examples.

Range and Abundance: Ranked G2?. This community has only been documented on Fort Liberty but may potentially be found anywhere in the Sandhills Region. Similar communities could possibly occur in South Carolina.

Associations and Patterns: It is common for beaver ponds of the Open Water Subtype and Sandhills Mire Subtype to occur interspersed with reaches of Sandhills Streamhead Swamp and Streamhead Pocosin along the streams. Ponds sometimes are single and sometimes are in complexes with multiple active and abandoned dams, with multiple patches of Open Water and Sandhills Mire Subtype. But other ponds or complexes may consist entirely of the Sandhills Mire Subtype. They are often bordered by Streamhead Pocosin but can be bordered by upland communities.

Variation: Three variants are recognized, based on Hall (2005):
1. Typic Variant, which remains quite heterogeneous;
2. Bog Variant, which appears to occur where adjacent Sandhill Seeps feed acidic seepage water into the mire, and seep plants mix with those of the mire;
3. Tussock Sedge Variant, strongly dominated by *Carex stricta*, to the exclusion of most other herbaceous species.

Hall (2005) suggested recognition of several additional types, most of which are more similar to each other than are these. Also distinct in Hall (2005) were those dominated by *Dichanthelium* *scabriusculum* and *Dichanthelium dichotomum*, as opposed to the more typical mixed vegetation. These need more study but appear to result from excessive sediment washing into a drained pond, and so may not be a natural variant. The three variants appear to be very distinct, perhaps more than the Typic Variant is from the Sandhills Marsh Subtype, at least in flora.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

The relationship of the Sandhills Mire Subtype and Sandhills Marsh Subtype is particularly problematic. See the discussion of this uncertainty in the description of the Sandhills Marsh Subtype. The Sandhills Mire Subtype was proposed by Hall (2005), who studied it intensively because of its apparent role as sole habitat for *Neonympha mitchellii francisci*. It has been documented only on Fort Liberty. Some evidence suggests that the Sandhills Mire Subtype appears to succeed from the Sandhills Marsh Subtype, but it can also apparently develop from a bare drained pond bed that had been open water. Lee Gerald (personal comm. 1990s) described the successional trend of Sandhills beaver ponds: *Sphagnum* comes in quickly in drained ponds, and sedge-grass vegetation develops on this. Shrubs and trees, especially *Acer rubrum, Alnus serrulata*, and *Cyrilla racemiflora,* invade the marsh over the space of 10-20 years, starting from the head of the pond and the edges. *Nyssa biflora*, persisting through the impoundment or newly established, along with *Acer rubrum*, tends to dominate the drained pond bed, with herbaceous cover beneath. This appears to represent the Sandhills Mire Subtype. Former ponds remained hardwood dominated and did not return to Streamhead Pocosin after 40 years.

Comments: The classification of the Sandhills Marsh and Sandhills Mire subtypes needs further consideration and possible revision. The Sandhills Mire Subtype was based on quantitative data on drained ponds on Fort Liberty (Hall 2005), but comparable data are not available elsewhere in the Sandhills. There were believed to be significant floristic differences between the mires of Fort Liberty and ponds elsewhere, but the relationship between those floristic differences and the successional stages of drained ponds remains unclear. Accumulation of species lists for ponds in the Sandhills Game Land indicates that the floristic differences between these areas are not strong and now appear to be less than the variation among ponds within each area. Since both early and late successional stages must occur in both places, the distinction needs to be clarified to be either a structural/successional one, or a more useful floristic split needs to be identified.

A different subtype name may be warranted. The term mire, implying an organic-soil wetland with flora of boggy character, applies well to both subtypes, perhaps better to the herbaceous, earlier successional subtype called Sandhills Marsh Subtype here.

See the Open Water Subtype and Typic Marsh Subtype descriptions for general comments and references on beaver ponds, landscape diversity, and ecosystem services. Because Sandhills beaver ponds accumulate more organic matter, and are less subject to erosion by severe floods, they may be even more important in sequestering carbon.

Rare species:
Vascular plants – Rhynchospora *macra*.
Invertebrate animals – *Neonympha helicta* and *Neonympha mitchellii francisci.*

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (CYPRESS–GUM SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands created by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Cypress–Gum Subtype covers portions or examples supporting a substantial canopy of *Taxodium* or *Nyssa*. These are generally remnant trees that established in a Cypress–Gum Swamp, but under the right circumstances, a similar canopy can become established once a pond has formed.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. It is not entirely clear what allows artificial ponds to resemble natural beaver ponds. Good mimics are usually old mill ponds that have long been unused. Larger reservoirs and smaller farm ponds do not seem to develop similar communities and have no natural community analogue.

The Cypress–Gum Subtype is distinguished from all other communities (except the Sandhills Mire Subtype) by a well-developed open or closed tree canopy, mostly of *Taxodium* or *Nyssa* in an active or recently drained impoundment. The conceptual boundary with other subtypes is placed at 50% canopy tree cover, since sparser trees may survive in any subtype. The Sandhills Mire Subtype, if it has a canopy, is distinguished by its distinctive well-developed herb layer of *Sphagnum* and herbs of highly acidic, organic soils.

Crosswalks: *Taxodium distichum / Lemna minor* Floodplain Forest (CEGL002420).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Atlantic Coastal Plain Small Brownwater River Floodplain Forest Ecological System (CES203.250).
Southern Atlantic Coastal Plain Large River Floodplain Forest Ecological System (CES203.066).
Atlantic Coastal Plain Small Blackwater River Floodplain Forest Ecological System (CES203.249).
Atlantic Coastal Plain Blackwater Stream Floodplain Forest Ecological System (CES203.247).

Sites: Coastal Plain Semipermanent Impoundments occur on the floodplains of blackwater or brownwater streams or rivers, rarely on tidal creeks. Beavers prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. On large river floodplains, beavers dam sloughs, tributary streams, or drainages from backswamps. Old mill ponds that mimic beaver ponds tend to be on relatively small streams. While beavers strongly prefer low gradient streams, very few streams in the Coastal Plain have high enough gradients to deter them. The Cypress–Gum Subtype occurs in both active and abandoned ponds.

Soils: Coastal Plain Semipermanent Impoundments can occur on any floodplain soil, though impoundment presumably modifies the preexisting soil if the pond lasts very long. The still water allows deposition of clay or muck. This layer may persist even after the pond drains and is revegetated. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam was breached, sediment stored in floodplains might remain in place for centuries.

Hydrology: The Cypress–Gum Subtype may be permanently flooded or may be unflooded but permanently saturated. The water may be shallow or deep.

Vegetation: The Cypress–Gum Subtype is a closed forest or open woodland dominated by water-tolerant trees: *Taxodium distichum*, *Nyssa aquatica*, *Nyssa biflora*, or *Taxodium ascendens*. In most examples in active ponds with deep water, there is only a sparse understory and shrub layer, consisting of individuals rooted on stumps and tree bases. Examples in shallow water, and on edges, have more cover of other trees and shrubs. *Acer rubrum* var. *trilobum* is the most common tree, but *Fraxinus caroliniana*, *Ilex opaca*, *Magnolia virginiana*, and occasionally other species may occur. Shrubs include *Cephalanthus occidentalis*, *Alnus serrulata*, *Rosa palustris*, *Cyrilla racemiflora*, *Morella cerifera*, *Itea virginica*, *Ilex laevigata*, and a variety of other species. Herbs vary widely. Deep water areas often have high cover of *Lemna* and other tiny floating plants, or of *Utricularia* spp. Any of the floating-leaf or submersed plant species of the Open Water Subtype, such as *Nymphaea odorata* or *Brasenia schreberi*, may occur, though at lower density. *Limnobium spongia* is extensive in several examples. Characteristic herbs of tree bases and stumps, such as *Boehmeria cylindrica* or *Triadenum walteri*, are often present in low numbers. In shallow water examples and on edges, a great range of herbs may occur. Any of the species of the Typic Marsh Subtype may be present, but more shade-tolerant species such as *Saururus cernuus* and *Carex* spp. are most likely.

Range and Abundance: Ranked G4G5. This subtype occurs throughout the Coastal Plain, including, though less commonly, in the Sandhills region. It presumably occurs in South Carolina, and probably occurs with little difference in character over much of the Southeast.

Associations and Patterns: The Cypress–Gum Subtype can be a site-specific subtype, a temporal phase, or a zone within a pond complex. Some impoundments may have only this subtype, while in others it is a zone grading to the Open Water Subtype in deeper portions. In other cases, especially where formed by damming sloughs or the edges of backswamps in large river floodplains, it may occupy the deeper part of a pond where Cypress–Gum Swamp was already established, while the Typic Marsh or Open Water Subtype occurs on the edges that were occupied by the less flood-tolerant trees of Bottomland Hardwoods.

Variation: The Cypress–Gum Subtype, as currently defined, is one of the most variable in the state, especially in differences among environments. The variation is not well studied, but two variants are proposed to reflect what likely are the most important differences:

1. Brownwater Variant occurs on brownwater and intermediate river floodplains. It has clayey soil, a canopy that includes *Nyssa aquatica*, and associated flora characteristic of brownwater swamps.

2. Blackwater Variant occurs in blackwater river and stream floodplains. It lacks *Nyssa aquatica* and has flora characteristic of more acidic, nutrient poor wetlands. Sandhills ponds are included in it but may be different enough to warrant an additional variant.

The differences between shallow and deep examples are also substantial, with primarily aquatic and tree-base flora in the latter and substantial herbaceous or shrub cover in the former. It may be worth distinguishing variants based on this, but it is not clear that the differences can be sorted out in a useful way. Variation should also be observed and characterized between examples where the canopy trees are relict from a pre-impoundment community and those where they were established in a long-lasting pond. These may have different dynamics.

The physical typology of beaver ponds and pond clusters described by Krues and Bason (2015) and summarized under the Open Water Subtype may be useful.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

The Cypress–Gum Subtype may form quickly, with a relict canopy, by impoundment of an existing Cypress–Gum Swamp. Once ponded water is present, the change in the character of the herb and shrub layers probably happens in a few years. The composition and structure may continue to change slowly after that, as additional pond species disperse into the pond, and as the most susceptible trees gradually die. As long as deep water remains, the trend generally will be toward a more open canopy over time, as all but the shallowest examples are unlikely to see new establishment even of *Taxodium* or *Nyssa* seedlings. However, short-term draining, followed by rebuilding of the dam, could allow a cohort of trees to become established. Without new tree establishment, the Cypress–Gum Subtype might gradually succeed to the Open Water Subtype, but it is unclear if most beaver ponds last long enough for this to happen. This may be more likely in the deeper water in the middle of the larger mill ponds, which would place more stress on the established trees. Townsend and Butler (1996) noted that beavers did not cut *Nyssa* and *Taxodium*, and that they were more likely to build ponds where more preferred food trees dominated.

The Cypress–Gum Subtype can also develop as a secondary community, through establishment in open areas of an existing pond. This requires a temporary drawdown of water level to allow seedling establishment and is likely to result in an even-aged stand. It is unclear how common this is, but it may not be uncommon to have temporary dam breaches or drainage in both beaver ponds and mill ponds.

When a pond drains permanently, the Cypress–Gum Subtype may quickly succeed to Cypress–Gum Swamp, but this is not well known. If the soil is changed in character by deposition of clay or muck in the pond, the area may not return to the previous community for quite some time. In the Sandhills, the Sandhills Mire Subtype might develop from the Cypress–Gum Subtype as well as from the Sandhills Marsh Subtype. For secondary communities, the trees may have established on pond edges that did not previously support Cypress–Gum Swamp, but they may remain dominant for the rest of their life span.

Comments: See the Typic Marsh Subtype and other subtypes for general comments and references on beaver ponds, landscape diversity, and ecosystem services.

The Cypress–Gum Subtype is distinctive in that the flood tolerance of *Taxodium* and *Nyssa* allow them to persist for many years, creating a shaded pond environment with much structural diversity. They likely are particularly important for birds and other vertebrates. They may be good sites for colony-nesting birds such as herons.

The NVC association corresponding to this subtype is very broadly defined and thus is a poor fit for this subtype. *Taxodium distichum* Semipermanently Flooded Woodland (CEGL004442), another association noted as overlapping this concept in earlier drafts of the 4^{th} Approximation, has been merged in the NVC.

A Successional Subtype, included in earlier drafts of the 4^{th} Approximation but never incorporated into NVC, has been dropped. Successional ponds may be partially or fully drained and may be affected by the vegetation established before drainage. Zonal communities can also succeed to each other even if a pond is not drained. Since the subtypes are broadly defined and overlap the kinds of successional vegetation, it seems best to treat most successional ponds as parts of the other subtypes, at least for the present.

Rare species:
Vascular plants – *Persicaria hirsuta* and *Sagittaria macrocarpa*.

PIEDMONT AND MOUNTAIN FLOODPLAINS THEME

Concept: Piedmont and Mountain Floodplain communities occur on alluvial soils or in areas that are presently or recently influenced by overbank flooding by rivers or streams. They include forests and also include bars, scoured areas along the channel that are too recently deposited or too frequently disturbed to support forests, and areas impounded by beavers. Characteristic vegetation distinguishes Piedmont and Mountain Floodplains even where flooding is rare or has been eliminated by dams, stream incision, or other alterations. Floodplain communities show influence by water but they may or may not meet the conditions for jurisdictional wetlands.

Distinguishing Features: Piedmont and Mountain Floodplain communities are distinguished by occurring in stream or river floodplains, showing evidence of influence by overbank flooding. A suite of characteristic alluvial species, such as *Platanus occidentalis, Betula nigra, Xanthorhiza simplicissima, Chasmanthium latifolium,* and *Elymus hystrix*, indicates this environment, and at least several members should be present to distinguish floodplain communities from upland communities or other wetlands such as Mountain Bogs and Fens. Invasive non-native plants such as *Microstegium vimineum* and *Stellaria media* also tend to be much more frequent and abundant in floodplains than in uplands. Most examples also have combinations of plant species not typically found in Mountain or Piedmont upland forests, such as a mixture of upland and wetland species instead of, or in addition to, the alluvial species. Most floodplains have alluvial soils, though sometimes in bodies too small to map, but areas that show signs of scouring or movement of material by water during common flood conditions (e.g., 5-year floods) should also be included. In the Mountain Region, not all flat valley bottoms support floodplain communities. Many are occupied by Mountain Cove Forests or even oak forests.

Within this theme, communities are distinguished first by being forested or open. Nonforested communities include canebrakes, beaver ponds, pools, stream bars, and shore areas kept open by more intense flood disturbance. Forested communities are distinguished by geographic region and the related floristic differences, and by floodplain size. The mountain communities occur in the Blue Ridge but also in the mountainous foothill areas where gradients tend to be steeper and where the flora of the Mountain Region is present. The Piedmont communities occur in the rest of the Piedmont Region, extending through the Fall Zone. They are separated from the Coastal Plain Floodplains theme where floodplains are bordered by Coastal Plain sedimentary formations and are no longer confined by harder igneous and metamorphic rock of the Piedmont. Floodplains tend to abruptly widen and gradients to decrease at this point, changing flooding dynamics and sediment deposition.

Large floodplains have depositional landforms that are large enough to form separate natural communities – natural levees, lower backswamps and sloughs, and bottomland ridges and terraces. Smaller floodplains may have such landforms, but the scale is too small to form separate communities. Often such features are just the size of a few trees; they are treated as a single community that fills the floodplain. As noted by Matthews, et al. (2011), the distinction is the size of the floodplain, not the size of the river. Large rivers in gorges or confined to narrow floodplains by hard rock lack large depositional landforms and have mixed vegetation. In the soft Triassic sedimentary rocks, moderate-size creeks can form large floodplains with well-developed depositional landforms. These Triassic basin floodplains can share characteristics with Coastal Plain floodplains, but their flora remains more related to the Piedmont.

Sites: Piedmont and Mountain Floodplain communities generally occur in distinct valley bottoms, where stream erosion and alluvial deposition have created a more level surface than in the adjacent uplands. At least some semblance of a bottom is often present along even small intermittent streams but, especially in the Mountains, slopes may adjoin a channel without any recognizable floodplain or floodplain community. Narrow bands of floodplain vegetation may occur on steeper slopes at the base of bluffs or upland slopes next to rivers. Larger floodplains may have distinct raised natural levees along the river, but sometimes the rapid deposition, coarse sediment deposits, and increased floodwater currents associated with levees occur on the riverbank without a distinct raised area. Large floodplains sometimes have substantial microrelief, with wet sloughs or backswamp basins and ridges creating different environments. Some have broad terraces that are flatter, are well above the river, but still have alluvial soils that flood in the largest floods and that support floodplain communities.

Soils: Soils include several series of alluvial soils, usually Inceptisols and Entisols, but sometimes Ultisols on the older terraces.

Hydrology: Piedmont and Mountain Floodplains generally flood for relatively short periods, due to the high gradient of the rivers, and floodwaters usually have significant current. Only places where water flow is trapped by basins or beaver dams retain surface water much of the year. Nevertheless, variations in wetness are enough to create differences in communities. When not flooded, soil drainage can vary substantially; areas near the river channel tend to be well drained, while interior areas may be well drained or poorly drained.

Rivers usually have a single channel, which may meander or be fairly straight. Islands and multiple channels occur but are not common. River channels appear to be quite stable, and course changes appear rare, though undercutting of banks can topple trees. However, bars within the channel may be reworked fairly frequently. Overflow channels parallel to the river are sometimes present.

Vegetation: Piedmont and Mountain Floodplain vegetation is extremely variable. The forest communities share a large pool of species in all strata, and species group less clearly than those in the Coastal Plain Floodplains theme. There is a set of wetter communities that have fewer tree species, but their characteristic species, such as *Fraxinus pennsylvanica*, *Ulmus americana*, and *Acer rubrum*, also occur in many other floodplain communities. A suite of species, such as *Platanus occidentalis, Betula nigra*, and *Acer negundo*, as well as *Chasmanthium latifolium*, are indicative of natural levees, but they can also occur in more mixed forests in other settings. Many species occur primarily in floodplains but can be found in uplands where soils are basic. *Lindera benzoin, Juglans nigra, Aesculus sylvatica, Phryma leptostachya, Elymus virginicus*, and *Elymus hystrix* are a small sample of this suite of species. Nonnative species are present more often than not. Several exotic species frequently occur in the same site, and often they dominate the herb or shrub layer. Much more than in the Coastal Plain, upland species are an abundant part of the mix in most Piedmont and Mountain Floodplains. There is substantial biogeographic variation in flora, with a number of species largely limited to the Mountains and foothills, some to the lower Piedmont.

Although nonforested communities are more limited in acreage in Piedmont and Mountain Floodplains, they are important parts of the diversity. Piedmont/Mountain Semipermanent Impoundment communities, in beaver ponds, may once have been very extensive. They represent a diverse collection of aquatic, marsh, and shrubland vegetation. Canebrakes, now nearly gone, may once have been extensive. Rocky Bar and Shore communities represent several subtypes, with sparse to moderate-density vegetation. They range from nearly monospecific to some of the most species-rich communities in North Carolina.

Dynamics: Natural vegetation dynamics in the forests of the Piedmont and Mountain Floodplains theme are similar to those of most upland hardwood forests: long-lived trees dominate, tree populations are multi-aged, and tree replacement occurs primarily in small gaps where not affected by beavers or bank erosion. Flash floods can cause local damage, especially in the Mountains. Otherwise, though floods in forests of this theme may scour the ground surface locally and disturb herbaceous vegetation, mortality of trees due to erosion or wetness is rare. Most trees are killed by wind, lightning, or disease. Severe storms occasionally create medium or larger canopy gaps. Natural levees, with exposure to the open channel, may be particularly susceptible to windthrow, but the sandy soils of smaller stream bottoms may also make them vulnerable. The author has observed multiple areas where hurricane-caused windthrow in the Piedmont was concentrated in small stream bottoms while adjacent uplands were less disturbed. Increased disturbance of this sort may be the reason for the abundance of *Liriodendron tulipifera, Liquidambar styraciflua*, and other trees that disperse widely, readily occupy openings, and benefit from severe disturbance. Many of the most characteristic alluvial tree species, such as *Platanus occidentalis, Betula nigra, Acer negundo*, and *Celtis laevigata,* also have these traits. However, notably, other trees that have these characteristics, such as *Pinus taeda* and *Pinus virginiana*, while sometimes present in floodplains, are not abundant except in human-cleared areas.

While flooding is not an important natural disturbance in the forested communities in this theme, it is a crucial environmental factor in the non-forest communities in this theme. Scouring, battering, removal of soil, and reworking of sediment are the processes that keep the bar communities open. In Floodplain Pool and Piedmont/Mountain Semipermanent Impoundment communities, long-term inundation prevents establishment of a tree canopy.

Flooding is an important natural process that provides nutrients and redistributes material. Large floods in mountainous areas can leave new deposits of cobbles or boulders along smaller creeks or larger rivers. Piedmont and Mountain Floodplains may have either a net loss or net accumulation of sediment. Wrack, flood-piled litter and wood, or the bare ground they create when they decay or are moved may be important microsites. Thanks to the frequent influx of nutrient-rich fine sediments, floodplain soils are generally the most fertile in these regions.

While sediment accretion is slow at present, there was a period of rapid deposition, especially in Piedmont rivers, during the 1700s and 1800s, caused by erosion driven by widespread clearing and plowing of uplands. This change in sediment dynamics was accompanied by construction of numerous mill dams and by the extirpation of beavers. The full consequences of these changes are not clear. Walter and Merritts (2008) suggest that no Piedmont streams, at least in the range of 1^{st} to 3^{rd} order, escaped drastic alteration. Their sediment cores and trenches through floodplain deposits suggest a past with multiple anabranching channels, extensive organic-rich soils, and abundant wetland and aquatic macrophytes rather than the single deep, meandering channel, and drier floodplains that prevail today. It should be noted that, though their primary study area in the Pennsylvania Piedmont had a very high density of mills, their map of mill density throughout the Piedmont showed a different situation in North Carolina and South Carolina. Here, mill density was ¼ to ½ that of Pennsylvania, suggesting that many streams or reaches must have escaped. Even without extensive damming, however, a large influx of sediment may have aggraded floodplains. Walter and Merritts (2008) suggested seepage as the cause of wet conditions in floodplains in the past, with seepage sources now blocked by accumulated sediment. However, such conditions could also have been created by beaver ponds, and they may also have been favored by the cooler, wetter climate of the Pleistocene.

Hydrological changes caused by land clearing and urbanization in watersheds and along tributaries confound these effects. Active headward erosion and entrenchment can still be observed along some smaller streams in both rural and urban areas, and the underlying causes are not always clear. Many of the larger floodplains have also been hydrologically altered, as well as fragmented, by large reservoirs.

Agriculture, and secondary succession in its aftermath, are important factors in the higher parts of medium and large floodplains. Because bottomlands were the focus of cultivation by Native American cultures, some floodplain areas may have a very long history of repeated shifting cultivation. With European settlement, long term cultivation occurred in many areas that are now forested. Some areas of successional forest are readily recognizable by furrows and by vegetation composition, but some are not as readily distinguishable from unplowed areas as they are in the uplands. The tree species that invade abandoned fields remain more prominent in climax forests. *Liquidambar styraciflua* and *Liriodendron tulipifera* most often dominate successional forests in even-aged stands. Successional patterns were described in detail by Oosting (l942), who noted that *Betula nigra* or *Platanus occidentalis* may form uniform stands in abandoned fields away from the banks and levees where they otherwise occur.

Piedmont and Mountain Floodplains are particularly susceptible to invasion by exotic plants, because of their high fertility, transport of seeds by flood waters, and perhaps local scouring and sediment movement. Land clearing and human disturbance exacerbates invasion, but even the least disturbed floodplains are very vulnerable. Brown (2002) found unusually high numbers of different exotic species in the most frequently flooded riparian sites. Brown and Peet (2003) addressed patterns of invasibility. In general, in minimally altered Mountain riparian areas, the number of exotic species increases with the number of native species in riparian communities, and both increase with flooding frequency. The authors conclude that species richness is driven by immigration processes and propagule pressure. However, at the finest scales, native and exotic species richness are negatively correlated, presumably because plants are competing more directly for space. Such relationships have not been examined in the Piedmont but probably are similar.

The most poorly known natural dynamic process of floodplains is that of beavers (*Castor canadensis*). Beavers were extirpated early in European settlement in North Carolina, and they were absent until reintroduced in 1939. They have since spread throughout the state and have been in some areas for decades. But it is unclear to what extent they have reached a natural equilibrium in any given place. Trapping and management of beavers occurs in many areas, and natural predators are no longer present. Beavers prefer 2nd order streams (Snodgrass 1997) and they strongly prefer low gradients. Many Piedmont and most Mountain streams probably are too steep and swift for them. At the least, the higher gradients and occurrence of flash floods would have reduced the life span of beaver dams compared to the Coastal Plain. Aquatic communities in ponds may have been less stable and less diverse. However, flood-damaged dams could have been rebuilt in the same places rather than leading beavers to relocate. An important question for small streams is whether all parts of a stream are attractive for pond building or if certain sites are naturally favored, and hence whether ponds shifted randomly and eventually affected the whole area, or if certain sites were chronically ponded while others never were. See the description of Piedmont/Mountain Semipermanent Impoundment for more on the dynamics of beavers and beaver ponds.

It is somewhat unclear how important fire naturally was in Piedmont and Mountain Floodplains. Smaller floodplains are well connected to upland forests, as are the peripheral parts of larger floodplains. Fire probably could not spread soon after litter had been redistributed by flooding, but at other times it might carry though most of a forest, at least as far as the river channel. However, moist conditions in floodplains and in adjacent mesic upland forests would limit fire intensity, so that burning might have had limited ecological effect. Additionally, sloughs and swamps would block the spread of fire to many parts of larger floodplains. Given the focus of Native American settlement in larger river bottoms, anthropogenic fire probably was locally very frequent in later prehistoric times.

One additional major uncertainty about floodplain community dynamics concerns canebrakes. *Arundinaria tecta* is the prevailing cane species in the Piedmont, *Arundinaria gigantea* in the Mountains. Definitive historical references to canebrakes in North Carolina are scarce, compared to states farther south and farther west. Both cane species are common in many large and medium floodplains, and their stalks were widely used by the Cherokee and other native peoples, but it is unclear how numerous or how large the areas dominated by them were. Dominance by cane could have been self-perpetuating in the presence of regular fire, with the flammable vegetation promoting more frequent and intense fires that would perpetuate its dominance.

Comments: Piedmont and Mountain Floodplain communities have been less intensively studied than those of the Coastal Plain. Descriptive site reports are less numerous, especially for vegetation on larger rivers, where few unaltered examples remain, and for the smallest streams, which often are ignored. The smallest stream bottoms also are poorly represented in plots, because they often are narrow enough to make it difficult to fit standard size plots in them. Broad scale vegetation descriptions in the Piedmont, such as Peet and Christensen (1980) and Wells (1974), describe floodplain vegetation but usually in general categories such as alluvial and swamp sites. In the Mountains, many of the most comprehensive studies focus on rugged areas; studies such as McLeod (1988), Newell (1997), Cooper and Hardin (1970), and DuMond (1969) address alluvial vegetation based on the small amounts in their study areas. However, a plot-based study of Piedmont floodplains by Matthews (2011) and of several Mountain Region rivers by Brown (2002) have helped bring specificity and higher resolution to these communities.

The classification of Piedmont and Mountain Floodplain communities has been particularly confusing and problematic. The circumscription and central concepts of the 3rd Approximation have been modified in several important ways. The 4th Approximation more distinctly separates Piedmont from Mountain floodplains. While there is a rapid change in floodplain geomorphology and processes between the Piedmont and Coastal Plain, which supports a sharp break in communities at the theme level at the Fall Zone, there is no similar break in character at the Blue Ridge escarpment. Attempting to recognize Piedmont-like rivers in the Mountains did not work well. The 4th Approximation divides these communities, based on the presence or absence of flora typically associated with the Mountain Region and with states to the west. As in many upland communities, this flora is often present in floodplains in the foothills area of the western Piedmont, and such floodplains are treated as Montane Alluvial Forest.

The Piedmont communities of large floodplains are treated as analogous to the bottomland hardwoods and swamps of the Coastal Plain, with each representing a portion of the elevation/wetness gradient. Bottomlands are characterized by being dry enough to favor some of the same species found in Brownwater Bottomland Hardwoods, particularly *Quercus michauxii* and *Quercus pagoda*. Swamps are wet enough that these species are scarce or absent. The 3rd Approximation's characterization of bottomlands as typically being dominated by *Liriodendron* or *Liquidambar*, using some of the few descriptions of these communities found at the time, appears to have been based on successional forests. Though these species are present in the less altered examples, their strong dominance suggests past cultivation or clearcutting. Oaks appear abundant in less altered examples. While *Liriodendron* remains typical of Piedmont Bottomland Forest and is largely absent from Piedmont Swamp Forest, the broad moisture tolerance of *Liquidambar* makes it equally at home in both.

While some floodplains can be extensively covered by either swamp or bottomlands, are complex mosaics. The bottomland oak species are only minor species in the swamps, largely confined to the Bottomland Transition Variant of Piedmont Swamp Forest. However, Triassic Basin floodplains tend to be wetter and have more swamp. It is also true that large bottomlands elsewhere are most often dominated by *Liquidambar* or *Liriodendron*, because most have been cultivated in the recent past. Oak-dominated bottomlands are more likely to be found on medium size floodplains and in complex floodplains with much swamp, places that were less suitable for cultivation.

KEY TO PIEDMONT AND MOUNTAIN FLOODPLAINS

1. Vegetation a forest; a well-developed closed or somewhat open canopy of tall trees present when not recently disturbed.

  2. Mountain or mountain-like floodplain; occurring in the Blue Ridge region or in the foothills portion of the western Piedmont and having species characteristic of the Blue Ridge, such as *Betula lenta, Halesia tetraptera, Tilia americana* var. *heterophylla, Betula alleghaniensis*, and *Rhododendron maximum*.

    3. Occurring on a large river, with a well-developed floodplain; alluvial species such as *Platanus occidentalis, Betula nigra, Acer negundo, Fraxinus pennsylvanica, Arundinaria gigantea, Alnus serrulata,* and *Boehmeria cylindrica* generally abundant and diverse; species such as *Celtis laevigata, Liquidambar styraciflua, Quercus pagoda, Quercus imbricaria, Chasmanthium latifolium*, and *Elymus riparius* may be present.

      4. Occurring on a high terrace with alluvial soil but rarely flooded; forest dominated by upland oaks, hickories, or pines, such as *Quercus alba, Quercus rubra, Carya tomentosa, Carya pallida, Pinus rigida*, or *Pinus echinata*, with a relatively low diversity and abundance of alluvial species and mesophytic species ……………………………………………………………………………..................................... **Montane Alluvial Forest (High Terrace Subtype)**

      4. Occurring on a more typical lower floodplain; forest containing many alluvial or wetland species.

        5. Occurring in low areas, such as sloughs, which retain standing water for long periods, or occasionally in uniformly wet floodplains; forest dominated by a small number of the most water-tolerant species, such as *Acer rubrum, Fraxinus pennsylvanica*, *Carpinus caroliniana, Boehmeria cylindrica, Impatiens capensis, Carex* spp., and *Lycopus*, with limited presence of more mesophytic species............ **Montane Floodplain Slough Forest**

        5. Occurring on typical floodplain surfaces that are not flooded for long periods nor high enough to be very dry; alluvial species common and relatively diverse, though mixed with mesophytic and some upland species.... **Montane Alluvial Forest (Large River Subtype)**

    3. Occurring on a small river or creek, with limited but some floodplain development; alluvial species present in limited abundance and diversity; canopy often a mix of species shared with Acidic Cove Forest (*Tsuga canadensis, Acer rubrum, Betula lenta, Liriodendron tulipifera*, etc.) combined with species of rich sites, such as *Lindera benzoin, Asimina triloba, Carpinus caroliniana, Rudbeckia laciniata*, and *Amphicarpaea bracteata* ……………………………………………………………………..**Montane Alluvial Forest (Small River Subtype)**

  2. Piedmont floodplain; occurring in the eastern or central Piedmont, or, if occurring in the western Piedmont, lacking species characteristic of the Blue Ridge.

    6. Occurring on a large floodplain on a large river or on a medium-sized creek within a Triassic basin; fluvial landforms such as natural levees, sloughs, bottomlands, and terraces large enough to support separate communities; at least two different forest communities present in the floodplain on at least one side of the river.

      7. Community occurring in a low portion of the floodplain, in sloughs, backswamp basins, or occasionally in uniformly wet floodplains; flooded for substantial periods; canopy naturally dominated by water-tolerant species such as *Acer rubrum, Fraxinus pennsylvanica, Ulmus americana, Quercus lyrata*, or *Quercus phellos*, with limited presence of other floodplain species and with no mesophytic or upland species; herb layer dominated by water-tolerant species such as *Saururus cernuus, Boehmeria cylindrica, Ludwigia palustris*, and

wetland *Carex* species, though other floodplain species may be present……………………
………………………………… .... **Piedmont Swamp Forest**

7. Community not in a low portion of the floodplain; not flooded for long periods; water-tolerant species of trees and herbs may be present but do not dominate and are confined to limited wet microsites.

8. Community occurring adjacent to the river, on a natural levee (higher depositional area next to the channel) or on a level or lower area that has distinct vegetation; alluvial species such as *Platanus occidentalis, Betula nigra, Acer negundo, Celtis laevigata,* and *Fraxinus pennsylvanica* dominant or codominant under natural conditions, though widespread species such as *Liriodendron tulipifera* and *Liquidambar styraciflua* may codominate and species of rich sites such as *Carya cordiformis, Acer floridanum*, and *Juglans nigra* may be abundant.

9. Community on a higher levee that has abundant *Fagus grandifolia* and often other upland species along with alluvial species (Note that Piedmont Alluvial Forest can also have these species along with alluvial species) ……………………………………….
…………… .... **Piedmont Levee Forest (Beech Subtype)**

9. Community on a more typical levee or riverbank, lacking *Fagus grandifolia* and most other upland species.......................................**Piedmont Levee Forest (Typic Subtype)**

8. Community not adjacent to a river channel or, if so, not showing any different character from the rest of the floodplain; on fluvial ridges, terraces, or uniform flats that are not extremely wet; forest with limited or no *Platanus occidentalis, Betula nigra, Acer negundo*, or *Celtis laevigata* (except occasionally in successional condition); dominated by bottomland oaks, hickories, *Liquidambar styraciflua*, and *Liriodendron tulipifera*; may have some upland species.

10. Community on a high terrace or higher fluvial ridges; flooding infrequent, though soils are alluvial; forest with a substantial component of upland species such as *Quercus rubra, Quercus alba,* and *Fagus grandifolia*, along with bottomland oaks, hickories, and other species; more water-tolerant species such as *Quercus lyrata, Ulmus americana*, and wetland herbs such as *Saururus cernuus, Juncus effusus*, and wetland *Carex* spp. generally absent . ...**Piedmont Bottomland Forest (High Subtype)**

10. Community on lower floodplain ridges or possibly a low terrace; flooding more frequent, though still generally of brief duration; forest with limited upland species; bottomland oaks, hickories, *Liquidambar*, and *Liriodendron* dominate in natural condition; wetland herbs more widespread, though not dominant.

11. Forest with *Quercus palustris* or *Quercus bicolor* as a substantial component; rare community of the northern Piedmont. ....
....................................**Piedmont Bottomland Forest (Northern Low Subtype)**

11. Forest without *Quercus palustris* or *Quercus bicolor*, or with only limited amounts; widespread community of the eastern and central Piedmont. ....
....**Piedmont Bottomland Forest (Typic Low Subtype)**

6. Occurring on a small floodplain, either on an intermittent stream, a 1st to 3rd order stream, or on a larger river with a confined floodplain and without large fluvial landforms such as natural levees, sloughs, bottomlands, and terraces that support separate communities; only one forest community in the floodplain on both sides of the stream; composition mixed throughout

the width of the floodplain, with alluvial species occurring with widespread species and mesophytic species throughout the floodplain.

12. Floodplain well-developed, though medium sized or small; well-developed channel present; multiple alluvial species such as *Platanus occidentalis, Fraxinus pennsylvanica, Betula nigra, Acer negundo*, and *Celtis laevigata* present and fairly abundant, though *Liquidambar* or *Liriodendron* usually dominate...........................**Piedmont Alluvial Forest**

12. Floodplain very small and/or marginally developed, though distinct from upland; channel may or may not be well developed; forest with few or no alluvial species; *Liriodendron, Liquidambar*, or *Quercus phellos* generally dominate; upland species such as *Fagus grandifolia, Quercus rubra*, or *Quercus alba* may be abundant.

13. Community in an unusually flat area with hardpan conditions (shrink/swell soils) associated with mafic or clayey rocks; generally occurring with Upland Depression Swamp Forest or Xeric Hardpan Forest; canopy generally dominated by *Quercus phellos* and *Liquidambar styraciflua*…………………………………………………………………. .... **Piedmont Headwater Stream Forest (Hardpan Subtype)**

13. Community in a typical small floodplain, without hardpan conditions; associated with typical acidic or basic upland communities; canopy dominated by *Liriodendron* or *Liquidambar* along with upland species ………………………………………………… ………………………………… **Piedmont Headwater Stream Forest (Typic Subtype)**

1. Vegetation not a forest; trees, if present at all, not forming a true canopy over most of the community due to long-term standing water, frequent flood damage, lack of time since the substrate was deposited, or dominance by *Arundinaria*.

14. *Arundinaria tecta* or *Arundinaria gigantea* forming a dense thicket; tall trees may be present but do not form a full canopy .... **Piedmont/Mountain Canebrake**

14. *Arundinaria* absent or sparse.

15. Community a natural depression or blocked slough which holds standing water permanently or through much of the growing season..................................... **Floodplain Pool**

15. Community not a natural depression; open because of long-term standing water created by a beaver dam or because of frequency and severity of flood scouring.

16. Community presently or recently part of a beaver pond; if the beaver pond has drained, vegetation remains wetter and distinctly different from typical floodplain forest communities.

17. Community with permanent or semipermanent standing water deep enough to eliminate most emergent vegetation; vegetation of floating aquatic plants such as *Lemna* or *Nymphaea*, submersed aquatic plants, or vascular vegetation absent over most of the area; emergent vegetation limited to edges and higher microsites; other plants limited to microsites on logs, stumps, and bases of a few surviving trees... ....**Piedmont/Mountain Semipermanent Impoundment (Open Water Subtype)**

17. Community with only shallow standing water or with water drained but vegetation not recovered to typical floodplain forest.

18. Community dominated by herbaceous vegetation; shrubs and trees limited.

19. Community in the Mountains or mountain-like foothills region..............………. …**Piedmont/Mountain Semipermanent Impoundment (Montane Marsh Subtype)**

19. Community in the Piedmont, outside of the foothills region …………………..…. ...**Piedmont/Mountain Semipermanent Impoundment (Piedmont Marsh Subtype)**

18. Community dominated by shrubs or young trees; in Piedmont or Mountains .... **Piedmont/Mountain Semipermanent Impoundment (Shrub Subtype)**

16. Community not recently affected by impoundment by beavers; kept open by frequency and severity of flooding; located in or adjacent to the river channel .. **Rocky Bar and Shore** (see key A).

Key A. Rocky Bar and Shore.

1. Substrate predominantly of bedrock, kept largely free of soil by flood scouring; plants limited to small pockets of sediment and to fractures in the rock.

2. Community in the Mountains. .... **Mountain Bedrock Scour Subtype**

2. Community in the Piedmont, known only along the Yadkin River in the Uwharrie region .... **Yadkin Falls Bedrock Scour Subtype**

1. Substrate of loose deposited material, ranging from boulders and cobbles to sand and silt.

3. Community in shallow flowing water at least most of the time; substrate with abundant boulders or cobbles; sparse to moderate vegetation generally consisting of a single strongly dominant species.

4. Community dominated by *Carex torta*; in the Mountain region or mountain-like foothills .... **Twisted Sedge Subtype**

4. Community not dominated by *Carex torta*; generally in the Piedmont region.

5. Community dominated by *Justicia americana*. .... **Water Willow Subtype**

5. Community not dominated by *Justicia americana*.

6. Community dominated by *Podostemum ceratophyllum* on submerged rocks; potentially throughout the Piedmont.. **Riverweed Subtype**

6. Community dominated by *Zizaniopsis miliacea*; confined to the eastern Piedmont near the fall zone, perhaps unique to the Cape Fear River ………………………….. ………...**Southern Wild Rice Subtype**

3. Community substrate above water level except in flood; substrate a mix of sand, silt, cobbles, and potentially boulders.

7. Community a mix of species with some shrub component, with *Xanthorhiza simplicissima* or *Alnus serrulata* generally most abundant; on medium to small rivers; in the Mountain region or foothills. ....**Alder–Yellowroot Subtype**

7. Community not a mix with *Xanthorhiza* or *Alnus* predominant; in the Mountains or Piedmont; on medium to large rivers.

8. Community strongly dominated by *Zizaniopsis miliacea*; confined to the eastern Piedmont near the fall zone..**Southern Wild Rice Subtype**

8. Community a variable mix of species, including small trees, shrubs, perennial and annual herbs, generally with no strong dominant; often very high species richness....... .... **Mixed Bar Subtype**

MONTANE ALLUVIAL FOREST (SMALL RIVER SUBTYPE)

Concept: Montane Alluvial Forests are communities of floodplains in the Mountain Region and foothills of the upper Piedmont. They consist of a mix of species of alluvial or floodplain settings combined with those of Rich Cove Forest, Acidic Cove Forest, and other upland communities. The Small River Subtype occurs on smaller floodplains, where upland species predominate and characteristic alluvial species are less abundant.

Distinguishing Features: Montane Alluvial Forests are distinguished from Rich Cove Forests and Acidic Cove Forests, with which they may share many species, by evidence of flooding as well as by more than a trace presence of some of a characteristic suite of wetland or alluvial indicator species, such as *Platanus occidentalis, Betula nigra*, and *Alnus serrulata*. Not all flat valley bottoms near streams develop as Montane Alluvial Forests; many are Rich Cove Forest or Acidic Cove Forest indistinguishable from those on slopes. The alluvial indicator species may codominate, but usually are less abundant. Sites that lack them altogether should be classified as cove forests or other upland communities. Flood-dispersed exotic plant species also are often abundant in Montane Alluvial Forests and are usually scarce in upland forests. *Microstegium vimineum, Lonicera japonica*, and *Murdannia keisak* may appear in uplands or nonriverine wetlands where these habitats are severely disturbed but are common even in relatively undisturbed floodplains. Montane Alluvial Forests are distinguished from Piedmont or other lowland floodplain forests by containing a substantial component of montane species, generally shared with both Rich Cove Forest and Acidic Cove Forest. These may include *Betula lenta, Tsuga canadensis, Halesia tetraptera*, *Tilia americana* var. *heterophylla, Aesculus flava, Betula alleghaniensis,* and *Rhododendron maximum*.

The Small River Subtype, besides occurring in smaller, less well-developed floodplains, is distinguished from the Large River Subtype by being more like cove forests, having lesser abundance and richness of the suite of alluvial indicator plant species. *Platanus occidentalis* and *Xanthorhiza simplicissima* are the most frequent; *Betula nigra, Alnus serrulata, Arundinaria gigantea, Boehmeria cylindrica*, and a few others are occasional. Also characteristic is a combination of acid-tolerant canopy species such as *Liriodendron tulipifera, Tsuga canadensis, Betula lenta, Acer rubrum, Betula alleghaniensis*, and *Halesia tetraptera* with lower strata of richer sites, such as *Asimina triloba, Lindera benzoin, Carpinus caroliniana, Rudbeckia laciniata, Amphicarpaea bracteata*, or any of a number of species shared with Rich Cove Forests. However, lower strata often are at least partly dominated by *Rhododendron maximum* or *Leucothoe fontanesiana*, and acid-tolerant herbs may predominate. In contrast, the Large River Subtype generally has more abundance and diversity of alluvial indicator plant species present. These include some species rarely or never found on smaller rivers, such as *Fraxinus pennsylvanica, Juglans cinerea, Acer negundo, Celtis laevigata, Liquidambar styraciflua, Quercus imbricaria, Quercus pagoda, Chasmanthium latifolium*, and *Elymus riparius*. The Large River Subtype also often has upland species of drier communities, such as *Quercus* spp., *Oxydendrum arboreum, Nyssa sylvatica, Danthonia spicata*, and *Piptochaetium avenaceum*, while the Small River Subtype consists largely of mesophytic plants.

The Small River Subtype may resemble Swamp Forest–Bog Complex in its dominant canopy trees and shrubs, but it will contain multiple alluvial species throughout the community. Wetland species may be present in small numbers but will not be concentrated in boggy openings with *Sphagnum* and multiple species characteristic of bogs.

Crosswalks: *Tsuga canadensis - Liriodendron tulipifera - Platanus occidentalis / Rhododendron maximum - Xanthorhiza simplicissima* Wet Forest (CEGL007143).
G637 Appalachian-Interior-Northeast Floodplain Forest Group.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).

Sites: The Small River Subtype occurs on flat areas near streams or small rivers. The characteristics that lead to Montane Alluvial Forest on some of these areas but not on many others are not well known.

Soils: The Small River Subtype probably generally occurs on some kind of alluvial soil, but it may often not be recognized in mapping. Mapped soils include Toxaway (Cumulic Humaquept), Rosman (Fluventic Haplumbrept), or Transylvania (Fluventic Humic Dystrudept).

Hydrology: The Small River Subtype is intermittently flooded. Flooding is of brief duration and probably doesn't happen in most years. Because of high stream gradients, these areas may have flash floods with substantial current, occasionally enough to be a significant natural disturbance. Other than in local small seepages or depressions, soils are probably well drained when not flooded.

Vegetation: The Small River Subtype may be dominated or codominated by *Liriodendron tulipifera, Tsuga canadensis*, or *Acer rubrum*, or more often is a diverse mix of trees. Characteristic floodplain species are present in several strata, but usually in low numbers. *Platanus occidentalis* is the most frequent such species, but *Betula nigra* may also occur. Other species that occur with high frequency in CVS plot data or site descriptions, also generally noted in local studies such as Newell (1997), McLeod (1988), Cooper and Hardin (1970), and Dumond (1969), are *Pinus strobus, Fraxinus americana*, and *Quercus alba.* Also fairly frequent are *Quercus rubra, Fagus grandifolia, Betula nigra*, and *Aesculus flava*. A diversity of other canopy trees may occasionally be present, including *Carya cordiformis*, other *Carya* spp., *Betula alleghaniensis*, and *Juglans nigra*. The understory is usually dominated by *Carpinus caroliniana*, and *Acer rubrum, Halesia tetraptera*, or other canopy species may be abundant. Other frequent understory species include *Ilex opaca, Oxydendrum arboreum, Benthamidia* (*Cornus*) *florida*, less frequently *Nyssa sylvatica*, *Asimina triloba*, *Acer pensylvanicum*, and a number of others. The shrub layer usually includes patches dominated by *Rhododendron maximum* and *Leucothoe fontanesiana*, and *Lindera benzoin* may dominate patches in some examples. Other frequent shrubs include *Xanthorhiza simplicissima* (usually on the stream bank but sometimes more widespread), *Hydrangea arborescens, Arundinaria gigantea, Alnus serrulata, Hamamelis virginiana, Kalmia latifolia, Swida* (*Cornus*) *amomum*, and *Calycanthus floridus*. A great diversity of additional species is found with low frequency. Vines are usually not extensive, but *Toxicodendron radicans* and the exotic *Lonicera japonica* occur with high frequency. The herb layer may be sparse to dense but is seldom as lush as in Rich Cove Forests. *Polystichum acrostichoides, Rudbeckia laciniata, Arisaema triphyllum, Amauropelta* (*Parathelypteris*) *noveboracensis, Mitchella repens, Athyrium asplenioides*, *Viola sororia*, and the exotic *Microstegium vimineum* are frequent in both CVS plot data and site descriptions. *Dichanthelium boscii, Sanicula canadensis, Eurybia divaricata, Ranunculus* *recurvatus,* and *Potentilla canadensis* are also at least fairly frequent in plot data, while *Impatiens capensis*, *Ageratina altissima, Packera aurea, Tiarella cordifolia, Boehmeria cylindrica, Eutrochium purpureum, Amphicarpaea bracteata, Juncus effusus, Osmundastrum cinnamomeum*, and *Scirpus polyphyllus* are fairly frequent in site reports. The genera *Carex*, *Viola*, and *Solidago* are frequent, but include multiple species and often aren't identified to species. A tremendous diversity of additional species occurs with low frequency, including most species of Rich Cove Forest, many species of oak forests, species shared with other floodplain forests, and some wetland species. Of 440 species in the CVS plots analyzed, 114 occur only once, another 83 twice. A similar diversity of species, many of them different ones, is mentioned in only one or two site reports.

Range and Abundance: Ranked G3. Good remaining examples are fairly rare in North Carolina, with fewer than 30 occurrences known. Alluvial sites are not uncommon in montane areas, but very few examples of their communities remain intact. Surrounded by more rugged terrain, the alluvial valleys are the favored sites for fields, houses, towns, highways, and reservoirs.

The NVC association is considered widespread, ranging southward to Georgia, westward to Tennessee and Kentucky, and possibly into Virginia. However, its concept may not match North Carolina's community well and may be overly broad.

Associations and Patterns: The Small River Subtype may occur as either a large patch or small patch community. Bands may be 100 acres or more along a river. Other patches are naturally limited by small areas of floodplain development, which give way to steeper slopes and upland vegetation both upstream and downstream. Examples generally are bordered by Rich Cove Forest or Acidic Cove Forest on adjacent slopes. They may occasionally be associated with Swamp Forest–Bog Complex or Southern Appalachian Bog in areas where drainage becomes poor. They may contain small patches of Floodplain Pool or Low Elevation Seep.

Variation: The Small River Subtype is an extremely variable community. The large number of low-constancy species in both plots and sites is interesting, since most are common in the region and since flooding allows more seed dispersal than in many communities. The distance decay of similarity described by Brown (2002) for several larger rivers likely also is an important factor in the Small River Subtype. It may also suggest great variation in environmental conditions. Individual occurrences may be heterogeneous or fairly uniform. Variation associated with stream and valley size, soil fertility, and amount of alluvial influence should be studied further. Two variants are tentatively defined, based on elevation and potentially biogeography:

1. Montane Variant occurs in the Blue Ridge region itself.

2. Foothills Variant occurs in the foothills area east of the Blue Ridge escarpment. It may contain Piedmont species that are scarce or absent in the Montane Variant.

Dynamics: Dynamics are generally like those described for the Piedmont and Mountain Floodplains theme as a whole. In their detailed study of age structure in alluvial forests at Coweeta, Hedman and Van Lear (1995) described old-growth stands as having broken heterogeneous overstories with various sized gaps and various sized trees filling them, interspersed with dominant and superdominant trees. The average diameter was diluted by the many small trees. The stands were uneven-aged, with a steeply sloping size distribution for trees up to 30 cm dbh, indicating that most do not live that long. The curve was flatter for trees that had reached the canopy, where they can live a long time, and steepened as mortality increased with old age. The authors also suggested that *Tsuga canadensis*, *Pinus strobus*, and oaks increased in old growth, while *Liriodendron, Betula*, *Tilia*, and *Prunus serotina* were more prevalent in early successional stages.

As in all floodplain forests, sediment deposition provides a nutrient subsidy, though this may not be very different from the nutrient status of Rich Cove Forests. This community is perhaps more susceptible to serious disturbance by flooding than the Large River Subtype. Occasional extreme flash floods may substantially rework sediments, uproot trees, and scour out herbs, at least in parts of an occurrence.

Beavers may impound the Small River Subtype where the stream gradient is low enough, but it is unclear what proportion of examples are susceptible.

Comments: As discussed in the theme description, the relationship of Piedmont and Mountain Floodplain communities has been changed from the 3rd Approximation. Montane Alluvial Forest now includes foothills floodplain communities which contain montane flora as described here, and the Piedmont Alluvial Forest has been narrowed to communities that lack it. Even larger Mountain floodplains don't tend to have communities differentiated by natural levee and bottomlands, so the distinction between the Large River Subtype and Small River Subtype is more subtle and is treated as a difference between subtypes rather than full types.

No community analogous to Piedmont Headwater Stream Forest has been recognized in the Mountains. Small streams there tend to be associated with steeper slopes, and they support upland forests instead. However, an example of a possible analogous community in the South Mountains needs further investigation.

Reports on the Small River Subtype in published literature are scarce. However, McLeod (1988) and Newell (1997) included some data on the Small River Subtype.

Liriodendron tulipifera - Pinus strobus - (Tsuga canadensis) / Carpinus caroliniana / Amphicarpaea bracteata Forest (CEGL008405) is an equivalent and fairly similar association in the Central Appalachians.

Rare species:
Vascular plants – *Diervilla rivularis, Glyceria laxa, Polemonium reptans* var. *reptans, Thalictrum macrostylum, Verbesina walteri, Viola appalachiensis,* and *Waldsteinia lobata*.

Nonvascular plants – *Rhabdoweisia crenulata*.

MONTANE ALLUVIAL FOREST (LARGE RIVER SUBTYPE)

Concept: Montane Alluvial Forests are communities of floodplains in the Mountain Region and foothills of the upper Piedmont. They consist of a mix of species of alluvial or floodplain settings combined with those of Rich Cove Forests and other upland communities. The Large River Subtype covers examples on the floodplains of larger, lower elevation rivers, which have a substantial component of plant species shared with lowland bottomland communities of adjacent provinces as well as a substantial component of montane species.

Distinguishing Features: Montane Alluvial Forests are distinguished from Rich Cove Forests and Acidic Cove Forests, with which they may share many species, by evidence of flooding as well as by more than a trace presence of some of a characteristic suite of wetland or alluvial indicator species, such as *Platanus occidentalis, Betula nigra*, *Alnus serrulata*, and *Xanthorhiza simplicissima*. The Large River Subtype usually has a substantial number of alluvial species. It is distinguished from the Small River Subtype by floristic differences that include the presence of a large suite of lowland floodplain plants, such as *Liquidambar styraciflua, Quercus imbricaria*, and *Fraxinus pennsylvanica*. See the Small River Subtype description for more details. It is distinguished from the Montane Floodplain Slough Forest by drier conditions, with only short-term flooding. This is associated with a large suite of mesic species that are absent from the sloughs. It is distinguished from the High Terrace Subtype by dominance by mesophytic and alluvial species, though oaks and other upland species are also often present.

Crosswalks: *Platanus occidentalis - Liriodendron tulipifera – (Betula alleghaniensis) / Alnus serrulata - Leucothoe fontanesiana* Floodplain Forest (CEGL004691).
G637 Appalachian-Interior-Northeast Floodplain Forest Group.
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The Large River Subtype occurs along larger rivers, which tend to be at lower elevations. Most or all examples are on 4^{th} or higher order streams.

Soils: The Large River Subtype occurs on distinctive alluvial soils. Series mapped for known examples include Biltmore (Typic Udipsamment), Iotla (Fluvaquentic Dystrudept), Potomac (Typic Udifluvent), and Dellwood (Fluventic Haplumbrept). However, of the soils listed by Brown (2002) as predominant along her three study rivers, only Colvard (Typic Udifluvent) is an alluvial soil. The others are upland Typic Hapludults (Evard, Clifton, Saluda), or other upland soils (Hayesville, Rabun, Edneyville, Ditney).

Hydrology: The Large River Subtype is intermittently flooded. Flooding is of fairly brief duration, though longer than in the Small River Subtype, and doesn't happen in most years. The gradient is less than in the Small River Subtype, and catastrophic flash floods are less likely. Nevertheless, flooding can occasionally be a significant natural disturbance that topples trees, scours smaller plants, or deposits new sediment, as well as moving litter and woody debris and creating wrack piles. Other than in local small seepages or depressions, soils are probably well-drained when not flooded, but large flat areas may be less well drained than in the Small River Subtype.

Vegetation: The Large River Subtype is a forest of highly variable composition. In plots collected by CVS and Brown (2002), primarily on three rivers, the only highly constant species that sometimes dominate are *Liriodendron tulipifera* and *Acer rubrum*. However, trees with fairly high frequency that are sometimes abundant include *Platanus occidentalis, Halesia tetraptera, Tsuga canadensis, Juglans nigra, Quercus alba, Quercus rubra, Robinia pseudo-acacia, Carya tomentosa, Carya cordiformis*, and *Juglans cinerea*. Other canopy trees that have lower frequency in the plot data but may be present in some examples include *Betula lenta, Fraxinus pennsylvanica, Pinus strobus, Aesculus flava, Fagus grandifolia, Tilia americana* var. *heterophylla*, *Betula nigra, Liquidambar styraciflua, Quercus imbricaria*, and *Pinus rigida*. The most constant understory species, often dominant, is *Carpinus caroliniana*. Other fairly frequent understory trees include *Benthamidia* (*Cornus*) *florida*, *Ilex opaca, Nyssa sylvatica, Amelanchier arborea/laevis,* and *Prunus serotina*, as well as canopy species. Frequent shrubs include *Lindera benzoin, Xanthorhiza simplicissima, Swida (Cornus*) *amomum, Rhododendron maximum, Pyrularia pubera, Alnus serrulata, Ilex verticillata, Viburnum cassinoides, Kalmia latifolia*, *Corylus americana, Euonymus americanus*, and *Arundinaria gigantea*, along with the exotic *Ligustrum sinense* and *Rosa multiflora*. *Toxicodendron radicans*, *Parthenocissus quinquefolia*, and *Clematis virginiana* are vines that are highly constant, and *Vitis aestivalis, Smilax rotundifolia, Smilax glauca,* and the exotic *Lonicera japonica* are frequent in plot data. The herb layer is even more variable. Frequent species that may be abundant include *Impatiens capensis, Festuca subverticillata, Verbesina alternifolia, Solidago rugosa, Amauropelta* (*Parathelypteris*) *noveboracensis, Solidago curtisii*, and *Carex blanda*. Other frequent herb species in plot data include *Rudbeckia laciniata, Polystichum acrostichoides, Viola sororia, Persicaria virginiana, Boehmeria cylindrica, Eutrochium purpureum, Galium triflorum, Geum canadense, Amphicarpaea bracteata, Elymus virginicus, Eurybia divaricata, Verbesina occidentalis, Arisaema triphyllum, Apios americana, Ranunculus recurvatus, Lycopus virginicus, Bidens aristosa, Sanicula canadensis, Stellaria pubera, Cryptotaenia canadensis, Oxalis stricta, Dioscorea villosa, Elephantopus carolinensis, Athyrium asplenioides, Leersia virginica, Dichanthelium laxiflorum, Eutrochium maculatum, Passiflora lutea, Salvia lyrata, Sedum ternatum, Solidago flexicaulis, Viola stricta, Arisaema dracontium, Blephilia ciliata, Bromus pubescens, Carex laxiflora, Dichanthelium commutatum*, and *Stachys latidens*. Less frequent species in plots, but perhaps frequent on other rivers, include *Laportea canadensis, Luzula multiflora, Luzula acuminata, Pilea pumila, Packera aurea, Mitchella repens, Glyceria striata, Tradescantia subaspera, Persicaria longiseta*, and *Actaea racemosa*.

Range and Abundance: Ranked G2?. Large intact occurrences are particularly rare in North Carolina. Many of the rare remnants are on river islands or in narrow bands. Large rivers are limited in the North Carolina Mountains, and floodplains that are not flooded by reservoirs or occupied by fields or developed areas are scarce and fragmented. This community is also attributed to Tennessee, South Carolina, and possibly Georgia.

Associations and Patterns: The Large River Subtype occurs naturally as a large patch community, with some examples potentially once occupying hundreds of contiguous acres in large bottomlands. However, many of the examples that now remain are naturally small patches, occurring on islands or in flats too small to cultivate or develop. The Large River Subtype may contain embedded High Terrace Subtype or Montane Floodplain Slough patches and may border Rocky Bar and Shore communities along the river. Patches of Piedmont/Mountain Canebrake may once have been common inclusions, though their frequency and extent in North Carolina is unclear. Adjoining uplands may contain any upland community, including cove, oak, and pine forests, as well as cliffs.

Variation: This subtype remains a broadly defined community, but there seems no good way to reliably subdivide it. The extensive alteration of floodplain forests throughout the mountains, by reservoirs, farming, pasturing, and development leaves too few remnants to distinguish overall natural patterns. Brown (2002) found that data from the three rivers she studied, the Little Tennessee, Nolichucky, and New, were separated to some degree geographically as well as by landform and other environmental variables. However, widespread species predominated on all rivers, and the species distinct to each river were of low constancy or of obscure interpretation. The presence of *Quercus imbricaria, Pyrularia pubera*, and *Itea virginica* only on the Little Tennessee, with *Arundinaria gigantea* and *Betula nigra* occurring primarily there, may suggest a distinct subtype of more southerly floodplains or of larger floodplains, but some of these species also occur on other rivers that don't fit this pattern. Since vegetational differences may be due to differences in elevation, river size, river gradient, and biogeography or dispersal limitations, as well as land use history, it is not clear how to define variants based on them.

Dynamics: The dynamics of the Large River Subtype are similar to those of the Piedmont and Mountain Floodplains theme in general. They are expected to be intermediate between the Small River Subtype and the floodplain communities of the Piedmont.

Comments: Besides the NVC association synonymized with this subtype, several others are attributed to North Carolina, creating confusion.

Platanus occidentalis - Fraxinus pennsylvanica - Quercus imbricaria Floodplain Forest (CEGL007339) is an association of Kentucky and Tennessee, which was attributed to NC on the basis of a single plot in a small grove of *Quercus imbricaria* in the Great Smoky Mountains. Other floodplains in NC also have *Quercus imbricaria*, which is a component of the association synonymized above. It appears that this plot, along with the floodplain forest around it, falls within the range of variation represented by this subtype, and does not warrant recognition of a distinction in North Carolina.

Liquidambar styraciflua - Liriodendron tulipifera - (Platanus occidentalis) / Carpinus caroliniana - Halesia tetraptera / Amphicarpaea bracteata Floodplain Forest (CEGL007880) is a floodplain association attributed to North Carolina. It appears to be a successional forest that would represent one of several degraded versions of this subtype. *Liquidambar styraciflua* is a low-constancy species on North Carolina mountain lowland rivers but does not follow a pattern that would warrant recognizing a distinct association.

Betula nigra - Platanus occidentalis / Alnus serrulata / Boehmeria cylindrica Floodplain Forest (CEGL007312) is a widespread association that has been attributed to NC for both the Piedmont and Mountains. Its relationship to other associations, including this one, needs to be clarified but appears to overlap. Mountain examples would fall within the range of variation represented by the Large River Subtype. If present in the mountains of North Carolina, it would likely represent a depauperate segregate of this subtype or possibly a successional bar community.

Rare species:
Vascular plants – *Bromus latiglumis, Carex projecta, Parthenocissus inserta, Spigelia marilandica, Spiraea virginiana,* and *Steironema* (*Lysimachia*) *tonsum.*

Vertebrate animals – *Ambystoma talpoideum*.

MONTANE ALLUVIAL FOREST (HIGH TERRACE SUBTYPE)

Concept: Montane Alluvial Forests are communities of floodplains in the Mountain Region and foothills of the upper Piedmont. They consist of a mix of species of alluvial or floodplain settings combined with those of Rich Cove Forests and other upland communities. The High Terrace Subtype covers examples on higher terraces of medium to large rivers, where evidence of flooding and some characteristic alluvial species are present, but where upland oak or pine species dominate.

Distinguishing Features: Montane Alluvial Forests are distinguished from upland forests by evidence of flooding as well as by more than a trace presence of some of a characteristic suite of wetland or alluvial indicator species, such as *Platanus occidentalis, Betula nigra*, *Alnus serrulata*, and *Xanthorhiza simplicissima*. In the High Terrace Subtype, the abundance of these species is low, but the combination of them with species of dry uplands is unique. Communities on terraces that show no significant evidence of alluvial species or processes should be regarded as Montane Oak–Hickory Forest, Acidic Cove Forest, or other upland communities.

Crosswalks: *Quercus (alba, coccinea, falcata, velutina) / Kalmia latifolia* Forest (CEGL004098).
G150 Southern Appalachian Oak Forest & Woodland Group.
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The High Terrace Subtype occurs on higher floodplain areas, which may be obvious terraces or may appear simply as ridges or high areas of floodplain. They may even occur on islands in the river. They may occur either in gorges or in open river valleys.

Soils: Soils are alluvial soils, perhaps old enough to have more horizon development than those in lower areas. The few known examples are mapped as Rosman (Fluventic Humic Dystrudept) and Woolwine-Fairview-Westfield complex (Typic Kanhapludult). It is unclear if the latter was recognized as an upland soil or was an alluvial soil inclusion in a larger map unit.

Hydrology: The High Terrace Subtype is intermittently or infrequently flooded for brief periods. The description of the most closely related NVC association says flooding occurs annually for examples in Alabama, but this frequency appears unlikely in the known North Carolina sites.

Vegetation: The High Terrace Subtype is generally dominated by upland oaks, pines, or hickories but includes species shared with other floodplain communities as well as possibly with mesic communities. Plot data collected by CVS, NatureServe, and by Brown (2002), as well as site descriptions, show a range of possible codominant trees, including *Quercus alba, Quercus rubra, Quercus velutina, Quercus montana, Pinus rigida, Pinus virginiana, Pinus strobus, Pinus echinata, Carya tomentosa, Carya cordiformis, Carya pallida, Acer rubrum, Platanus occidentalis, Robinia pseudo-acacia, Fraxinus pennsylvanica, Fraxinus americana, Tsuga canadensis, Betula lenta*, and *Quercus imbricaria*. Understory trees with high constancy are *Carpinus caroliniana, Benthamidia* (*Cornus*) *florida*, *Ilex opaca*, *Halesia tetraptera*, and *Nyssa sylvatica*. Also frequent are *Oxydendrum arboreum, Sassafras albidum, Amelanchier arborea/laevis*, and *Acer pensylvanicum*. The shrub layer may be open or dense. Species that are at least fairly frequent and sometimes abundant include *Pyrularia pubera, Kalmia latifolia,* *Calycanthus floridus, Viburnum cassinoides, Hamamelis virginiana, Rhododendron maximum*, and *Arundinaria gigantea*, while *Euonymus americanus* and *Xanthorhiza simplicissima* may also be frequent. The same vines frequent in most floodplains, *Toxicodendron radicans, Parthenocissus quinquefolia* and *Smilax rotundifolia,* are frequent in the High Terrace Subtype, though cover is generally not high. The herb layer ranges from moderate to dense and is similarly variable. Species with high constancy in plot data include *Carex pensylvanica, Potentilla canadensis, Polystichum acrostichoides*, and *Chimaphila maculata*. *Piptochaetium avenaceum* may dominate a few examples. Other herbs at least fairly frequent include *Dichanthelium laxiflorum, Dichanthelium clandestinum, Danthonia spicata, Carex laxiflora, Sanicula canadensis, Maianthemum racemosum, Elephantopus carolinianus, Dioscorea villosa, Solidago* spp. (*erecta, curtisii, flexicaulis, caesia, juncea), Amphicarpaea bracteata, Salvia lyrata, Prunella vulgaris, Verbesina alternifolia, Eurybia divaricata, Lysimachia quadrifolia, Hylodesmum nudiflorum, Galium circaezans, Scutellaria elliptica*, and *Heuchera americana*. A great number of other herb species occur with lower frequency. They include widespread rich-site species such as *Prosartes lanuginosa* and *Dichanthelium boscii*, typical floodplain species such as *Luzula multiflora* and *Arisaema triphyllum,* and species of dry uplands such as *Pityopsis graminifolia, Coreopsis major*, and *Yucca filamentosa*. A combination of species otherwise typical of disparate communities is characteristic of individual examples of the High Terrace Subtype.

Range and Abundance: The synonymized NVC association is ranked G4? but this community likely is much rarer. It appears extremely rare in North Carolina, with only a handful of examples known. Examples are known on the Little Tennessee, French Broad, and Nolichucky, as well as the Jacob Fork in the foothills. They presumably could be found on any larger or medium size river, but occurrence on flat land with only infrequent flooding likely has led to the loss of most examples that once existed, and those that remain tend to be small.

Associations and Patterns: The High Terrace Subtype may potentially occur with the Large River Subtype or with Montane Floodplain Slough and may occur adjacent to Rocky Bar and Shore communities along the river. However, examples may border uplands and river channels and not be associated with any other floodplain community.

Variation: The handful of known examples are all quite different from each other. An example with Carya pallida on the Nolichucky River seems quite different from the examples on the Little Tennessee, though both fit within the concept of this subtype. Because examples are so few, patterns of variation have not been sorted out.

Dynamics: Dynamics are similar to other Piedmont and Mountain Floodplain forests. Though flooding is less frequent, nutrient input, sediment deposition, litter movement, and other effects are a recognizable influence. Especially in confined gorges, floods may have enough current to cause disturbance to vegetation. A component of weedy species is often present even where there has not been artificial disturbance. Because conditions are dry and many examples are adjacent to uplands, fire may be an important influence in some examples.

Comments: The NVC crosswalk to this type is questionable. The association was defined as a Cumberland Plateau community; it was initially extended to North Carolina based on a Blue Ridge Parkway plot at Sandy Bottom. However, several other examples of this subtype are known. This association seems the closest existing fit in the NVC, but a new association may be appropriate. While the NVC puts its association in an upland forest alliance and group, the author believes that the alluvial soils, occasional flooding, and universal association with rivers is a more important aspect of this community as it occurs in North Carolina.

Rare species:
Vascular plants – *Bromus latiglumis*.

MONTANE FLOODPLAIN SLOUGH FOREST

Concept: Montane Floodplain Slough Forests are wetland forests in lower areas of large mountain river floodplains, generally formed as abandoned channel segments or naturally blocked low areas. Long flooding duration largely restricts plant composition to hydrophytic species.

Distinguishing Features: Montane Floodplain Slough Forests are distinguished from Montane Alluvial Forests by having a longer flooding period, which leads to vegetation dominated by wetland species. While many species of both communities can occur in either, only the most water-tolerant shared species, such as *Boehmeria cylindrica, Impatiens capensis, Onoclea sensibilis, Lycopus* spp., and *Carex* spp. are abundant or frequent in Montane Floodplain Slough Forest. *Acer rubrum* var. *trilobum, Nyssa biflora, Salix nigra, Acer saccharinum, Cephalanthus occidentalis*, and many herbs are virtually never found in Montane Alluvial Forest, while others are found only in the wettest microsites.

Montane Floodplain Slough Forests are distinguished from Floodplain Pools by having shorter-term flooding. Trees are able to root throughout the community at normal forest densities, while Floodplain Pools support them primarily on the edges, if at all. Montane Floodplain Slough Forests are distinguished from Piedmont/Mountain Semipermanent Impoundment by lacking present or recent impounded water (though a few examples may be ambiguous). If a wetland area is not in an obvious depression surrounded by drier vegetation, care should be taken to determine if a beaver dam or other dam is present.

Montane Floodplain Slough Forest may potentially be difficult to distinguish from the Floodplain Subtype of Low Elevation Seep. Seeps are saturated for long periods of time, longer than Montane Floodplain Slough Forest sites tend to be. However, they are configured so that extensive standing water does not occur except for the brief periods that the entire floodplain is inundated. The two communities may share many wetland species, but the overall vegetation reflects the different environment. Species characteristic of saturated sites, such as *Sphagnum* spp., *Lorinseria areolata,* and most *Carex* species are more abundant and diverse in seeps, as are some less flood-tolerant species such as *Lindera benzoin*. The two communities can potentially occur together, with a seep grading into a slough forest as the influence of seepage diminishes away from the upland edge and a basin becomes deeper.

Crosswalks: *Acer rubrum var. trilobum – Fraxinus pennsylvanica / Carex crinita - Peltandra virginica* Floodplain Forest (CEGL004420).
G637 Appalachian-Interior-Northeast Floodplain Forest Group.
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: Montane Floodplain Slough Forests occur in low places in large- to medium-sized floodplains in the Mountain Region and potentially the foothills. They may be sloughs, overflow channels, abandoned channel segments, or areas where drainage has become blocked by alluvial deposition. It is possible they would form in abandoned beaver ponds if wetness were increased by clay deposition or remnants of a dam.

Soils: Montane Floodplain Slough Forest soils are mapped as a variety of alluvial soils, including Codorus (Fluvaquentic Dystrudept), Iotla (Fluvaquentic Dytrudept), Cullowhee (Fluvaquentic Humadept), and Hatboro (Fluvaquentic Endoaquept). They may represent inclusions of wetter soil than these series. Sloughs that are closed basins typically without current have clay deposited in still water. Sloughs that are overflow channels likely have sandy soils, or interlayered sand, silt, and clay. Those that stay saturated much of the time may have organic-rich soils.

Hydrology: Montane Floodplain Slough Forests are regularly flooded for long periods. Standing water may persist into the growing season but seldom or never lasts through the season. Some examples are in overflow channels, where substantial current may occur during floods, while others hold water but have no more current than the rest of the floodplain in floods.

Vegetation: Montane Floodplain Sloughs are dominated by wetland and floodplain tree species. *Acer rubrum*, sometimes var. *trilobum*, is constant in plot data and site descriptions, and *Fraxinus pennsylvanica* is also frequent. Other canopy species are variable. They include *Platanus occidentalis, Liriodendron tulipifera,* and less frequently, *Nyssa sylvatica, Betula nigra, Pinus rigida, Pinus strobus*, and *Salix nigra*. The understory, if there is one, is most often dominated by *Carpinus caroliniana* or canopy species. Species uncommon in the region, including *Nyssa biflora* or *Acer saccharinum,* may be present in a few examples. Shrubs tend to be low in density. They include a variety of water-tolerant species, none at very high frequency, including *Swida* (*Cornus*) *amomum, Alnus serrulata, Ilex verticillata, Cephalanthus occidentalis, Leucothoe fontanesiana*, *Viburnum cassinoides, Rosa palustris*, *Itea virginica,* and even some species more typical of bogs, such as *Toxicodendron vernix* and *Eubotrys racemosa*. The exotic *Ligustrum sinense* or *Rosa multiflora* may be present. Vines are not abundant, but *Lonicera japonica, Toxicodendron radicans, Muscadinia rotundifolia*, or other species may be present. Herbs may be dense, but where water stands the longest, the ground may be bare or may be occupied mainly by short-lived plants. Frequent herb species include *Boehmeria cylindrica, Impatiens capensis, Bidens frondosa, Lycopus* spp., *Carex* spp. (including *crinita, lupulina, tribuloides, stipata, atlantica,* and others), and *Microstegium vimineum*. A number of wetland species may be present at lower frequency, including *Mimulus ringens, Onoclea sensibilis, Persicaria punctata, Glyceria striata, Orontium aquaticum, Peltandra virginica, Sparganium americanum*, and many others. Species more typical of seeps or bogs may occasionally be present, including *Lorinseria areolata, Oxypolis rigidior, Platanthera peramoena, Osmundastrum cinnamomeum*, and *Sphagnum* sp. Species shared with other floodplain forests, such as *Elymus virginicus* or *Rudbeckia laciniata*, may be present in small numbers. The exotic *Murdannia keisak* is a particular threat to these communities; it can come to dominate the ground cover.

Range and Abundance: Ranked G1. This community is very rare in North Carolina, with only a few examples known. Examples are scattered through the Mountain Region. The equivalent association is not attributed to any other state except possibly Tennessee.

Associations and Patterns: Montane Floodplain Slough Forests are small patch communities. They usually are embedded in Montane Alluvial Forest (Large River Subtype), occasionally in the Small River Subtype, and may be adjacent to uplands. They may occur near Swamp Forest–Bog Complex, Southern Appalachian Bog, Low Elevation Seep, or other wetland communities.

Variation: No variants are recognized. Examples vary in wetness and also in amount of sediment deposition and current during floods. They also vary in flora from more alluvial to more bog-like, probably in response to fertility and to how much the soil remains saturated when standing water is absent.

Dynamics: Montane Floodplain Slough Forests flood more often and for longer duration than other mountain floodplain forests. Water stands long enough to exclude most upland species. Though not well known, it is likely that wetness kills plants that established in dry years, and that wet years are stressful even for some of the established plants. During dry conditions, the high fertility and reduced competition may lead to high productivity.

Some sloughs are in overflow channels, where they may carry substantial currents during floods. For them, scouring, movement of wrack, and battering by floating material may be an additional natural disturbance, at least locally. The most extreme scouring may change the drainage patterns, potentially making them either wetter or drier. This could naturally turn a Montane Floodplain Slough Forest into Montane Alluvial Forest (Large River or Small River Subtype) or, alternatively, into Floodplain Pool.

Being in the lowest parts of the floodplain, Montane Floodplain Slough Forests may be particularly susceptible to impoundment by beavers. It is possible that residual effects of beaver ponds – residual dam materials, altered channels, and clay deposition, could make sites wetter and lead to the creation of Montane Floodplain Slough Forest patches.

Comments: Montane Floodplain Slough Forests are analogous to Piedmont Swamp Forests in their geomorphic environment and in their relationship to other floodplain communities. They differ because of the higher gradients and differing flood dynamics in mountainous terrain, as well as because of the Blue Ridge flora.

Rare species:
Vascular plants – *Palustricodon* (*Campanula*) *aparinoides* var. *aparinoides*, *Platanthera peramoena, Senecio suaveolens,* and *Thalictrum macrostylum*.

Vertebrate animals – *Glyptemys muhlenbergii*.

PIEDMONT ALLUVIAL FOREST

Concept: Piedmont Alluvial Forests are forests of narrow floodplains, either on small streams or on large rivers where the floodplain is narrowed by bedrock. These are floodplains with limited differentiation of communities by depositional landforms, with natural levees, backswamps, and sloughs absent or too small to create separate communities. Flooding is of shorter duration and more variable than on larger floodplains, either because of the smaller watershed of small stream or because of the steeper gradient of confined floodplains of larger rivers. On large rivers, they occur only where the full width of the floodplain, rather than just one side, is narrow. These forests contain a mixture of alluvial and upland species.

Distinguishing Features: Piedmont Alluvial Forests are distinguished from larger river floodplain forests by occurring on small floodplains that lack levees, bottomlands, and swamps large enough to support distinct communities. This correlates with a lower abundance and diversity of characteristic floodplain species. Most of the canopy is of widespread species such as *Liquidambar styraciflua* and *Liriodendron tulipifera*, and upland species are likely to be present, mixing with characteristic alluvial species such as *Platanus occidentalis, Betula nigra*, or *Celtis laevigata*. Piedmont Alluvial Forests are distinguished from Piedmont Headwater Stream Forests by occurring on somewhat larger floodplains and in having a significant presence and diversity of characteristic floodplain species such as *Platanus* and *Betula*. Upland species are present but are of limited abundance, while in the Piedmont Headwater Stream Forests they are more predominant.

Piedmont Alluvial Forests are distinguished from Mesic Mixed Hardwood Forests by the presence of characteristic alluvial and wetland species, such as *Platanus, Betula*, *Fraxinus,* and *Xanthorhiza simplicissima*. Additional species such as *Aesculus sylvatica, Elymus virginicus, Elymus hystrix,* and *Chasmanthium latifolium* may be shared with Basic Mesic Forests but are present in the floodplains even in the absence of basic rock substrate. Piedmont Alluvial Forests are distinguished from Montane Alluvial Forests by the lack of a significant portion of species characteristic of the Blue Ridge, such as *Aesculus flava, Tsuga canadensis, Halesia tetraptera, Juglans cinerea*, and *Quercus imbricaria*. Floodplain communities in the upper Piedmont that have characteristic montane species should be classified as Montane Alluvial Forest.

Crosswalks: *Liquidambar styraciflua – Liriodendron tulipifera / Lindera benzoin / Arisaema triphyllum* Floodplain Forest (CEGL004418).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).
Piedmont/Low Mountain Alluvial Forest (3rd Approximation).

Sites: Piedmont Alluvial Forests occur along most 2nd and 3rd order streams, some 1st order streams, and along higher order streams where the floodplain is narrow.

Soils: Soils are fertile, loamy or sandy alluvial soils with limited horizon development. The largest number are mapped as Chewacla (Fluvaquentic Dystrudept), with many also mapped as Congaree (Typic Udifluvent), Wehadkee (Typic Fluvaquent), and a few mapped as Peawick (Aquic

Hapludult) or Riverview (Fluventic Dystrudept). A number are small enough to not be distinguished from upland soils in mapping.

Hydrology: Piedmont Alluvial Forests are intermittently flooded for brief periods. Flood flows often have substantial current. When not flooded, soils are moist but are wet only in small microsites associated with seepage or small depressions or sloughs.

Vegetation: Piedmont Alluvial Forests are naturally closed forests except in canopy gaps. Matthews, et al. (2011), CVS plot data, and qualitative site reports often show the canopy as strongly or weakly dominated by *Liriodendron tulipifera* or *Liquidambar styraciflua*, but sometimes as a mix without a strong dominant. It usually includes some individuals of more specifically alluvial species: *Platanus occidentalis, Betula nigra, Fraxinus pennsylvanica, Acer negundo, Celtis laevigata*, and *Ulmus americana*. Other trees of rich upland or floodplain sites, such as *Acer floridanum, Juglans nigra, Ulmus rubra*, *Carya cordiformis, or Carya ovata* are present less frequently, but can be abundant, while *Quercus phellos, Pinus taeda*, *Quercus nigra,* or *Acer rubrum* may also be present. Some typically upland trees, particularly *Fagus grandifolia, Quercus rubra*, *Quercus alba*, or *Pinus echinata* are also usually present. The understory may be dominated by *Acer floridanum, Acer negundo, Carpinus caroliniana, Ilex opaca*, *Asimina triloba, Benthamidia* (*Cornus*) *florida*, or a diverse mix of species. Species more typical of uplands, such as *Oxydendrum arboreum* or *Nyssa sylvatica,* may also occur. The shrub layer may be sparse or fairly dense, with *Lindera benzoin* or the exotic *Ligustrum sinense* or *Elaeagnus umbellata* often dominant, and *Aesculus sylvatica* sometimes present. *Xanthorhiza simplicissima* is often present near the channel in rocky areas. Vines often are prominent and fairly diverse: *Parthenocissus quinquefolia, Toxicodendron radicans, Muscadinia rotundifolia, Smilax rotundifolia, Smilax bona-nox, Campsis radicans, Bignonia capreolata*, and the exotic *Lonicera japonica* are present with high constancy. The herb layer is quite variable, with a diversity of species potentially present. Patches may be dominated by widespread mesic species such as *Polystichum acrostichoides*, *Athyrium asplenioides*, and in some places *Amauropelta* (*Parathelypteris*) *noveboracensis*, or by characteristic alluvial species such as *Chasmanthium latifolium, Elymus virginicus,* or *Elymus hystrix*. Other species with high constancy in plots include *Geum canadense, Amphicarpaea bracteata, Boehmeria cylindrica, Arisaema triphyllum, Botrypus virginicus, Oxalis stricta/dillenii*, *Salvia lyrata, Festuca subverticillata, Sanicula canadensis,* and *Carex blanda.* Other characteristic species of moderate or lower frequency include *Viola sororia, Galium circaezans, Galium triflorum*, *Persicaria virginiana, Impatiens capensis, Ranunculus abortivus, Carex radiata, Carex oxylepis, Solidago caesia, Dichanthelium commutatum, Verbesina occidentalis, Verbesina alternifolia, Phryma leptostachya, Juncus coriaceus, Brachyelytrum, Galium aparine, Rudbeckia laciniata, Podophyllum peltatum, Carex debilis, Glyceria striata, Symphyotrichum* spp., *Leersia virginica,* and *Lycopus virginicus*. In spring, *Claytonia virginica, Erythronium umbilicatum, Thalictrum thalictroides, Hepatica americana*, and *Stellaria pubera* may be prominent. The herb layer can often become dominated by exotic species, particularly *Microstegium vimineum*, ground-covering *Lonicera japonica, Glechoma hederacea,* or *Stellaria media*. Numerous other non-native species occur in fewer examples.

Range and Abundance: Ranked G4 but probably G5. This is one of the most widely distributed natural communities in the Piedmont, a matrix community that makes up a minority of the landscape mosaic in most places other than the foothills. Patches tend to be narrow. They may be connected in dendritic networks that amount to substantial acreage or they may be segmented by altered vegetation or man-made barriers. In the past they likely were segmented by beaver ponds. The related NVC association, as defined, ranges from Georgia to Maryland and westward into Tennessee and West Virginia.

Associations and Patterns: Piedmont Alluvial Forests may be bordered by any Piedmont upland community, with Mesic Mixed Hardwood Forest and Dry-Mesic Oak–Hickory Forest being most common. Smaller upstream reaches and tributaries may have Piedmont Headwater Stream Forest. Piedmont Alluvial Forests, where not disrupted, connect downstream to larger floodplain communities such as Piedmont Bottomland Forest.

Variation: Piedmont Alluvial Forest is one of the broadest and most heterogeneous community types in the 4th Approximation. Vegetation varies in amounts of alluvial, upland, and generalist species (*Liquidambar* and *Liriodendron*), in diversity of the herb layer, and in heterogeneity of microsites, but these patterns are confusing. Matthews, et al. (2011) recognized two associations that correspond to Piedmont Alluvial Forest. They could be tried as variants. However, they appear to combine several characteristics in surprising ways, so that it is hard to know how to apply them to new occurrences.

1. *Liriodendron tulipifera – Liquidambar styraciflua / Lindera benzoin / Amphicarpaea bracteata* appears to have more alluvial influence, with more indicators of high fertility, but there are contradictory indications such as greater abundance of *Fagus* and smaller role for *Betula nigra*.

2. *Liriodendron tulipifera – Betula nigra / Cornus florida / Sanicula canadensis var. canadensis* has a larger upland component (e.g., *Oxydendrum arboreum* and *Quercus alba*) and lower fertility, but also apparently has more *Betula nigra*, which is less frequent on smaller streams.

Based on the author's experience, a different set of variants is recommended. These are based on the size of the river, with a third variant for small stream bottoms in the Uwharrie Mountains area that have distinctive species composition. Despite Mathews, et al. (2011) noting that floodplains communities are similar on narrow floodplains regardless of size of the stream, there are some differences in vegetation and presumably in dynamics that seem a promising basis for subdivision.

1. Creek Variant occurs along smaller streams in most of the Piedmont, generally 1st to 3rd order, of a size that never is associated with larger floodplain communities. They tend to be dominated by *Liquidambar* and *Liriodendron* with a smaller and less diverse component of alluvial species and a larger component of upland species. They conceptually grade to Piedmont Headwater Stream Forests.

2. River Variant occurs along larger streams, generally 4th order or larger, of a size that in other geologic settings would support large floodplain communities. They tend to be dominated by a mix of *Liquidambar* with more *Platanus, Celtis, Fraxinus*, and with the presence of alluvial species that seldom appear along smaller creeks, such as *Betula nigra* and *Acer negundo*. They have fewer upland trees, though *Quercus rubra, Fagus grandifolia Acer floridanum* and others may be present. They conceptually grade to Piedmont Levee Forest. They show further variation between

examples that are lower or higher relative to the river. Scouring by floods and redistribution of litter and wood is more vigorous than in the Creek Variant.

3. Uwharrie Variant occurs along many of the smaller streams in the Uwharrie Mountains area. The canopy is a mix of *Liquidambar, Liriodendron*, and upland species like the Creek Variant, but several shrub species occur in it that are seldom present elsewhere. Most frequent is *Kalmia latifolia,* but *Cyrilla racemiflora, Symplocos tinctoria*, *Calycanthus floridus, Alnus serrulata*, and *Hamamelis virginiana* are frequently present. Though shrubs are generally not extremely dense, herb diversity tends to be lower. A provisional association in the NVC — *Fagus grandifolia – Quercus* spp. / *Kalmia latifolia – Hamamelis virginiana / Galax urceolata* Forest [Provisional] (CEGL004549) — may correspond to this. It was initially described as a mesic forest of the Uwharrie area, but further examination of the plot attributed to it shows it to be a floodplain forest that corresponds to Piedmont Alluvial Forest or Piedmont Headwater Stream Forest.

Dynamics: Dynamics of Piedmont Alluvial Forests are similar to those described for the Piedmont and Mountain Floodplains theme in general. Given that Walter and Merritts (2008) found most mill dams on 1^{st} to 3^{rd} order streams, it is likely that Piedmont Alluvial Forests are the communities most affected by them, though dams were less dense than in their study area in Pennsylvania.

Comments: Piedmont Alluvial Forests and the related Piedmont floodplain communities have been some of the most confusing communities in the 3^{rd} Approximation, and they remain difficult to classify. One of the most difficult problems has been the treatment of small floodplains on larger rivers. The 3^{rd} Approximation treated them as Piedmont Levee Forest, limiting Piedmont Alluvial Forest to small streams. Based on later field experience and the work of Matthews, et al. (2011), the 4^{th} Approximation broadens the concept of Piedmont Alluvial Forest to include them. At the same time, experience has shown that all floodplain communities in the Mountain Region and many in the foothills are distinct from those of the rest of the Piedmont and are better treated as a separate Montane Alluvial Forest. Thus, the previous concept of Piedmont/Low Mountain Alluvial Forest has been split into Piedmont and Mountain portions. However, Piedmont Alluvial Forest remains a heterogeneous collection with particularly gradual gradation into conceptually related communities.

Published literature on Piedmont Alluvial Forests is uncommon. However, qualitative descriptions in the Natural Heritage Program's county inventories and site survey reports are abundant. Morgan (1962) likely is one of a number of local theses that provide some description.

Rare species:
Vascular plants – *Baptisia alba, Cardamine dissecta, Cardamine douglassii, Carex impressinervia, Carex lupuliformis, Eurybia mirabilis, Fothergilla major, Magnolia macrophylla, Phacelia covillei, Primula meadia, Sida elliottii* var. *elliottii,* and *Stewartia ovata.*

Nonvascular plants – *Cryphaea nervosa*.

Vertebrate animals – *Hyla versicolor*.

PIEDMONT HEADWATER STREAM FOREST (TYPIC SUBTYPE)

Concept: Piedmont Headwater Stream Forests are forests of floodplains along the smallest Piedmont streams, generally intermittent to first or second order, where flooding and alluvial processes have some, but limited, influence on vegetation and most characteristic alluvial species are absent or scarce. They have vegetation that consists largely of species of broad ecological tolerance and of upland species, but occur on distinct floodplains, have vegetation in combinations not usually found in upland community types, and have a few characteristic floodplain species. The Typic Subtype covers most examples, on typical small streams, excluding only those with the specialized characteristics of the Hardpan Subtype.

Distinguishing Features: Piedmont Headwater Stream Forests are distinguished from other floodplain communities by the near absence of alluvial species such as *Platanus occidentalis, Betula nigra*, and *Celtis laevigata*, though other riparian species such as *Xanthorhiza simplicissima, Lindera benzoin*, or wetland species such as *Osmundastrum (Osmunda) cinnamomeum, Osmunda spectabilis (regalis)*, or *Viburnum nudum* may be present. Widely tolerant species such as *Liriodendron tulipifera* and *Liquidambar styraciflua*, and upland species such as *Quercus alba, Quercus rubra*, and *Fagus grandifolia* are generally present in both this type and in Piedmont Alluvial Forest. However, upland species are more abundant and diverse in this type. Piedmont Headwater Stream Forests are distinguished from Mesic Mixed Hardwood Forest, with which they may share many species, by the presence of riparian and/or wetland species as well as by evidence of flooding. In most examples, Piedmont Headwater Stream Forests contain a number of species that, while common and not strictly tied to floodplains, are nevertheless absent in the adjacent upland communities.

The Typic Subtype is distinguished from the Hardpan Subtype by not occurring in broad, gently sloped bottoms with dense clay hardpan substrates. Generally, the soil in the Typic Subtype is coarse textured. *Quercus phellos* and *Carya carolinae-septentrionalis* are both largely absent from the Typic Subtype but are frequent, sometimes dominant, in the Hardpan Subtype.

Crosswalks: *Liriodendron tulipifera – Quercus alba – (Liquidambar styraciflua) / Ilex opaca / Polystichum acrostichoides* Piedmont Floodplain Forest (CEGL004900).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).
Piedmont/Low Mountain Alluvial Forest (3rd Approximation).

Sites: Piedmont Headwater Stream Forests occur in the smallest, least well-developed floodplains, along intermittent or first order perennial streams, occasionally on second order streams. Floodplains are not well developed, but some area of flat land with alluvial soil or evidence of transported sediment, as well as of flooding, is present.

Soils: Soils are often sandy but probably are very heterogeneous at a fine scale. They presumably are more fertile than the adjacent uplands but less so than in larger floodplains. They probably represent some kind of Entisol or Inceptisol. Soil mapping almost never distinguishes them from the adjacent upland soils.

Hydrology: Piedmont Headwater Stream Forests are intermittently flooded for brief periods. Flood flows can have substantial velocity. When not flooded, soils are moist but are wet only in small microsites associated with seepage or small depressions or sloughs.

Vegetation: Piedmont Headwater Stream Forests are usually dominated by *Liriodendron tulipifera* or by a mix of species where it is abundant. *Liquidambar styraciflua* is usually present and sometimes codominant, but less often than in Piedmont Alluvial Forest. Upland species, most constantly *Quercus alba* but almost as frequently *Quercus rubra* and *Fagus grandifolia* are usually abundant. *Acer rubrum* often is in the canopy as well as the understory. A wide variety of additional canopy species occur with low frequency and low abundance, including *Pinus taeda, Pinus echinata, Carya ovata, Ulmus alata, Fraxinus* sp., and *Quercus phellos*. Understory species with high constancy and often reported as dominant in qualitative site reports are *Ilex opaca* and *Oxydendrum arboreum*, less often *Carpinus caroliniana*. Among the large number of species that may occur at low frequency and abundance are *Benthamidia* (*Cornus*) *florida, Nyssa sylvatica, Juniperus virginiana,* and *Magnolia tripetala*. Shrubs are generally sparse and variable. Species include *Hamamelis virginiana, Ilex decidua, Xanthorhiza simplicissima, Hypericum hypericoides, Arundinaria tecta, Alnus serrulata*, and a diversity of others. In the Uwharrie Mountains area, *Kalmia latifolia* may be present. Vines may include *Parthenocissus quinquefolia, Smilax rotundifolia, Muscadinia rotundifolia*, and less frequently *Toxicodendron radicans*, *Bignonia capreolata*, and others. The exotic *Ligustrum sinense, Elaeagnus umbellata*, and *Lonicera japonica* are sometimes present but at much lower frequency and generally less cover than in Piedmont Alluvial Forest. The herb layer may be fairly dense or sparse. The most constant species is *Polystichum acrostichoides*, which may dominate patches. A large pool of other herbs may occur, most with low frequency. Many are shared with adjacent mesic or dry-mesic upland forests, such as *Hexastylis arifolia, Polygonatum biflorum, Danthonia spicata, Phegopteris hexagonoptera, Podophyllum peltatum, Galium* spp., *Nabalus altissimus*, and *Elephantopus tomentosus*. Many others are widespread species but are not often present in the adjacent upland forests, such as *Chasmanthium laxum, Carex* spp., *Amauropelta* (*Parathelypteris*) *noveboracensis, Athyrium asplenioides, Iris cristata, Packera aurea, Arisaema triphyllum, Amphicarpaea bracteata, Ranunculus* spp., *Botrypus virginicus, Sanicula canadensis,* and *Viola* spp. Some are species shared with other floodplain forests having more alluvial influence, but occur with lower frequency and abundance, such as *Elymus hystrix, Elymus virginicus, Leersia virginica, Luzula acuminata, Boehmeria cylindrica*, and the exotic *Microstegium vimineum*. Some are wetland species present locally in small numbers, such as *Osmundastrum cinnamomeum*, *Lycopus virginicus, Lobelia cardinalis, Onoclea sensibilis*, various *Carex* spp., and *Sphagnum* sp. In general, whatever the adjacent upland community and the species shared with it, the diversity is higher in the Piedmont Headwater Stream Forest and includes multiple species not found uphill.

Range and Abundance: Ranked G3G4 but probably more common. The Typic Subtype occurs throughout the Piedmont except in mountainous foothill areas. The equivalent NVC association is poorly known. North Carolina is the only state it is definitively recognized in, but it could potentially range throughout the Piedmont from Maryland to Georgia.

Associations and Patterns: Piedmont Headwater Stream Forests usually occur in narrow bands, sometimes only 5-10 meters wide. Bands may be hundreds of meters long, but many are interrupted by areas where upland communities come all the way to the stream channel, and many quickly join larger floodplains with Piedmont Alluvial Forest. They are matrix communities in the sense of being widely distributed in landscape mosaics but are not well developed in every natural landscape. Many landscapes appear to contain numerous streams with Piedmont Headwater Stream Forest or Piedmont Alluvial Forest but not both. Most examples grade to Mesic Mixed Hardwood Forest or Dry-Mesic Oak–Hickory Forest or their basic counterparts. They join downstream into Piedmont Alluvial Forest or directly to larger floodplains.

Variation: Examples are heterogeneous at a fine scale. Variation among occurrences is not well known. Examples in the Uwharrie Mountains area that contain *Kalmia latifolia* may warrant distinguishing as a variant, as was done in Piedmont Alluvial Forest, but the case is less compelling for these smaller floodplains. A small stream forest in Box Creek Wilderness in the South Mountains is surrounded by montane communities and may represent a distinct variant or an unrecognized mountain analogue. However, this has not been found to be a reoccurring pattern; it has not been identified in any other foothill or Mountain landscape.

Dynamics: Dynamics of Piedmont Alluvial Forests are similar to those described for the Piedmont and Mountain Floodplains theme in general, except alluvial deposition is less and flooding is even less likely to cause mortality for any plants. However, the author's observations suggest even these small floodplains are more susceptible to windthrow than adjacent upland forests.

Comments: Piedmont Headwater Stream Forest is one of the more recently recognized community types. In the 3rd Approximation, it was treated as poorly developed Piedmont/Low Mountain Alluvial Forest or as part of the Mesic Mixed Hardwood Forest or Basic Mesic Forest. Qualitative site descriptions are fewer than for most communities, because they often were ignored, or their descriptions were mixed with those of larger floodplains. Very little plot data exist for it either, partly because many occurrences are not wide enough to easily fit homogeneous plots. It was not recognized in Matthews, et al. (2011), apparently because few or no plots represented it.

Fagus grandifolia – Quercus spp. / *Kalmia latifolia – Hamamelis virginiana / Galax urceolata* Forest [Provisional] (CEGL004549) was initially described as a mesic forest of the Uwharrie area, but further examination of the plot attributed to it shows it to be a floodplain forest closely related enough to this type to be questionably distinct.

Rare species:
Vascular plants – *Carex impressinervia* and *Collinsonia tuberosa*.

Vertebrate animals – *Hemidactylium scutatum*.

PIEDMONT HEADWATER STREAM FOREST (HARDPAN SUBTYPE)

Concept: Piedmont Headwater Stream Forests are forests of floodplains along the smallest Piedmont streams, where flooding and alluvial processes have some, but limited, influence on vegetation and most characteristic alluvial species are absent or scarce. The Hardpan Subtype is a rare community that occurs in flat terrain with dense or shrink-swell clay soils and is transitional to Upland Depression Swamp Forest or Mixed Moisture Hardpan Forest. Limited rooting depth, lack of internal soil drainage, and soil texture give these sites a distinctive character.

Distinguishing Features: Piedmont Headwater Stream Forests are distinguished from other floodplain communities by the near absence of alluvial species such as *Platanus occidentalis, Betula nigra*, and *Celtis laevigata*. The Hardpan Subtype is distinguished from the Typic Subtype by occurring in unusually gently sloping bottoms with a dense clay hardpan substrate, and by characteristic vegetation. *Quercus phellos*, and sometimes *Quercus michauxii*, *Carya ovata*, or *Carya carolinae-septentrionalis,* are abundant in this subtype while largely absent in the Typic Subtype. *Liriodendron* is correspondingly scarce in the Hardpan Subtype.

The Hardpan Subtype can be distinguished from Mixed Moisture Hardpan Forest and Upland Depression Swamp by having evidence of flowing water, visible stream channels (often multiple braided or anastomosing channels), and by flora that includes at least some floodplain species. *Liquidambar styraciflua*, which is often abundant in this community, is abundant in the other communities only in successional forests.

Crosswalks: *Quercus phellos – Quercus alba – (Quercus michauxii) – Carya carolinae-septentrionalis* Wet Forest (CEGL004042).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).

Sites: The Hardpan Subtype occurs in areas of unusually flat terrain, usually associated with mafic rocks such as gabbro or diabase. It could potentially occur in acidic clayey sites as well. A floodplain landform may be difficult to discern; the community may or may not be associated with a visible topographic break. A distinct stream channel with defined banks and bed may cross it, or the focus of flow may be merely a line of exposed soil where water has removed the litter.

Soils: Because of the low gradient and dense soil, alluvial movement likely is minor, and soil profiles may not differ from adjacent areas. Known examples are associated with mafic rocks and their soils presumably are high in base saturation. Soil mapping does not distinguish these floodplains from the adjacent upland soils. They are mapped as part of the associated hardpan or shrink-swell soils such as Iredell (Vertic Hapludalf) or Lignum (Aquic Hapludult).

Hydrology: The Hardpan Subtype is intermittently to seasonally flooded. Because of the impermeable soil and the low gradient in both the floodplain and the adjacent uplands, water flow is slow, and flooding may persist for a longer time than in most Piedmont floodplains. Flooding is shallow and current slow, sufficient to redistribute litter but able to move only limited sediment or coarser material.

Vegetation: The Hardpan Subtype is most often dominated by *Quercus phellos* and *Liquidambar styraciflua*. Frequent in site descriptions and in the few CVS plots are *Carya ovata, Carya carolinae-septentrionalis, Acer rubrum (*including var. *trilobum* as well as *rubrum*)*, Ulmus americana*, *Fraxinus* sp., and *Quercus alba*. *Liriodendron tulipifera* may be present but is less important than in the Typic Subtype. Other species that occur with low frequency but are notable include *Quercus michauxii, Quercus shumardii*, *Quercus pagoda*, and *Celtis laevigata*. The understory often contains *Ulmus alata, Carpinus caroliniana*, and *Nyssa sylvatica*. Shrubs are generally sparse, and none have high frequency. They include both species of other floodplain forests, such as *Lindera benzoin* and *Ilex decidua*, but also species of wetter areas, such as *Vaccinium fuscatum, Ilex verticillata*, and *Eubotrys racemosa*. Vines include *Smilax rotundifolia, Toxicodendron radicans, Campsis radicans, Lonicera sempervirens*, and the exotic *Lonicera japonica*. The herb layer is usually moderate to dense. *Danthonia spicata, Glyceria striata, Leersia virginica, Chasmanthium latifolium, Elymus virginicus*, and the exotic *Microstegium vimineum* have moderate to high frequency. *Carex* species as a group are also frequent and abundant, and multiple species are represented. *Isoetes* sp. sometimes forms dense stands in sloughs or even in channel beds. Many other herbs occur with low frequency, including wetland species such as *Ludwigia alternifolia, Lycopus virginicus*, *Osmunda spectabilis*, and *Oxypolis rigidior*; common floodplain species such as *Arisaema triphyllum, Mitchella repens*, and *Viola* spp.; species often associated with weedy settings, such as *Ambrosia artemisiifolia, Apocynum cannabinum*, and *Oxalis dillenii*; and a variety of others, such as *Solidago rugosa, Podophyllum peltatum*, *Hypoxis hirsuta*, *Endodeca serpentaria, Scutellaria integrifolia,* and *Lobelia puberula*.

Range and Abundance: Ranked G2. The handful of examples is scattered in the eastern Piedmont, mostly in areas with substantial amounts of mafic rock. The equivalent NVC association is poorly known. North Carolina is the only state it is definitively attributed to, but it could potentially range from Virginia to Georgia.

Associations and Patterns: The Hardpan Subtype is a small patch community with limited length, which gives way to the Typic Subtype or to Piedmont Alluvial Forest as the stream and floodplain becomes more developed downstream. It is associated with other hardpan communities such as Upland Depression Swamp Forest, Mixed Moisture Hardpan Forest, and sometimes Xeric Hardpan Forest. Other upland communities of mafic rocks such as Dry-Mesic Basic Oak–Hickory Forest may also border it.

Variation: Examples vary in how extremely the hardpan character is developed. If examples are found on acidic hardpans, they likely will represent a distinct variant or possibly a different subtype.

Dynamics: Dynamics of the Hardpan Subtype are not well known but are presumed to be generally similar to other Piedmont floodplain communities. They do not have the sandy soils that seem to contribute to increased susceptibility to windthrow in the Typic Subtype, but shallow rooting may have the same effect. Because of the low gradient, scouring by floods probably is negligible. The nutrient subsidy provided by flooding likely is small, but the high base saturation associated with the mafic rock substrate may nevertheless make them fertile.

Comments: This community is newly recognized and has limited exploration to date. However, several CVS plots represent it. It is more distinct from the Typic Subtype than are most subtypes, but recognition of it can still be subtle in the transition to other communities.

Rare species:
Vascular plants – *Isoetes virginica*.

Vertebrate animals – *Hemidactylium scutatum*.

PIEDMONT LEVEE FOREST (TYPIC SUBTYPE)

Concept: Piedmont Levee Forests are forest communities of natural levee deposits or river front riparian zones on large Piedmont floodplains. The Typic Subtype encompasses the common examples where characteristic levee species such as *Platanus occidentalis, Betula nigra, Celtis laevigata*, and *Acer negundo* dominate in combination with widespread species such as *Liquidambar styraciflua, Liriodendron tulipifera*, and *Acer rubrum*. *Fagus grandifolia* is scarce or absent.

Distinguishing Features: The Piedmont Levee Forest community is distinguished from other communities of large Piedmont floodplains, as well as uplands, by significant presence of the characteristic levee species: *Platanus occidentalis, Betula nigra, Acer negundo*, and *Celtis laevigata,* in unaltered examples. *Fraxinus pennsylvanica* too distinguishes it from communities other than Piedmont Swamp Forest. It is distinguished from Piedmont Alluvial Forest by occurring on larger floodplains — those with differentiated levee, bottomland, and terrace zones large enough to support distinct communities. The distinguishing characteristic is the size of the floodplain, not the river. Where large rivers flow through confined areas without extensive floodplain development, the narrow floodplains generally support Piedmont Alluvial Forest, with a mix of levee, bottomland, and upland species. However, occasionally they will more resemble a Piedmont Levee Forest. While Piedmont Levee Forest usually occurs along large rivers, it also occurs in the wide floodplains that develop along medium size creeks in Triassic basins.

Piedmont Levee Forests are distinguished from Montane Alluvial Forests by the absence of characteristic montane species such as *Tsuga canadensis, Pinus strobus*, *Betula lenta*, and various herb species shared with Rich Cove Forest.

The Typic Subtype is distinguished by dominance by typical floodplain species, with little or no presence of *Fagus grandifolia* and limited component of other upland species.

Crosswalks: *Fraxinus pennsylvanica – Platanus occidentalis – Celtis laevigata / Chasmanthium latifolium* Piedmont Floodplain Forest (CEGL007013).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: Piedmont Levee Forests occur on natural levees, stable forested point bar deposits, or on the river front edge of flatter terraces. They occur on broad floodplains, usually along larger rivers. They may also occur on creeks as small as 3rd order in Triassic basins, where broad floodplains form more readily. Even on larger rivers, Piedmont Levee Forests require a substantial floodplain and are generally absent where floodplain width is limited.

Soils: Soils are coarse or medium-textured, formed in recent alluvial deposits with little or no horizon development. Most examples are mapped as Congaree (Typic Udifluvent), Chewacla (Fluvaquentic Dystrudept), or Wehadkee (Fluvaquentic Endoaquept). Soils are among the most fertile in the Piedmont, thanks to ongoing nutrient input.

Hydrology: Piedmont Levee Forests are intermittently flooded for short periods. The flood flow can have substantial velocity. When not flooded, they are well-drained, thanks to the coarse soil texture and proximity to the channel bank.

Vegetation: Piedmont Levee Forests are naturally closed forests punctuated by canopy gaps. The forest is a varying mix of a large pool of possible species. Frequent species in Matthews, et al. (2011) and site descriptions include *Fraxinus pennsylvanica, Platanus occidentalis, Betula nigra, Celtis laevigata*, *Acer negundo, Liquidambar styraciflua, Liriodendron tulipifera, Ulmus americana, Ulmus alata, Juglans nigra, Acer floridanum,* and *Acer rubrum*. Less frequent trees include *Quercus phellos, Carya cordiformis, Carya ovata, Carya carolinae-septentrionalis, Quercus michauxii, Quercus nigra, Quercus pagoda,* and sometimes small numbers of *Quercus alba, Quercus rubra*, or *Fagus grandifolia*. The understory is frequently dominated by *Carpinus caroliniana, Acer negundo*, or *Asimina triloba*. Other species, such as *Ilex opaca, Benthamidia* (*Cornus*) *florida,* or *Nyssa sylvatica*, may also occur. The shrub layer is moderate to fairly dense. Dominant species are most often *Ilex decidua, Lindera benzoin*, *Arundinaria tecta*, or currently, exotic species such as *Ligustrum sinense*. Other shrubs include *Aesculus sylvatica, Viburnum prunifolium, Alnus serrulata*, or the exotic *Rosa multiflora*. Vines are often extensive and fairly diverse. Highly constant species include *Toxicodendron radicans, Smilax rotundifolia, Muscadinia rotundifolia, Parthenocissus quinquefolia, Bignonia capreolata*, and the exotic *Lonicera japonica*. Frequent but less constant are *Campsis radicans, Thyrsanthella* (*Trachelospermum*) *difformis*, and *Vitis sp.* The herb layer is generally dense, sometimes lush. *Chasmanthium latifolium* or *Elymus virginicus*, or exotic species such as *Microstegium vimineum* or *Glechoma hederacea*, may dominate, but often there is a diverse mix with no strong dominant. In the spring, *Nemophila aphylla* often has high cover. The most constant additional species include *Boehmeria cylindrica, Arisaema triphyllum,* several *Carex* species (e.g., *radiata, amphibola*), *Festuca subverticillata, Persicaria virginiana*, *Glyceria striata*, *Galium aparine*, and *Viola* spp. Fairly frequent species include *Polystichum acrostichoides, Persicaria* spp., *Laportea canadensis, Carex intumescens, Carex typhina, Sanicula canadensis, Geum canadense, Pilea pumila, Verbesina alternifolia, Verbesina occidentalis, Commelina virginica, Dichanthelium commutatum, Leersia virginica, Lycopus virginicus, Impatiens capensis, Juncus coriaceus*, and *Solidago* spp. Other herbs that have lower constancy in plot data but appear characteristic include *Elymus hystrix, Corydalis flavula, Osmorhiza longistylis, Asarum canadense, Melica mutica*, and *Arisaema dracontium*.

Range and Abundance: Ranked G3G4. This community occurs throughout the Piedmont except in the foothills area. Recognizable examples are abundant on large rivers and are often present when no other floodplain communities remain intact. A strip is often left when the rest of a floodplain is cleared or clearcut, and higher levees may remain forested when lower areas are drowned by impoundments. However, examples that are at full natural width, not subject to extreme edge effects from both sides, and not dominated by exotic plants in one or more strata are rare. Examples without hydrology modified by upstream dams or urbanization are still more rare. The equivalent NVC association ranges from Virginia to Georgia.

Associations and Patterns: Piedmont Levee Forests occur naturally as large patch communities, forming continuous, though fairly narrow, bands that would add up to substantial acreage. Many examples now exist as small patches. Piedmont Levee Forest grades into Piedmont Swamp Forest or Piedmont Bottomland Forest away from the channel. It usually is bordered by the river channel, but Sand and Mud Bar or Rocky Bar and Shore communities may border it. It may contain embedded Floodplain Pool communities.

Variation: Plot data analysis by Matthews, et al. (2011) recognized two kinds of levee forests, which are treated as variants. However, they noted substantial overlap in settings and soil characteristics. The author, too, has observed the nominal plant species in different combinations. These variants need further investigation into how distinct they are.

1. Sugarberry-Elm Variant, which Matthews, et al. named *Ulmus americana–Celtis laevigata/Lindera benzoin/Osmorhiza longistylis*, tends to occur farther downstream, on larger floodplains, and to be more fertile.

2. Ash-Sycamore Variant, which Matthews, et al. named *Fraxinus pennsylvanica–Platanus occidentalis/Acer negundo/Chasmanthium latifolium* tends to occur farther upstream, farther inland, tends toward smaller floodplains, and though fertile, is somewhat less so. The composition suggests an earlier stage of succession, but given its occurrence in different settings, as well as the avoidance of obviously successional vegetation in CVS sampling, it is more likely a result of different flooding dynamics.

Dynamics: General dynamics of Piedmont Levee Forests are similar to Piedmont and Mountain Floodplains in general. The current during floods is stronger on the levees than in most other parts of the floodplain. Vegetation may be battered by floating debris and soil may be locally scoured, though it is rare for large plants to be killed by this. Some tree mortality occurs through undercutting along the riverbank. Conversely, new deposition of bars can create new sites for forest development; however, these processes appear much slower than in the Coastal Plain, despite the stronger currents and greater potential for sediment movement.

Natural levees form because sediment deposition is concentrated on the riverbank. The coarsest material falls out there; sand deposits are common, though a layer of silt and clay is also left at the end of floods. The periodic input of nutrients in flood-deposited sediment makes levee sites very fertile, perhaps the most fertile sites in the Piedmont, and plant growth is rapid in these communities. The levees probably were the most affected by the massive influx of sediment during the early decades of European agriculture and by ongoing changed conditions. Rates of erosion in uplands remain higher than natural. The loss of forest cover and the increase in bare ground and impervious surfaces has led to faster runoff, but large dams have altered flood regimes and have removed sediment from some reaches.

Piedmont Levee Forests are among the most susceptible communities to invasion by exotic plants, due to a combination of high fertility, higher light levels along the bank, creation of bare ground patches by flood scouring and wrack movement, and dispersal of seeds by floodwaters. *Lonicera japonica, Microstegium vimineum,* and *Ligustrum sinense* have come to dominate large areas to the exclusion of the native herb layer, while *Glechoma hederacea, Stellaria media, Rosa multiflora, Youngia japonica, Murdannia keisak, Hedera helix,* and *Nandina domestica*, are sometimes abundant.

Most of the ecological characteristics of Piedmont Levee Forest communities are probably related to flooding and river dynamics. The most typical tree species have traits of ruderal or early successional species, such as small or readily dispersed seeds, response to high fertility and light, and rapid growth. Many will spread from the levees into cleared or logged areas in other parts of the floodplain, acting as early successional species there. However, it appears that the less altered Piedmont Levee Forests did not originate by catastrophic disturbance and that these species are stable long-term components. The levee environment, with its high light levels, high fertility, bare ground created by scouring and sediment deposition, and susceptibility to wind throw, favors such adaptations. Large-seeded, slower-growing trees are also components of the community, but they generally are much less abundant on the levees than in other parts of the floodplain.

Comments: Piedmont Levee Forest communities share many species with Brownwater Levee Forest (High Levee Subtype), enough that individual plots can be difficult to distinguish. However, the differences in river gradients, hydrology, sediment dynamics, and landscape patterns (e.g., the addition of Cypress–Gum Swamp), as well as floristic differences at broader scales, make it a worthwhile boundary.

There has been much confusion in the NVC over Piedmont floodplain communities and over levee forests in various regions. The association synonymized above was created to cover Piedmont Levee Forests in North Carolina and adjacent states. Several other associations have been attributed to levee forests in the North Carolina Piedmont, while at the same time being attributed to other regions. Two of those problematic associations have been dropped from the NVC or are no longer attributed to North Carolina. The remaining one — *Betula nigra – Platanus occidentalis / Alnus serrulata / Boehmeria cylindrica* Floodplain Forest (CEGL007312) — is a broadly defined concept attributed to all southeastern states, including the North Carolina Piedmont and Coastal Plain. It is used as a synonym for Brownwater Levee Forest (Bar Subtype), but in the Piedmont might overlap the concept of Piedmont Levee Forest.

Rare species:
Vascular plants – *Cardamine douglassii, Camassia scilloides, Carex jamesii, Carya laciniosa, Enemion biternatum, Euphorbia mercurialina, Eurybia mirabilis, Phacelia covillei, Phacelia maculata, Ruellia strepens, Scutellaria australis, Scutellaria nervosa, Sida elliottii* var. *elliottii, Silphium connatum, Silphium perfoliatum, Stachys matthewsii,* and *Urtica chamaedryoides*.

Vertebrate animals – *Hyla versicolor*.

PIEDMONT LEVEE FOREST (BEECH SUBTYPE)

Concept: Piedmont Levee Forests are forest communities of natural levee deposits or river front riparian zones on large Piedmont floodplains. The Beech Subtype encompasses examples on higher, more stable levees, where *Fagus grandifolia* is a major component.

Distinguishing Features: The Piedmont Levee Forest community is distinguished from other communities of large Piedmont floodplains, as well as uplands, by significant presence of the characteristic levee species: *Platanus occidentalis, Betula nigra, Acer negundo*, and *Celtis laevigata* in natural condition. *Fraxinus pennsylvanica* too distinguishes it from communities other than Piedmont Swamp Forest. It is distinguished from Piedmont Alluvial Forest by occurring on larger floodplains — those with differentiated levee, bottomland, and terrace zones large enough to support distinct communities.

The Beech Subtype is distinguished from the Typic Subtype by dominance or codominance by *Fagus grandifolia*. It is distinguished from Piedmont Alluvial Forest and Piedmont Headwater Stream Forest, which have some, though usually less, *Fagus*, by occurrence on a large floodplain with differentiated landforms. The characteristic levee species are also present in larger numbers and greater diversity. Piedmont Bottomland Forest (High Subtype) may sometimes also contain *Fagus*, but it will be a relatively minor component mixed with floodplain and upland oaks rather than levee species. The Beech Subtype is distinguished from mesic forests dominated by *Fagus* by the occurrence of alluvial species and by being located in a floodplain and adjacent to a stream or river.

Crosswalks: *Fagus grandifolia – Acer floridanum / Asimina triloba / Toxicodendron radicans / Carex blanda* Forest (CEGL007321).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: The Beech Subtype occurs on natural levee deposits or the river front edge of flatter terraces. The known examples are in Triassic basin floodplains and near the Fall Zone, on medium size streams rather than large rivers.

Soils: Soils are coarse or medium-textured, formed in recent alluvial deposits with little or no horizon development. Most examples are mapped as Chewacla (Fluvaquentic Dystrudept) or Wehadkee (Fluvaquentic Endoaquept).

Hydrology: The Beech Subtype is intermittently flooded, usually only for brief periods.

Vegetation: The Beech Subtype canopy includes codominant or abundant *Fagus grandifolia*. *Fraxinus pennsylvanica, Liquidambar styraciflua*, and *Betula nigra* have high constancy in known occurrences. Other species that are fairly frequent in known examples include *Quercus phellos, Quercus pagoda,* and *Liriodendron tulipifera*. A number of species occur at lower frequency, including *Platanus occidentalis, Ulmus americana, Quercus michauxii, Quercus alba*, and *Ulmus americana*. In the understory, *Carpinus caroliniana* is the most constant species, and *Acer floridanum, Ilex opaca, Asimina triloba*, and *Crataegus* spp. are fairly frequent. *Ilex decidua* often dominates the shrub layer. Other frequent species include *Arundinaria tecta, Viburnum prunifolium, Viburnum dentatum/carolinianum/recognitum*), and the exotic *Ligustrum sinense*. Vines are often prominent. Constant species in the known sites are *Toxicodendron radicans* and *Bignonia capreolata*. Other frequent species include *Smilax rotundifolia, Parthenocissus quinquefolia,* and the exotic *Lonicera japonica*; other typical species of floodplains, such as *Muscadinia rotundifolia* and *Campsis radicans*, may also be present. The herb layer generally is dense. *Chasmanthium latifolium, Carex* spp., *Asarum canadense*, or *Microstegium vimineum* may dominate patches. In season, spring ephemeral species such as *Claytonia virginica, Erythronium umbilicatum*, and *Thalictrum thalictroides* may be abundant. A large number of additional species may occur, most with low cover and fairly low frequency, including *Persicaria virginiana, Arisaema triphyllum, Viola* spp., *Mitchella repens, Sanicula canadensis*, *Geum canadense, Epifagus virginiana, Athyrium asplenioides*, and many others.

Range and Abundance: Ranked G3? Only a few occurrences are known in North Carolina, but this subtype may be overlooked or difficult to recognize in earlier site descriptions. However, it has not been found in most floodplains surveyed since the concept was distinguished. The known examples are all in Triassic basins or near the fall zone. If this proves true with more study, it limits the abundance in the state compared to most floodplain communities. The equivalent NVC association ranges from North Carolina to Georgia.

Associations and Patterns: The Beech Subtype, like the Typic Subtype, is associated with Piedmont Bottomland Forest and potentially Piedmont Swamp Forest in broad floodplains. It appears to be a small patch community but could occur as long narrow bands that would add up to a large patch size.

Variation: The Beech Subtype is a relatively narrowly defined community. Its variation is not well known.

Dynamics: General dynamics of the Beech Subtype are similar to the Typic Subtype and to Piedmont and Mountain Floodplains in general. Because the levees are higher above the stream in the Beech Subtype, and appear to occur along streams with lower gradients, flooding probably is even shorter in duration but also probably less energetic than in the Typic Subtype.

Comments: This subtype was not recognized in Matthews, et al. (2011). It is unclear if any plots represent it.

Rare species:
Vascular plants – *Carya laciniosa* and *Enemion biternatum.*

Vertebrate animals – *Hyla versicolor*.

PIEDMONT BOTTOMLAND FOREST (HIGH SUBTYPE)

Concept: Piedmont Bottomland Forests are communities of the locally higher parts of large Piedmont floodplains, away from the river and naturally dominated by a mix of bottomland oaks, hickories, *Liriodendron tulipifera*, and *Liquidambar styraciflua*, rather than the characteristic Piedmont Levee Forest species. They occur on terraces, on the higher parts of depositional ridge and swale systems, and on some wide flat floodplains. The High Subtype represents those on the highest floodplains and terraces, where an appreciable number of upland oaks, hickories, and other plants mix with the bottomland species. Levee communities are often present adjacent to the river, but this subtype sometimes covers most of higher medium-sized floodplains. Most examples have been found on medium-sized rivers, but examples probably once were common on higher terraces of larger rivers as well.

Distinguishing Features: Piedmont Bottomland Forests are distinguished from Piedmont Levee Forests by lack or scarcity of the characteristic levee species. *Platanus occidentalis, Betula nigra*, and *Celtis laevigata* are generally absent, though they may briefly invade cleared areas. *Fraxinus pennsylvanica, Ulmus americana*, and *Acer negundo* may be present but are not as abundant as they are in the Piedmont Levee Forest or Piedmont Swamp Forest. Bottomland Forests may occasionally occur on wide flat floodplains without obvious levees, where they may extend up to the riverbank.

Piedmont Bottomland Forest is distinguished from Piedmont Swamp Forest by shorter flooding duration and by vegetation reflecting the drier conditions over the bulk of the community. In the most intact examples, oaks are characteristic, along with *Liriodendron tulipifera, Liquidambar styraciflua*, and *Acer rubrum*. Upland species such as *Quercus alba* or *Fagus grandifolia* may be present as minority components. While more water-tolerant trees such as *Quercus lyrata, Fraxinus pennsylvanica*, and *Ulmus americana* may be present, they are less abundant than in Piedmont Swamp Forests, and often occur only locally, in wet microsites.

The High Subtype is distinguished from the two low subtypes by having an appreciable component of upland oaks and hickories, or *Fagus*, associated with a higher elevation above the river. In successional examples where oaks are scarce, this may be hard to distinguish. Other strata of the vegetation also have more mesophytic, less water-tolerant composition. Matthews, et al. (2011) found a number of species that were more common in the High Subtype than the Low Subtype, or only present there, including *Amphicarpaea bracteata, Asarum canadense, Botrypus virginianus, Chasmanthium latifolium, Dichanthelium boscii, Dichanthelium laxiflorum, Hexastylis arifolia, Hypericum hypericoides, Polygonatum biflorum, Polystichum acrostichoides, Mitchella repens, Benthamidia* (*Cornus*) *florida, Fagus grandifolia*, and *Quercus nigra*. Although Matthews, et al. (2011) did not include samples of them, communities of high bottomlands with *Fagus grandifolia* dominant or co-dominant are included in this subtype.

Crosswalks: *Liquidambar styraciflua – Quercus (phellos, nigra, alba) / Carpinus caroliniana* Floodplain Forest (CEGL007006).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
Oak-hickory flats (Matthews, et al. 2011).

Sites: Piedmont Bottomland Forests occur on floodplain ridges and on irregular or flat terraces well above the river. They usually are behind a natural levee or riparian zone with Piedmont Levee Forest but may sometimes extend to the riverbank.

Soils: Soils are coarse to fine-textured alluvial soils. Most are mapped as Chewacla (Fluvaquentic Dystrudept), less often as Riverview (Fluventic Dystrudept) or other alluvial soils.

Hydrology: The High Subtype is intermittently flooded for short periods; it may go some years without flooding, even along rivers without altered hydrology. Wetness varies locally with microtopography and soil texture. Though most of the extent is likely well-drained when the river is not in flood, local low areas or areas with clayey soils may be poorly drained.

Vegetation: The High Subtype is a forest with a mix of trees that includes both bottomland and some upland species. In the Matthews, et al. (2011) plot data analysis, the most constant abundant canopy trees were *Liquidambar styraciflua* and *Acer rubrum*, but *Quercus phellos, Quercus nigra, Quercus pagoda, Liriodendron tulipifera, Ulmus americana, Ulmus alata*, *Fagus grandifolia*, and *Fraxinus pennsylvanica* occurred with at least fairly high frequency (25-75%). Additional species that occur with lower constancy include *Carya ovata, Carya cordiformis,* and *Carya carolinae-septentrionalis*. *Carpinus caroliniana* is the most constant and usually dominant understory species, but *Ilex opaca, Benthamidia florida*, and *Ilex opaca* may be abundant. The shrub layer is generally moderate in density but may be dense. The most frequent species are *Ilex decidua, Viburnum prunifolium, Euonymus americana,* and *Arundinaria tecta*. Less frequent species include *Aesculus sylvatica* and *Asimina triloba*. *Ligustrum sinense* can sometimes become dense. Vines are diverse. Frequent species include *Bignonia capreolata, Parthenocissus quinquefolia, Smilax rotundifolia, Toxicodendron radicans, Muscadinia rotundifolia,* the non-native *Lonicera japonica*, and less frequently, *Gelsemium sempervirens* and *Vitis* spp. The herb layer may be dense but more often is sparse to moderate or patchy. Species with high frequency include *Chasmanthium latifolium, Asarum canadense, Carex* spp. (*intumescens, debilis*, and others), *Elymus virginicus, Commelina virginica, Elephantopus carolinensis, Ranunculus abortivus, Dichanthelium commutatum, Sanicula canadensis, Boehmeria cylindrica, Polygonatum biflorum, Poa cuspidata*, *Arisaema dracontium*, *Solidago* spp., and *Viola* spp. *Microstegium vimineum* and other non-native species such as *Stellaria media* and *Glechoma hederacea* can be dense, especially in more altered or successional examples, but are less likely to be extensive than in Piedmont Levee Forest. Less frequent herbs in plot data include *Dichanthelium boscii, Elymus hystrix, Hexastylis arifolia, Salvia lyrata, Carex typhina, Impatiens capensis, Leersia virginica*, and *Ruellia caroliniensis*. Many other species are noted in site descriptions, including *Chasmanthium laxum, Persicaria virginiana, Packera aurea, Polystichum acrostichoides*, *Cryptotaenia canadensis*, *Melica mutica, Danthonia spicata,* and *Mitchella repens*.

Range and Abundance: Ranked G3G4 but probably rarer. This community often is converted to agriculture even where lower parts of the floodplain remain intact. In North Carolina, the High Subtype occurs throughout the eastern and middle Piedmont, both in Triassic Basins and on large rivers elsewhere. Known good occurrences are fewer than for the Typic Low Subtype. The association also occurs in Virginia and possibly in South Carolina and Georgia.

Associations and Patterns: The High Subtype occurs naturally as a large patch community but is now often reduced to small remnants. Few occurrences are large. It is usually associated with Piedmont Levee Forest, sometimes with Piedmont Swamp Forest or with the Typic Low Subtype; sometimes it occupies all or most of a floodplain's width. It may contain embedded Floodplain Pools. On the edge of the floodplain, it will grade to various mesic or dry-mesic upland forests, most commonly to Mesic Mixed Hardwood Forest.

Variation: Examples of the High Subtype are quite variable in plant composition, but the widespread and varying levels of alteration make natural patterns difficult to discern. Matthews, et al. (2011) recognized three types of oak-hickory flats, the broad grouping equivalent to the High Subtype. However, one was associated with smaller floodplains and, though grouped with high bottomlands in their analysis, shares many species with Piedmont Alluvial Forest and would probably be recognized as it in the field. A second was represented only by a few plots from a single Triassic Basin site. Because plots from other Triassic basins did not group with it, it is not taken as indicating a distinct Triassic basin variant, and it is unclear why it appears different.

Dynamics: As the most elevated of Piedmont floodplain communities, the High Subtype is flooded least frequently and for the briefest periods. Unlike the Piedmont Levee Forest, flood waters likely have slowed by the time they spread out over this community, so that scouring and even movement of litter and debris may be minimal. However, deposition of sediment, with its nutrient subsidy, presumably still is important in making these communities more fertile and productive than uplands. It is unclear how the altered hydrological regimes caused by land clearing in the watersheds has affected them.

Beaver ponds are probably much less frequently created in the High Subtype but may occur where sloughs or tributary streams can be dammed.

The combination of fertile alluvial soils, flat ground, and limited flooding has made sites of the High Subtype particularly attractive for agriculture. They probably were the primary focus of prehistoric agriculture. The descriptions by early colonial travelers of large expanses of open grassland, especially those that mention plains in regions that are not extensively flat, may well have been long linear expanses of old fields on large bottomlands. The more extensive colonial and modern agriculture have left few large or even medium sized examples unaffected. Where not still cultivated, most areas of appropriate sites support successional vegetation, especially the larger patches on the largest rivers. Even examples that appear the least altered may have been affected by farming long ago, though effects of the shifting agriculture of prehistoric peoples presumably have vanished over the centuries. Areas that have been cleared or heavily logged in the more recent past tend to be strongly dominated by *Liquidambar* or *Liriodendron*, but *Pinus taeda* may come to dominate. Species of the Piedmont Levee Forest, especially *Platanus occidentalis* but also *Betula nigra, Acer negundo*, *Fraxinus pennsylvanica*, and *Celtis laevigata* sometimes also establish in successional forests in these sites, aided by their readily dispersed seeds and perhaps by remnant levee vegetation usually left at least on the riverbanks.

Comments: As noted in the comments on the Piedmont and Mountain Floodplains theme, the classification of bottomland and swamp forest has been particularly confused, and for that reason the central concepts and circumscription of the 3rd Approximation communities have been changed more than others in the 4th Approximation. The primary confusion for the High Subtype is that it was characterized as being naturally dominated by *Liriodendron* and *Liquidambar*, while that now appears to be a successional condition.

Matthews, et al. (2011) called their class that is equivalent to this subtype "oak-hickory flats." They described them as being primarily on medium size floodplains, usually filling relatively featureless floodplains. However, occurrences in the Natural Heritage database also include a number on larger rivers and a number occurring with other communities. This discrepancy may be somewhat a matter of interpretation, but examples on larger rivers often are small remnants that may have been inaccessible or may have been rejected as too altered.

Rare species:
Vascular plants – *Callitriche terrestris, Cardamine dissecta, Cardamine douglassii, Eurybia mirabilis, Phacelia covillei, Polemonium reptans var. reptans, Scutellaria australis, Scutellaria nervosa, Silphium connatum,* and *Silphium perfoliatum.*

Vertebrate animals – *Hyla versicolor*.

PIEDMONT BOTTOMLAND FOREST (TYPIC LOW SUBTYPE)

Concept: Piedmont Bottomland Forests in general are communities of the higher parts of large Piedmont floodplains, away from the river and naturally dominated by a mix of bottomland oaks, hickories, *Liriodendron tulipifera*, and *Liquidambar styraciflua*, rather than the characteristic Piedmont Levee Forest species. The Typic Low Subtype covers the lower or intermediate parts of that local elevational range, with most examples on lower terraces, ridges, and flat floodplains, without an appreciable component of upland species, and lacking the distinctive composition of the Northern Low Subtype. *Quercus lyrata* may be present but is not dominant as it may be in Piedmont Swamp Forest.

Distinguishing Features: Piedmont Bottomland Forests are distinguished from Piedmont Levee Forests by lack or scarcity of the characteristic levee species. They are distinguished from Piedmont Swamp Forest by shorter flooding duration and by vegetation reflecting the drier conditions. In the most intact examples, oaks are characteristic, along with *Liriodendron tulipifera, Liquidambar styraciflua*, and *Acer rubrum*.

The Typic Low Subtype is distinguished from the Northern Low Subtype by the absence or near absence of *Quercus palustris*. It is distinguished from the High Subtype by the predominance of bottomland species without an appreciable component of most upland species. Plants that Matthews (2011) found to be more common in this subtype and less common or absent in the High Subtype include *Saururus cernuus, Carex lupulina, Carex tribuloides, Elymus virginicus, Glyceria striata, Juncus effusus, Persicaria virginiana, Ulmus americana*, and *Quercus lyrata*. However, a few characteristically upland species still occurred with some frequency in this type, including *Quercus alba* and *Carya ovata*. A number of more mesophytic species are largely absent in this subtype. In examples cleared in the past, *Liquidambar* or *Liriodendron* may strongly dominate, so that distinguishing the subtypes can be difficult. However, in more intact examples, at least some bottomland oaks will be present.

Crosswalks: *Quercus pagoda – Quercus phellos – Quercus lyrata – Quercus michauxii / Chasmanthium latifolium* Swamp Forest (CEGL007356).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: Piedmont Bottomland Forests occur on floodplain ridges and on irregular or flat terraces well above the river. They usually are behind a natural levee or riparian zone with Piedmont Levee Forest but may sometimes extend to the river channel. The Typic Low Subtype is most extensive and well-developed in Triassic basin floodplains but may potentially occur on any large floodplain.

Soils: Soils are coarse to fine-textured alluvial soils. Most are mapped as Chewacla (Fluvaquentic Dystrudept), less often as Riverview (Fluventic Dystrudept) or other alluvial soils.

Hydrology: The Typic Low Subtype is intermittently flooded for short periods, but somewhat longer and more frequently than the High Subtype. Wetness may vary with microtopography and soil texture. Though most parts are likely well-drained when the river is not in flood, local low areas or areas with clayey soils may be poorly drained.

Vegetation: The Typic Low Subtype is a forest consisting of a mix of bottomland and swamp species. In Matthews, et al. (2011), the most constant trees are *Fraxinus pennsylvanica, Acer rubrum, Liquidambar styraciflua*, *Quercus phellos*, and *Ulmus americana*, but *Quercus michauxii, Quercus pagoda, Quercus lyrata*, and *Carya carolinae-septentrionalis* are frequent and often dominant or codominant. Other trees that are fairly frequent, though not codominant, include *Quercus nigra* and *Quercus alba*. The understory is dominated by *Carpinus caroliniana*, with no other typical understory species frequent. The only highly constant shrub species is *Ilex decidua*. *Viburnum prunifolium* and *Ligustrum sinense* are fairly frequent, as is *Rubus* sp. Vines are a regular component. *Bignonia capreolata, Parthenocissus quinquefolia, Smilax rotundifolia, Toxicodendron radicans*, and *Lonicera japonica* are highly constant, and *Thyrsanthella difformis* and *Vitis* spp. are also fairly frequent. Herbs have relatively low cover in plot data. *Boehmeria cylindrica, Arisaema triphyllum*, and *Viola* spp. are highly constant in plots. Also highly constant, despite efforts to avoid sampling altered examples, is the non-native *Microstegium vimineum*, which may have extensive cover. Other herb species that are at least fairly frequent include *Asarum canadense, Polystichum acrostichoides, Carex* spp. (*intumescens, typhina, tribuloides, blanda, amphibola, caroliniana, debilis* and others), *Ranunculus abortivus, Saururus cernuus, Chasmanthium latifolium, Elymus virginicus, Festuca subverticillata, Galium tinctorium, Glyceria striata, Impatiens capensis, Juncus coriaceus, Persicaria virginiana, Poa cuspidata, Sanicula canadensis, Sceptridium biternatum/dissectum, Solidago* spp., and *Erechtites hieracifolia*.

Range and Abundance: Ranked G2? but perhaps G3. This subtype is scattered in the eastern and central Piedmont. The largest examples are in Triassic basins, but examples in other areas are equally abundant. Good examples appear more numerous than for the High Subtype, as might be expected for wetter, less easily farmed sites, but extensive remnants are still few.

Associations and Patterns: The Typic Low Subtype is naturally a large patch community, occurring either as large contiguous expanses or as a major part of a mosaic of floodplain communities. However, it is now often reduced to small remnants; few existing occurrences are large. It is usually associated with Piedmont Levee Forest, sometimes with Piedmont Swamp Forest or with the High Subtype, but sometimes occupies all or most of a floodplain's width. It may contain embedded Floodplain Pools. On the edge of the floodplain, it will grade to various mesic or dry-mesic upland forests, most commonly Mesic Mixed Hardwood Forest.

Variation: Variation within this subtype is not well known. Matthews, et al. (2011) had only a single finer grouping in their classification that appears to correspond to this subtype.

Dynamics: As a community at intermediate elevation above the river, the Typic Low Subtype floods with higher frequency and duration than the High Subtype but lower than Piedmont Swamp Forest. Flood currents likely are slow when they reach this community, so that scouring and movement of litter and debris probably are minor, but deposition of nutrients in sediment probably is important for fertility. It is unclear how the altered hydrological regimes caused by land clearing in the watersheds has affected this community.

As this subtype is often locally the highest part of its floodplain, beaver ponds probably are relatively unlikely to flood much of it, but ponds may affect it near sloughs and tributary streams.

Comments: As noted in the comments on the Piedmont and Mountain Floodplains theme, the classification of bottomland and swamp forest has been particularly confused, and for that reason the central concepts and circumscription of the 3rd Approximation communities have been changed more than others in the 4th Approximation. The distinction between the Typic Low Subtype and Piedmont Swamp Forest remains among the more uncertain. As a community dry enough to support a substantial presence of multiple oak species, it is recognized as a subtype of Piedmont Bottomland Forest in the 4th Approximation, with Piedmont Swamp Forest narrowed from its 3rd Approximation concept to include only communities wet enough to largely exclude most of the oak species.

Analysis by Matthews, et al. (2011) recognized a *Quercus (phellos, pagoda, michauxii) – Ulmus americana / Ilex decidua / Arisaema triphyllum* community that appears to correspond to the Typic Low Subtype. Their analysis tied it to their swamp and bottomlands grouping rather than to the higher oak-hickory flats, but it is not clear why. *Quercus lyrata* occurs in it, but only in local wet inclusions. It does share a high abundance of the species most often dominant in swamps. However, it also contains a large number of species shared with the High Subtype and with their oak-hickory flats community, species which are absent in the swamps forests it is grouped with. They described it as generally occurring on wide, flat Triassic Basin floodplains. However, Natural Heritage Program records include a number of occurrences outside of Triassic basins that appear to represent this community.

Rare species:
Vascular plants – *Cardamine douglassii, Carex decomposita, Carya laciniosa, Eurybia mirabilis, Phacelia covillei, Polemonium reptans var. reptans, Scutellaria nervosa,* and *Urtica chamaedryoides*.

Vertebrate animals – *Hyla versicolor*.

Invertebrate animals – *Hylogomphus abbreviates.*

PIEDMONT BOTTOMLAND FOREST (NORTHERN LOW SUBTYPE)

Concept: Piedmont Bottomland Forests in general are communities of the higher parts of large Piedmont floodplains, away from the river and naturally dominated by a mix of bottomland oaks, hickories, *Liriodendron tulipifera*, and *Liquidambar styraciflua*, rather than the characteristic Piedmont Levee Forest species.

The Northern Low Subtype is a Virginia community that occurs along the state line, with only one North Carolina location known. It is similar in wetness to the Typic Low Subtype but contains an appreciable component of species that are common in Virginia but scarce in North Carolina, particularly *Quercus palustris*.

Distinguishing Features: The Northern Low Subtype is distinguished from the Typic Low Subtype and all other floodplain communities by having abundant *Quercus palustris*.

Crosswalks: *Quercus phellos – Quercus (palustris, lyrata) / Ilex decidua / Carex typhina* Floodplain Forest (CEGL006498).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: The North Carolina example occurs on a medium size floodplain on a large creek, occurring in lower portions of the floodplain. In Virginia, this community occurs in both large and medium size floodplains.

Soils: The North Carolina example is mapped as Chewacla (Fluvaquentic Dystrudept).

Hydrology: The flood regime appears to be similar to the Typic Low Subtype – intermittently flooded for short periods, but somewhat longer and more frequent than the High Subtype.

Vegetation: In the North Carolina example, the canopy is dominated by *Quercus phellos* and *Quercus bicolor*, with abundant *Quercus palustris* and a few *Quercus michauxii* and *Carya ovata*. The understory has abundant *Quercus palustris*. The shrub layer is dominated by *Viburnum prunifolium* and *Ilex decidua*. The herb layer is dominated by grasses and sedges, and *Claytonia virginica* is abundant in the spring. The exotic *Lysimachia nummularia* is also abundant. The NVC, largely based on data on Virginia examples, says *Quercus phellos* is the most constant species, while *Quercus palustris, Quercus lyrata*, and *Quercus michauxii* may dominate in varying combinations. *Quercus bicolor* is infrequent. Other trees include *Ulmus americana, Acer rubrum, Carya ovata, Ulmus alata, Celtis occidentalis*, and *Betula nigra*. *Carpinus caroliniana* is the predominant understory tree, *Ilex decidua* and *Viburnum prunifolium* the most constant shrubs. *Toxicodendron radicans, Smilax rotundifolia*, and *Campsis radicans* are common vines. The herb layer is usually dense. Patches are dominated by *Carex* spp. (*typhina, grayi, tribuloides, radiata, intumescens*), *Leersia virginica, Poa autumnalis, Glyceria striata*, and *Cinna arundinacea*. Other herbs include *Boehmeria cylindrica, Impatiens capensis, Lysimachia ciliata, Lycopus virginicus, Commelina virginica*, and *Saururus cernuus*. Spring ephemerals such as *Claytonia virginica* are also noted, as is frequent invasion by *Lysimachia nummularia*.

Range and Abundance: Ranked G3? This community is extremely rare in North Carolina, with only a single occurrence known. It has a rather narrow global range, otherwise limited to the southern half of Virginia.

Associations and Patterns: This community occurs as a small patch. Its North Carolina example is apparently associated with the Typic Low Subtype and may be in a slightly wetter microsite.

Variation: No detail is known about the variation in this subtype.

Dynamics: Dynamics are probably similar to the Typic Low Subtype. The one North Carolina example is upstream of a filled railroad grade, which may have increased its wetness.

Comments: This subtype is not covered by Matthews, et al. (2011), and no plots are known to exist in the one North Carolina example. The association was defined in central to southern Virginia, and its occurrence in North Carolina was recognized during the inventory of Kerr Lake lands, which occur in both states (Van Alstine, et al. 1999).

Rare species:
Vertebrate animals – *Hyla versicolor*.

PIEDMONT SWAMP FOREST

Concept: Piedmont Swamp Forests are communities of the wetter parts of large Piedmont floodplains, generally in backswamps and large sloughs but sometimes on low flat floodplains or in depressions on higher terraces. These areas are flooded for prolonged periods and support species tolerant of longer hydroperiods, such as *Fraxinus pennsylvanica, Ulmus americana, Acer rubrum var. trilobum*, *Quercus phellos*, and *Quercus lyrata*.

Distinguishing Features: Piedmont Swamp Forests are distinguished from all other Piedmont floodplain forests by their flood-tolerant species composition, generally dominated by *Fraxinus pennsylvanica, Ulmus americana, Acer rubrum*, or *Quercus lyrata*. The lower strata are similarly water-tolerant, with a relatively depauperate herb layer generally dominated by *Carex* spp., *Saururus cernuus*, *Boehmeria cylindrica* or other species tolerant of long hydroperiods.

Piedmont Swamp Forests and Floodplain Pools can both have standing water for long periods and both occur in linear sloughs or wider basins, but Floodplain Pools will have a central area of deeper water that stays flooded much or all of the year and lacks rooted trees. Many Floodplain Pools have water-tolerant trees rooted at their edges, generally of the same species as those in Piedmont Swamp Forest. These areas should be regarded as ecotones of the Floodplain Pool rather than Piedmont Swamp Forest unless they cover a substantial area. Montane Floodplain Slough is a similarly wet community of the Mountains that shares many species, but has a component of typical Blue Ridge flora and lacks some of the Piedmont species.

Drained beaver ponds that are succeeding to forest may be dominated by *Fraxinus pennsylvanica* and *Acer rubrum*. They should be treated as Piedmont/Mountain Semipermanent Impoundment as long as the history as a beaver pond is apparent and as long as the vegetation appears transient. If the pond changed the stream channel or resulted in deposition of a clay layer that made the site permanently wetter, it may develop into a stable Piedmont Swamp Forest.

Floodplain areas that have become wetter due to artificial impoundment by dams, roads, or other fill should not generally be classified as Piedmont Swamp Forest. They could be considered this type in rare cases where the impoundment is configured so as to create an identical hydrological regime and where enough time has passed for the vegetation to come to equilibrium with a composition resembling natural examples.

Crosswalks: *Acer rubrum – Fraxinus pennsylvanica / Saururus cernuus* Swamp Forest (CEGL006606).
G034 Oak - Sweetgum Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: Piedmont Swamp Forests occur in backswamp basins and sloughs on large floodplains, occasionally in locally wet areas on higher terraces, and occasionally on less differentiated low floodplains.

Soils: Soils are fine- to medium-textured, poorly drained alluvial soils. Because they tend to occur in basins where flood waters are still, there can be substantial clay deposition. Most examples are mapped as Wehadkee (Fluvaquentic Endoaquept) or Chewacla (Fluvaquentic Dystrudept). In the latter case, they likely represent inclusions of the wetter Wedhadkee series.

Hydrology: Piedmont Swamp Forests are seasonally to frequently flooded. They may stay inundated well into the growing season but rarely or never throughout the entire growing season.

Vegetation: Piedmont Swamp Forests are dominated by a mixture of the most water-tolerant tree species of the region. Matthews, et al. (2011) report that *Acer rubrum* and *Fraxinus pennsylvanica* are usually the most abundant species. *Ulmus americana, Liquidambar styraciflua, Quercus lyrata*, *Quercus phellos*, and rarely, *Nyssa aquatica* and *Carya aquatica* may be codominant. Less water-tolerant oaks, such as *Quercus michauxii* and *Quercus pagoda*, are absent or scarce. The understory is dominated by *Carpinus caroliniana* along with canopy species. Shrub cover is low to moderate; *Ilex decidua* is the predominant species, but *Ligustrum sinense* may be fairly abundant. Vines are prominent. *Bignonia capreolata, Parthenocissus quinquefolia, Toxicodendron radicans, Smilax rotundifolia, Muscadinia rotundifolia*, and *Lonicera japonica* all have high constancy in plots and may have substantial cover. The herb layer may be sparse to moderate but is lower in diversity than most of the Piedmont floodplain communities. *Saururus cernuus, Boehmeria cylindrica*, *Ludwigia palustris*, or any of several wetland species of *Carex* (e.g., *typhina, crinita, tribuloides, intumescens*) may dominate patches. Other herbs with high to moderate frequency include *Bidens frondosa, Viola* spp., *Chasmanthium latifolium, Dichanthelium commutatum, Carex grayi, Impatiens capensis, Glyceria striata, Lycopus virginicus, Juncus effusus*, *Leersia virginica*, and *Solidago* spp. Though not frequent in plots, *Zephyranthes atamasco* and *Dulichium arundinaceum* are sometimes seen dominating patches. Other species of higher bottomlands, such as *Persicaria virginiana, Pilea pumila, Ranunculus abortivus*, and *Microstegium vimineum* also occur fairly frequently in low abundance.

Range and Abundance: Ranked G3G4 but likely rarer. See comments below for discussion of the relationship to the NVC association. In North Carolina, this community is potentially scattered through the Piedmont, other than in the foothills, but both acreage and number of occurrences are disproportionately concentrated in the Triassic basins.

Associations and Patterns: Piedmont Swamp Forest occurs with other communities of large Piedmont floodplains, including Piedmont Levee Forest and Piedmont Bottomland Forest. It may occur as small patches or may potentially dominate large patches.

Variation: Matthews, et al. (2011) recognized five associations within their swamp group. One of these is treated as Piedmont Bottomland Forest (Typic Low Subtype). The other four are tentatively treated as variants here. Some may be distinctive enough to ultimately be treated as subtypes, but some may be transitional or overlap other community types.

1. Typic Variant, called *Fraxinus pennsylvanica-Acer rubrum-Ulmus americana/Ilex decidua-Crataegus marshallii/Carex typhina-Saururus cernuus* is the most typical of the concept and the most abundant sampled.

2. Overcup Oak Variant, called *Quercus lyrata – Acer rubrum – Fraxinus pennsylvanica/Saururus cernuus,* is very similar to the Typic Variant but is codominated by *Quercus lyrata*.

3. Water Tupelo Variant, called *Carya aquatica – Nyssa aquatica*, is a rare occurrence dominated by these Coastal Plain species, in the PeeDee basin near the Fall Zone. This variant needs to be investigated to see if it would be better treated as a disjunct example of a Coastal Plain community. If not, though extremely rare, it appears the most distinct of the variants and probably should be treated as a subtype.

4. Levee Transition Variant is called *Fraxinus pennsylvanica – Betula nigra – Platanus occidentalis/Alnus serrulata /Boehmeria cylindrica*. In addition to the trees more typical of levees and shrubs more typical of riverbanks than floodplain interior, this variant contains species in all strata that are shared with Piedmont Levee Forest. Matthews, et al. (2011) note that they occur in narrower floodplains that are confined by bedrock, farther inland and not in Triassic basins, and that they have sandier soils than other swamps. They also suggest that the wetness may be due to seepage or natural or manmade impoundment. Only 6 plots were found in this group. Further investigation is needed into how natural they are, into their ecological setting, and whether they would be better treated as part of Piedmont Levee Forest.

Dynamics: Piedmont Swamp Forests are flooded for longer durations than other Piedmont floodplain forest communities. The input of sediment makes them fertile, but the wetness, greater clay content, and acidity associated with it makes them less productive. The prolonged flooding appears to be important in keeping out uncharacteristic plant species and giving the community its distinctive composition. As the lowest part of the floodplain, impoundment and altered flood regimes may more significantly detract from their natural character than for other Piedmont floodplain forests.

As in Piedmont Levee Forest, the most abundant canopy trees have ruderal life history traits and act as successional species in other communities. It is unclear if this implies a greater disturbance frequency in Piedmont Swamp Forests. Other early successional tree species of uplands, and even of levees, are not frequent in them, presumably because of wetness. Though soils are not as loose as in other floodplain communities, trees may still be more susceptible to windthrow than in uplands because of shallow rooting in the wet soils. In addition, though not well documented under natural conditions, flooding may occasionally be long enough to be a natural stress that contributes to mortality of established plants. This can happen more easily under altered conditions. A number of swamp forests have been diked to make green tree reservoirs. In some, the canopy appears similar to before impoundment, though often more stressed, but the lower strata tend to be visibly altered. In others, the increased hydroperiod ultimately kills the trees. Incidental impoundment by roads and other fill may also potentially lead to canopy mortality.

The sites of many Piedmont Swamp Forest occurrences, those in sloughs or basins with narrow outlets, are particularly susceptible to being impounded by beavers. Little is known about the long-term interplay between these communities. It is possible that most swamps would spend longer periods as beaver ponds. It is also possible that the enhanced clay deposition in beaver ponds may alter sites in a way that leads Piedmont Swamp Forest to develop when the pond drains, even where it did not exist before.

Comments: The relationship of the NVC association linked to this community is unclear. That association is defined as extending into the Coastal Plain of Delaware and Maryland. At the same time, it does not extend to South Carolina and Georgia, where most floodplain communities are shared with North Carolina. Yet there is no reason to think North Carolina's Piedmont Swamp Forest is more northern in affinities than its other floodplain communities. Further splitting or reconfiguration of this association in NVC may be needed.

The concept of this community has been narrowed from the Piedmont/Mountain Swamp Forest of the 3rd Approximation. Swamp-like floodplain forests of the Mountain Region are now treated as Montane Floodplain Slough. However, a couple of broader swampy forests in the upper French Broad River basin remain of uncertain classification, and these may best be interpreted as disjunct examples of Piedmont Swamp Forest.

As noted in the comments on the Piedmont and Mountain Floodplains theme, the classification of bottomland and swamp forest has been particularly confused, and for that reason the central concepts and circumscription of the 3rd Approximation communities have been changed more than others in the 4th Approximation. Piedmont Swamp Forests now more specifically represent a portion of the floodplain moisture gradient, wet enough to have limited abundance of the typical bottomland oaks. They are more extensive in Triassic basins but can occur in all large floodplains. They are distinctly rarer and much less extensive than Piedmont Bottomland Forest. Though perhaps less universally used because of their greater wetness, many examples have been destroyed or altered by small and large dams.

Rare species:
Vascular plants – *Triadenum tubulosum.*

Vertebrate animals – *Hyla versicolor*.

PIEDMONT/MOUNTAIN CANEBRAKE

Concept: Piedmont/Mountain Canebrakes are communities dominated by dense thickets of *Arundinaria gigantea*, treeless or with an open canopy. No well-developed natural examples are known to remain in North Carolina, but altered remnants or restored examples may occur. They are mentioned in historical accounts by early travelers and are regarded as culturally important by Native Americans, but there is little detail on where they occurred or on what species besides can were present. Given the bias in traveler accounts, it is also unclear how abundant or extensive they were. There is confusion with historical accounts of more extensive canebrakes in states west of North Carolina.

Distinguishing Features: Piedmont/Mountain Canebrakes are distinguished by having a dense shrub layer of *Arundinaria gigantea*, occurring with limited tree cover. Areas of cane that appear to be naturally developed, or are restored in plausible natural settings, should be regarded as this type. Areas where *Arundinaria* occurs at low to moderate density under a typical forest canopy are not included, nor are stands of *Arundinaria appalachiana* in uplands. Abundance of *Arundinaria gigantea* in a forest may suggest past occurrence of a canebrake but the ability of the species to persist in forests makes this far from definitive. Presence of the species should not be taken as proof of a former canebrake without additional evidence. Methods of finding sites of past canebrakes, other than site-specific historical descriptions, are not known.

Piedmont/Mountain Canebrakes are distinguished from Peatland Canebrakes by occurring in these regions rather than in the Coastal Plain, and in being dominated by *Arundinaria gigantea* rather than *Arundinaria tecta*. Additionally, the only documented Coastal Plain canebrakes are in peatlands, while those in the Piedmont and Mountains were in bottomlands.

Crosswalks: *Arundinaria gigantea ssp. gigantea* Wet Canebrake (CEGL003836).
G034 Oak - Sweetgum Floodplain Forest Group.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: Piedmont/Mountain Canebrakes may potentially occur in either small or large floodplains. They are believed to be primarily in the Mountain Region but could occur in the upper Piedmont.

Soils: Piedmont/Mountain Canebrakes could potentially occur on any floodplain soil. If particular soil conditions are necessary, they are not known.

Hydrology: Canebrakes occurred on drier floodplain sites; they presumably were flooded intermittently for brief periods.

Vegetation: The vegetation is characterized by a dense stand of *Arundinaria gigantea*, which may be 10 to 20 feet tall or more. Trees may be absent, but an open or sparse tree canopy may be present in remnant or restored examples. The abundance and species in natural examples of the past is not known. Other shrubs may occur at low density beneath the cane or may be more abundant in open spots. Herbs can be expected to be largely absent beneath the dense cane cover.

Range and Abundance: Ranked G2? This community has largely disappeared from North Carolina. Only a couple of small, poorly developed examples of questionable origin are known. The former abundance, acreage, and distribution in North Carolina is unclear. It is generally believed to have been more prominent in the Mountains. Though Native Americans in the Piedmont were reported to use cane, and large cane stalks were reported to have been seen, it is less clear if there were well-developed canebrakes. Given the extensive trade among Native Americans, they may not even have been of local origin. The rough range map in Triplett, et al. (2010) show *Arundinaria gigantea* occurring only in the Blue Ridge and possibly western Piedmont in North Carolina, though it extends into the Coastal Plain in Georgia and southern South Carolina. The NVC association is attributed to a very wide range, extending from Virginia to Florida and westward to Texas and Missouri, and the NVC description cites several places where remnants occur. The nearest substantial remnant appears to be near the Ocmulgee River in the Georgia Piedmont or upper Coastal Plain.

Associations and Patterns: Piedmont/Mountain Canebrakes are generally described as large patch communities, though it is unclear how extensive examples in North Carolina were. They presumably were smaller than those on the much larger floodplains farther west. They could have occurred with various floodplain forests and likely bordered uplands at the edge of floodplains.

Variation: Nothing is known of the variation in this community. It is unlikely that the NVC association was uniform over the large range of climate and physiography to which it is attributed.

Dynamics: Most of what is believed about canebrake dynamics is interpreted from historical sources (reviewed in Platt and Brantley 1997). The widespread belief that they were maintained by fire is almost certainly true; the climate and sites where they occurred are capable of supporting forests. However, it is likely that a dense stand of cane is competitive enough to inhibit tree establishment even without fire. This likely was a situation of alternative stable states, where the flammability of dense cane promoted intense fires that would kill trees and sustain canebrakes, while the limited flammability in floodplain forests dampened fires. Because *Arundinaria* can spread by rhizomes, established canebrakes might have been able to expand into adjacent forests as long as fire was sufficiently frequent but might shrink in periods when fire became infrequent. If canebrakes with open tree canopies existed, they may have represented a nonequilibrium situation, where previously established trees persisted but could not reproduce. However, it is also possible that they existed as savannas, with established trees able to withstand fires and fire-free intervals occurrence often enough to allow their regeneration.

It is assumed by many that fire intervals were very frequent and were largely human caused. As with fire regime in other communities, most fires may have been ignited by humans near their settlements, but it is less clear that fires would not have occurred without them. The existence of numerous species adapted to fire required a period of evolution much longer than human presence in the hemisphere. It is likely that fire frequencies as high as often believed to have occurred around human settlements would not have been good for *Arundinaria*, which replenishes its biomass more quickly than trees but apparently still requires several years free of fire to retain vigor.

It is widely believed, as stated in the NVC description, that canebrakes are inherently early successional communities and may have all gotten their start in abandoned Native American fields.

However, it is a misleading characterization to group them with typical ruderal-dominated early-successional vegetation. They should not be expected to readily recover from disturbances that kill the dominant plants, nor are they likely to be what appears in recently disturbed areas. Canebrakes are unlikely to have been a frequently shifting community. *Arundinaria gigantea* is like most bamboos in fruiting only extremely rarely and by persisting and spreading mainly vegetatively. Unlike the wind-dispersed herbs and trees that we presently see capturing abandoned clearings, cane could invade openings only by already being present or by spreading from well-established stands on the edge. While trees are likely to invade canebrakes if there is no fire, it is probably better to view canebrakes as an alternative stable state that, once established, would persist in an environment that included fire at moderate frequency.

Before Native American populations were decimated by disease, many in the Piedmont and Mountains practiced shifting agriculture in sites similar to where canebrakes are believed to have occurred. Thus, it is possible that canebrakes were created by abandoned fields. However, it seems unlikely that widespread invasion coincided with the decline in human population if it depended solely on a human-caused fire regime. At the same time, *Arundinaria* could capture old fields before trees did only if fire was fairly frequent but not too frequent. The near-annual burning often attributed to humans would not favor the species. Additionally, established canebrakes would not have been attractive places to clear again. Without plows, the *Arundinaria* rhizomes could not be eliminated as trees could by girdling, and cane would have quickly regrown after cutting, as it did after fires. Given the usefulness of cane, it seems more likely that people would have maintained areas as a source of material. But the vast size of canebrakes reported in other states seems far beyond what people could have used or chosen to maintain.

An alternative possible creator of canebrakes, mentioned in Platt and Brantley (1997), was the huge roosts of passenger pigeons (*Ectopistes migratorius*). The vast amount of droppings is reported to have killed trees but would have led to fertile soil conditions that could support rapid vegetative spread for species able to benefit from it. Cane could have exploited such a situation if it was already present, but given its limited ability to spread by seed, would be unlikely to invade areas where it was absent.

Comments: The most definitive historical references to extensive canebrakes are from states farther west, primarily those around the Mississippi River. Smaller canebrakes are reported in the Cumberland Plateau.

Canebrakes are floristically depauperate compared to most floodplain communities. However, they are believed to have supported a distinctive fauna. A relatively large number of insects are specialists on *Arundinaria*, though they also use the species where it is not dominant. The distinctive vegetation structure was attractive to various vertebrates. Grazing animals such as bison (*Bison bison*) and elk (*Cervus elaphus*) presumably would have sought out the nutritious forage, but the limited sight distance and vulnerability to predators in the dense cane may have deterred them.

Rare species:
Invertebrate animals – Several undescribed species in an undescribed genus related to *Apameine* are associated with *Arundinaria* and presumably could occur in canebrakes.

FLOODPLAIN POOL

Concept: Floodplain Pools are sloughs or depressions in floodplains that hold standing water much or all of the year. Vegetation is sparse or consists largely of aquatic plants except at the edges. Most examples are narrow enough to be shaded by trees rooted in adjacent forest communities and most have a central portion with little emergent vegetation. Species of *Carex* are almost always present but other plants are quite variable.

Distinguishing Features: Floodplain Pools are distinguished from adjacent floodplain forests by their long hydroperiod, which prevents trees and most shrubs from being rooted within the pool interior. They are distinguished from Piedmont/Mountain Semipermanent Impoundments by the cause of flooding and corresponding differences in flood dynamics, as well as generally by differences in size scale. Floodplain Pools are generally much smaller than Semipermanent Impoundments, lack remnants of many dead trees, and have a less well-developed aquatic flora. The vascular plant species present in Floodplain Pools vary widely among examples. Most examples are naturally small, but examples smaller than 0.1 acre are not well enough developed to be recognized.

Crosswalks: *Peltandra virginica – Saururus cernuus – Boehmeria cylindrica / Climacium americanum* Marsh (CEGL007696).
G125 Eastern North American Freshwater Marsh.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: Floodplain Pools occur primarily in large- to medium-sized floodplains in both the Piedmont and Mountains. They may be near the river, on terraces, or at the edge of the upland. Most are clearly abandoned channel segments. Overflow channels that become blocked by natural levee deposition are a common origin but older sloughs at the base of bluffs are also common.

Soils: Little is known about the soils of Floodplain Pools. Clay probably is deposited in the still water and may form a layer more impermeable than the surrounding alluvium.

Hydrology: Floodplain Pools are either permanently flooded or seasonally flooded for long parts of the growing season. Flooding by the river may be frequent or uncommon, depending on where they are located. When not flooded by the river, they are filled by rainfall and runoff from their immediate surroundings. A few may receive seepage. Lower examples in overflow channels may have substantial current during floods, which may scour the bed and deposit sand.

Vegetation: Floodplain Pool communities generally have sparse or no vegetation in the middle. Trees may overhang from the adjacent floodplain or upland community, but at least some are often rooted in the wetter conditions at the edge of the pool. *Fraxinus pennsylvanica* and *Acer rubrum* (perhaps often var. *trilobum*) are highly constant in site descriptions. *Quercus lyrata, Quercus phellos, Liquidambar styraciflua*, and *Carpinus caroliniana* are frequent. Somewhat less frequent species include *Platanus occidentalis, Ulmus americana, Betula nigra*, and *Salix nigra*. Shrubs are also often present, most frequently *Cephalanthus occidentalis*, but potentially including *Ilex decidua, Ilex verticillata, Alnus serrulata, Swida* (Cornu*s*) *amomum*, *Eubotrys racemosa,* *Viburnum nudum*, and other wetland species. Herbs are largely confined to the edge as well. *Saururus cernuus* and various *Carex* species (*crinita, debilis, stipata, alata, lupulina,* and others) are highly constant, and *Persicaria* spp. are frequent. *Peltandra virginica, Impatiens capensis, Osmunda spectabilis*, and other wetland species often occur. The moss *Climacium americanum* often is present. A large number of other herbs of wetlands and of the surrounding floodplain forests may be present on the edges. More aquatic species, such as *Lemna* sp. and *Eragrostis hypnoides*, have been noted only occasionally.

Range and Abundance: Ranked G3. Floodplain Pools are scattered at low density throughout the Piedmont and at lower density in the valleys of the Mountain Region. Many unknown ones may exist since they cannot generally be seen on aerial photos or topographic maps. The synonymized NVC association is wide ranging to the north, occurring as far as Connecticut and possibly westward to Ohio and Tennessee. This probably is not a true reflection of the range of North Carolina's community. Similar communities likely occur at least in South Carolina and Georgia, and communities well to the north probably are very different.

Associations and Patterns: Floodplain Pools are small patch communities, many less than one acre in size. They may occur in clusters that have larger aggregate acreage but are seldom more than a few acres together. However, a handful of apparent but little studied examples are much larger, with single pools 5-15 acres in size. These need further study, as it is unclear if they could be of artificial origin or if they might be semipermanent impoundments.

Variation: Floodplain Pools are highly variable, though patterns of variation likely to be biologically important are not all well understood. Duration of standing water, frequency of river flooding, occurrence of scouring, steepness of the basin, age, and biogeographic region, may all cause variation. Two distinct variants can be recognized based on the aquatic animal communities:

1. Regularly Flooded Variant is flooded often by overbank stream flow and seldom dries up. It supports fish as the dominant animal component much of the time. This variant may be an important refugium for juvenile fish – a place where they can mature in the absence of larger predatory fish while still being able to return to the river before the pool dries up.

2. Infrequently Flooded Variant occurs on higher terraces or areas that are not flooded in most years. They are filled by rainwater rather than river water most years. They generally are free of fish and are attractive for amphibians. These differences are not known to be reflected in macro-vegetation, but they are important ecologically. The Infrequently Flooded Variant may support the amphibian component of a large area of surrounding floodplain and upland forests.

Differences between Piedmont and Mountain examples should also be sought. A large number of species are known only from Piedmont examples, fewer only from Mountain examples. However, most of the regional specialist species have very low frequency in examples.

Dynamics: Short-term Floodplain Pool dynamics are driven by the hydroperiod of standing water, as well as by river flooding. Shallower pools which dry up most years must have drastic seasonal fluctuations in aquatic fauna and may have short-lived plants that appear during drawdown. Pools may also change in composition in response to climatic cycles, with plants establishing during droughts which may then persist during wetter periods. In examples in overflow channels, floods may be a significant natural disturbance, causing major turnover of aquatic organisms and potentially scouring and reshaping the substrate. In other pools, river flooding may be only a rare or minor event.

In long-term dynamics, a few Floodplain Pools near the river channel may be short-lived, potentially drained by channel movement or erosion, or buried by sediment deposition. But elsewhere, most pools probably remain in place for decades if not centuries. They are probably more stable and persistent than Piedmont/Mountain Semipermanent Impoundments, though it is not certain this was true in the past. In the longer term, like Oxbow Lakes, Floodplain Pools are geologically short-lived. Sediment deposition will eventually fill them.

Comments: Floodplain Pools are transitional between vegetated wetland communities and aquatic communities. They are likely more distinctive for their aquatic fauna (and probably microflora) than for their higher plant communities.
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Floodplain Pools are somewhat analogous to the Oxbow Lake communities of the Coastal Plain. However, the geomorphic processes that form them differ in important ways, the flooding dynamics are different, and the lack of *Taxodium*, *Nyssa biflora*, and other Coastal Plain species gives them a very different character.

The wide-ranging northern NVC association is a questionable fit for North Carolina's Floodplain Pools. It was synonymized because no better fitting association was found. The floodplain pool environment must occur wherever there are large floodplains with similar geomorphic processes. How the biota vary is not well known. There is no reason to think that North Carolina's pools have more northern biotic affinities than its other floodplain communities, nor that they are not more similar to those that probably occur in South Carolina, Georgia, and other states to the south.

Floodplain Pools are little studied, especially by plant ecologists. The small size and aquatic character of them in wet seasons lead to lack of representation in CVS data and other plot studies. Even in descriptive reports, they often are not mentioned or not described in detail. There is a particular need for further study of the handful of much larger pools in the central Piedmont. It is unclear why they should form only in this region and why they should be so rare if they are of natural origin. They may turn out to represent a distinct rare variant or subtype. Alternatively, though they were treated as natural pools by the biologists who reported them, they may turn out to be unrecognized Piedmont/Mountain Semipermanent Impoundments or to be unrecognized artificial impoundments or excavations. Another possibility is that they represent an enlarged version of smaller pools formed by blocking of sloughs by sediment deposition on the riverbank. Such heavy deposition could be of semi-natural origin, in parts of the Piedmont where hilly topography and extensive agricultural clearing combined to maximize sediment loads in the rivers.

Rare species:
Vascular plants – *Carex decomposita, Didiplis diandra, Lycopus angustifolius,* and *Triadenum tubulosum*.

Vertebrate animals – *Ambystoma talpoideum, Hemidactylium scutatum,* and *Hyla versicolor*.

PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT (OPEN WATER SUBTYPE)

Concept: Piedmont/Mountain Semipermanent Impoundments are portions of Piedmont and Mountain floodplains affected by impoundment by beaver dams, along with rare small man-made ponds that resemble them. They include drained beaver ponds that are still distinguishable from pre-impoundment conditions.

The Open Water Subtype consists of open water, submersed aquatic plants, or floating-leaved aquatic plants, with little emergent vegetation, occurring in deeper ponds or portions of ponds.

Distinguishing Features: Semipermanent Impoundment communities are distinguished by vegetation and hydrology affected by impoundment by beavers. Small manmade impoundments are included if they produce a similar environment and vegetation, a situation that commonly occurs in the Coastal Plain but that is rare in the Piedmont or Mountains. Both small man-made ponds and larger reservoirs in the Piedmont and Mountains tend to bear little resemblance to natural beaver ponds and should not be treated as natural communities.

The Open Water Subtype is distinguished by the absence of appreciable emergent vegetation, consisting instead of unvegetated water, submersed plants, or floating-leaved aquatic plants over a substantial area. They may contain herbs, shrubs, or small trees growing on the bases of dead trees or stumps, and these may sometimes be abundant. Only larger expanses of deep open water should be counted as occurrences; these generally are wide ponds or long segments of a large stream channel. Small water-filled channels in otherwise more vegetated impoundments should be treated as parts of the other subtypes.

Crosswalks: *Nuphar advena - Nymphaea odorata* Aquatic Vegetation (CEGL002386).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).

Sites: Piedmont/Mountain Semipermanent Impoundments occur on floodplains of streams or rivers. Beavers generally prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. Ponds are also common on large river floodplains, where beavers dam sloughs or tributary streams. Beavers strongly prefer low gradient streams, and many Piedmont and especially Mountain streams are probably too swift for them.

Soils: Piedmont/Mountain Semipermanent Impoundments can occur on any floodplain soil, though impoundment modifies the preexisting soil if the pond lasts very long. Besides saturation, depletion of oxygen, and chemical reduction, the still water of ponds traps sediment and may allow deposition of relatively pure clay or organic matter over sizeable areas. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam was breached, sediment stored elsewhere in floodplains might remain in place for centuries.

Hydrology: The Open Water Subtype is permanently or nearly permanently flooded, with moderate to deep water.

Vegetation: This community may consist largely of open water with no visible macrophytes, or it may consist of sparse to dense floating-leaf or free-floating plants. *Nymphaea odorata* and floating *Sparganium americanum* are the most frequent species, but *Lemna* spp., *Azolla caroliniana*, *Wolffia brasiliensis*, and *Spirodela punctata* may dominate. Occasional ponds may have *Nuphar advena*, *Brasenia schreberi*, or *Nelumbo lutea*. Exotic macrophytes may potentially invade. Emergent plants, surviving trees, and plants rooted on stumps or logs may be sparsely present.

A diverse community of animals may use the ponds, including frogs and toads, lizards, turtles, snakes, and birds that are not common in the surrounding forest (Metts et al. 2001).

Range and Abundance: Ranked G4G5. This subtype occurs throughout the Piedmont and Blue Ridge, and presumably occurs in neighboring states. The crosswalked NVC association is a poor fit, and its range is not a good reflection of the range of the Open Water Subtype as defined here.

Associations and Patterns: This community can be the only extensive community in a pond, but it is more often a central zone with the Shrub Subtype or one of the marsh subtypes at the upper end and sometimes around the edges. In ponds where the beaver dam is within the stream channel, the Open Water Subtype may be confined to a narrow band in the channel.

Variation: Examples vary in presence and species of macrophytes, but specific variants or patterns need further study. The Mountain examples appear more likely to have unvegetated open water, but such situations are common in the Piedmont, too.

Krues and Bason (2015) described a physical typology of beaver ponds that may be useful in describing their variation. The main pond forms are described as: inundating (filling the floodplain), channel (flooding the channel only), and discontinuous (flooding part of floodplain and channel but with unflooded ground on levees or rises). This may be helpful, though additional categories would perhaps be needed for sloughs and for backswamps in large floodplains. The typology of cluster configurations described by the same authors also appears useful: pioneer (single pond), disjunct serial (several ponds nearby), and stair step serial (ponds running together). All three are frequent.

Dynamics: Beaver pond dynamics are unique among North Carolina's natural communities, contrasting with the stable site-driven mosaic that makes up most of the natural community landscape. They are among the most dynamic of communities, appearing and potentially disappearing rapidly, and occupying sites that previously supported very different communities.

Pond dynamics are dependent on the behavior of individual beaver families and on the broader dynamics of beaver populations. Each beaver colony consists of one breeding pair, along with subadult offspring and young. A given colony may maintain several ponds and several lodges or bank burrows. They are territorial, with a family excluding other beavers, so colonies are non-overlapping. New beavers will not move into a site if adult beavers are present (Allen 1982). Snodgrass (1997), at Savanna River Site, found colonies to be separated by more than 100 meters.

Individual ponds form rapidly when beavers build a dam large and high enough to back up deep water. Most trees die quickly, though more water-tolerant trees may survive on the edges. Young examples of the Open Water Subtype have recently dead trees, which gradually fall and decompose, eventually leaving a largely open water pond. Stumps may persist for many years, providing microhabitats for non-aquatic plants as well as for animals.

Colonization by aquatic plants takes some time, though it is not clear how long. Presumably this depends on proximity of populations and the abundance of dispersal vectors such as waterfowl. Beavers themselves could contribute to dispersal from nearby ponds, too. More mature ponds presumably are more diverse, as aquatic species accumulate over time.

When a dam is abandoned, the deep pond usually drains quickly, and the Open Water Subtype succeeds to one of the other subtypes, eventually returning to a floodplain forest community if not impounded again. If the pond lasts for a long time, sediment deposition may fill it, leading to succession from the Open Water Subtype to other subtypes. While drained ponds in northern states may persist as wet meadows for 50 years or more (Wright et al. 2002), forest return is much more rapid in most of North Carolina.

Beavers may directly affect the vegetation in and around ponds, though this is particularly poorly known in the Open Water Subtype. Beavers are generalist herbivores but have strong food preferences (Allen 1982). Though they are most widely known for eating trees and shrubs, they prefer herbaceous vegetation if it is available, including most of the aquatic species named above. While it has been suggested that their preferences among woody plants may influence forest succession in adjacent areas, a similar effect of selective feeding on herbaceous plants has not been suggested. However, it is at least conceivable.

The natural population dynamics of beavers and beaver ponds remain poorly known. No record remains of beaver abundance and behavior in early European times in most of the country, and indeed, the trade in beaver skins appears to have led to extirpation or substantial reductions by both Native Americans and European trappers before European settlers arrived in most localities. The author is not aware of any historical sources that indicate how abundant beavers were at the time of settlement, nor how early settlers interacted with them. Populations almost everywhere throughout the huge range of North American beavers are presently recovering from the heavy exploitation and often complete extirpation of the past.

There is extensive literature on beaver behavior, but relatively little specific to the South. Population dynamics may well be different where ponds do not freeze over in winter, where herbaceous food is often available year-round, and where landscapes and potential predators are different. Beavers were extirpated from North Carolina long ago but were reintroduced locally in 1939. They have now returned throughout most of the state, but at different times and rates. In addition, trapping and management to reduce their effect on forests, agriculture, and human infrastructure are widespread, and few ponds can be assumed to be free of such influences. An important question is the extent to which populations were naturally controlled by predation, and how this affected the life span of colonies. While it is possible that predation of one of a breeding pair would lead to abandonment of the pond, it would seem more likely that resident helpers or dispersing beavers would quickly replace them and that there would be no interruption in occupation.

Beaver ponds are widely believed to create a shifting mosaic, functioning as a metapopulation, with creation of individual ponds followed by abandonment and succession, and new ponds created elsewhere as beaver move. In the North, this is often explained as driven by depletion of woody food along the pond's shore and by the attractiveness of successional growth of *Salix* in succeeding ponds. It is unclear how much this applied in North Carolina. Crucial parameters that remain unknown are what fraction of a natural landscape would be occupied by which stages of beaver ponds at any given time, and how much of the landscape would ever be affected by them. Walter and Merrits (2008), in Pennsylvania, excavated stream sediment profiles below the European era deposits. They found that all exhibited multiple stable channels, organic-rich sediment across the width of the floodplain, and macrofossils of aquatic and scrub-shrub plants. Though they suggested this was a result of groundwater discharge, it seems more suggestive of beaver ponds. They cited studies finding similar results in the Piedmont from South Carolina to Pennsylvania. However, not many streams have had such sampling. They also did not address the question of how much of the time a given place was in a beaver pond versus a floodplain forest. Because of their sediment trapping ability, beaver ponds could be the depositional environment of much of the floodplain sediment without their being present most of the time.

Snodgrass (1997) found up to 27% of stream length affected by impoundments in some small watersheds, but much less in larger watersheds. Forty-one years after reintroduction, without management during most of that time, they had affected only 9% of stream length and 0.5% of the land area. He also found 0.1 square meter/ha/year newly impounded. Brzyski (2005), in the Georgia Coastal Plain, found only 0.07 colonies/km of stream, a very low density. Kroes and Bason (2015), in the Virginia and North Carolina Coastal Plain, found about 1 pond/100 sq. km. In the Adirondacks, Wright et al. (2002) found 26.7% of stream length affected, and 3.32% of the landscape. In all these studies, it is unclear how fully beaver populations had recovered, nor how much ongoing trapping and other management was occurring. Some referred to human destruction of ponds.

While beaver pond dynamics are sometimes portrayed as random colonization events followed by abandonment when woody food resources are consumed, the scenario is no doubt more complicated, with preferred sites occupied much of the time, marginal sites abandoned more quickly and spending less time ponded, and some areas unsuitable and rarely or never ponded. Fryxell (2001), working in boreal forest, found beaver occupancy to be complex, with a small number of ponds being source populations and a larger number being sinks whose colonies did not reproduce at replacement levels. About 20% of the ponds persisted through the 11-year study, but many pond sites were abandoned and recolonized repeatedly within that period. Rather than a shifting mosaic, the landscape appeared to consist of sites that were repeatedly reoccupied long before succession was completed. Abandonment appeared to have less to do with depletion of food than with marginal habitat that did not support consistent reproduction. The stable colonies had ponds with abundant aquatic plants, which might mean better food supply; however, it is unclear if those ponds are stable because they have more aquatic plants or if they have more aquatic plants because they are more stably maintained by beavers.

Comments: The NVC crosswalk for this community is so problematic that it may be better to have no crosswalk. It is defined as any vegetation with the nominal species, natural and artificial, in every state east of the Great Plains. There appears to be no further ecological meaning to it. A second association also appears to overlap this community, though rarely: *Nelumbo lutea* Aquatic Vegetation (CEGL004323). It too is defined without ecological meaning and attributed to a range from Ontario to Texas.

Rare species:
Vascular plants – *Carex decomposita, Didiplis diandra, Heteranthera pauciflora* (*multiflora*), *Hottonia inflata,* and *Lycopus angustifolius*.

PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT (MONTANE MARSH SUBTYPE)

Concept: Piedmont/Mountain Semipermanent Impoundments are portions of Piedmont and Mountain floodplains affected by impoundment by beaver dams, along with rare small man-made ponds that resemble them. This includes drained beaver ponds that are still distinguishable from pre-impoundment conditions. The Montane Marsh Subtype covers portions of Mountain examples with emergent or nonaquatic herbaceous vegetation predominating.

Distinguishing Features: Semipermanent Impoundment communities are distinguished by vegetation and hydrology affected by impoundment by beavers. Small manmade impoundments are included if they produce a similar environment and vegetation, a situation that commonly occurs in the Coastal Plain but that is rare in the Piedmont or Mountains. Both small man-made ponds and larger reservoirs in the Piedmont and Mountains tend to bear little resemblance to natural beaver ponds and should not be treated as natural communities.

As presently defined, the Montane Marsh subtype includes all examples with emergent or marshy vegetation in the Mountain Region. Open water examples in both the Mountain and Piedmont regions, with floating aquatic plants or without emergent plants, are classified as the Open Water Subtype. Shrub-dominated edge zones and successional ponds are classified as the Shrub Subtype. The Montane Marsh Subtype is characterized by substantially different vegetation and flora than the Piedmont Marsh Subtype, with more forbs and *Carex* species, sometimes flora shared with bogs, and without the many species of Coastal Plain affinities that can be present in the Piedmont. Species in the Montane Marsh Subtype but scarce or absent in the Piedmont Marsh Subtype include *Carex atlantica*, *Carex debilis*, *Carex folliculata*, *Cicuta maculata*, *Scirpus expansus*, *Chelone obliqua*, *Dichanthelium clandestinum*, *Eupatorium fistulosum*, *Eupatorium perfoliatum*, *Glyceria melicaria*, *Houstonia serpyllifolia*, *Hydrocotyle americana*, *Juncus gymnocarpus*, *Osmundastrum cinnamomeum*, *Oxypolis rigidior*, *Rubus alleghaniensis*, *Symphyotrichum puniceum*, *Thelypteris palustris*, and *Viola cucullata*.

Examples in the upper Piedmont are not well known but should be classified here if their vegetation better matches this subtype than any of the Piedmont subtypes.

Crosswalks: *Juncus effusus - Chelone glabra - Scirpus* spp. Southern Blue Ridge Beaver Pond Marsh (CEGL008433).
G599 Central Interior Wet Meadow, Marsh & Shrub Swamp Group.
Ecological Systems: South-Central Interior Small Stream and Riparian (CES202.706); South-Central Interior Large Floodplain (CES202.705).

Sites: Piedmont/Mountain Semipermanent Impoundments occur on floodplains of streams or rivers. Beavers generally prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. Ponds are also common on large river floodplains, where beavers dam sloughs or tributary streams. Beavers strongly prefer low gradient streams, and many Mountain streams are clearly too swift for them.

Within beaver ponds, the Montane Marsh Subtype typically occurs as a zone at the upper end and edges, or it may fill the bed of a drained pond. Beavers sometimes build small dams within entrenched channels, where open water is confined to the channel itself, and in these cases, marsh created by the elevated water table may occupy a broad part of the floodplain without extensive open water.

Soils: Piedmont/Mountain Semipermanent Impoundments can occur on any floodplain soil, though impoundment modifies the preexisting soil if the pond lasts very long. Besides saturation, depletion of oxygen, and chemical reduction, the still water of ponds traps sediment; this may allow deposition of relatively pure clay over sizeable areas, though this probably is less likely than in the Piedmont or Coastal Plain. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam is breached, sediment stored in other parts of floodplains might remain in place for centuries.

Hydrology: The Montane Marsh Subtype may be permanently or seasonally flooded with shallow water or may be unflooded but permanently saturated. Portions may also be affected by groundwater discharge.

Vegetation: Montane Marsh Subtype vegetation is dominated by herbaceous plants. Woody plants may be present with sparse to moderate cover, either as surviving trees, shrubs, and small trees established on edges and on stumps, or young trees and shrubs beginning to invade drained ponds. The herbaceous vegetation tends to be extremely variable among sites and is usually very patchy and heterogeneous within sites. The community as a whole may be quite rich in species in mature sites. Species strongly dominating in patches are less frequently noted than in the Piedmont Marsh Subtype.

Plant species that are often abundant include *Juncus effusus*, *Scirpus cyperinus*, *Scirpus expansus*, *Carex lurida*, *Carex atlantica*, *Carex debilis*, *Carex folliculata*, *Leersia oryzoides*, *Impatiens capensis*, *Dulichium arundinaceum*, *Mimulus ringens*, *Chelone obliqua,* and *Typha latifolia*. *Sparganium americanum* often dominates in drowned channels that have deeper water than most of the marsh but may rarely dominate larger expanses. Other species that are fairly frequent include *Boehmeria cylindrica*, *Dichanthelium clandestinum*, *Persicaria sagittata*, *Persicaria arifolia*, *Arisaema triphyllum* (including ssp. *stewardsonii*), *Athyrium asplenioides*, *Bidens tripartita*, *Cinna arundinacea*, *Epilobium coloratum*, *Eupatorium fistulosum*, *Eupatorium perfoliatum*, *Galium tinctorium*, *Glyceria melicaria*, *Houstonia serpyllifolia*, *Hydrocotyle americana*, *Juncus gymnocarpus*, *Ludwigia palustris*, *Lycopus virginicus*, *Osmundastrum cinnamomeum*, *Oxypolis rigidior, Sagittaria latifolia*, *Sambucus canadensis*, *Scutellaria lateriflora*, *Symphyotrichum puniceum*, *Thelypteris palustris*, and *Viola cucullata*. Woody species, which may be present in small numbers or as young individuals, include *Alnus serrulata*, *Cornus amomum*, *Rubus alleghaniensis*, *Rosa palustris*, and *Spiraea tomentosa*.

Range and Abundance: Ranked G4?. The Montane Marsh Subtype may occur throughout the Mountains. It may potentially occur in the foothills region, though no examples have been recorded from there. It is unclear where the transition from Piedmont Marsh to Montane Marsh might occur. This subtype potentially occurs in Virginia, Tennessee, and Georgia, possibly also South Carolina.

Associations and Patterns: This subtype may be either a zone within a complex of other subtypes or may be the only subtype present in drained ponds. In ponds where the dam is confined within the stream channel, a Montane Marsh Subtype community with a high water table but no standing water may dominate much of the floodplain. This subtype likely borders some other floodplain community, or an upland, on at least one side. Impoundments may be formed in Southern Appalachian Bog or French Broad Valley Bog communities, where they may drown and replace part or all of the bog, but they may coexist beside it for a time. The bog community will often reestablish itself when the pond drains.

Variation: This subtype is extremely variable among sites and often extremely heterogeneous within sites. While this variation is not well sorted out, two variants are provisionally proposed:

1. Typic Variant consists of typical early successional and generalist wetlands species.

2. Boggy Variant contains *Sphagnum* and other species shared with mountain bogs, such as *Carex folliculata*, *Carex atlantica*, and *Osmundastrum cinnamomeum*. This seems to be associated with acidic seepage. It could also apply to former bogs which were drowned by a beaver pond but retain some of their bog flora.

There may be merit in distinguishing zonal and successional variants, as is done for the Piedmont Marsh Subtype and Shrub Subtype, but there is less information on these variations in the Mountains.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

The Montane Marsh Subtype, as defined, has variable dynamics, with some being fairly stable zones and others being short-lived natural successional communities. Marsh vegetation may develop quickly when a pond is created or when a pond is drained and exposes a formerly flooded area. It will continue to develop and change over time, as additional species colonize and as the environment evolves. Marsh vegetation may also develop gradually from the Open Water Subtype, as sediment fills an older pond. Conversely, the marsh may be slowly or quickly colonized by shrubs or tree saplings and develop into the Shrub Subtype. Very little is known about the duration of these successional stages within the life of a pond.

A great question remains about the relationship between beaver ponds and mountain bog communities. They occupy similar settings in floodplains or stream bottoms, and a number of known bogs have been impounded by beavers in recent years. Impoundment replaces the bog vegetation with one of the subtypes of Piedmont/Mountain Semipermanent Impoundment, but the bog vegetation often persists on the edge of the pond and reoccupies the site if the pond drains.

The widespread tendency for Southern Appalachian Bog and French Broad Valley Bogs to be invaded by woody vegetation, potentially eliminating the distinctive bog community, has led to a frequent interpretation of bogs as early successional communities. See the extensive discussion of bog dynamics in the Mountain Bogs and Fens theme description. If disturbance is important in maintaining bogs, the most likely source of sufficient natural disturbance to create such early successional conditions is drained beaver ponds. It is therefore often believed that mountain bogs are created by beaver ponds and may be merely another successional stage of them. Though evidence is hard to come by, this hypothesis in its general form does not seem well supported by observations. The Montane Marsh Subtype shares a number of species with bog communities, but these tend to be the more generalist wetland species. Beaver ponds have a large suite of colonizing (ruderal or early successional) species not found in higher quality bogs, though some are found in bogs disturbed by grazing or removal of large amounts of vegetation. Conversely, higher quality bogs have a suite of species that are conservative, indicate low nutrient conditions, and do not readily disperse. Though there has been little study, it is possible that *Glyptemys muhlenbergii*, though known as bog turtles, would find habitat in the Montane Marsh Subtype.

While bogs can succeed impoundments if they were present before and if their flora persists on the edge, this is not the typical pattern. Most drained impoundments go from Montane Marsh Subtype to Shrub Subtype to forest without becoming a bog. There is no documented case of a place that was not a bog before impoundment becoming one after a pond has drained. In addition, mountain bogs are widely regarded to be more properly considered poor fens, with hydrology driven by ground water input. This is incompatible with the idea of them being a typical successional stage of drained beaver ponds. However, there is a subset of the Montane Marsh Subtype that has more bog-like vegetation, perhaps associated with ground water input, and it would be worth following more closely the future development of such areas.

Comments: As defined, this is an extremely variable and heterogeneous community. The NVC association synonymized above was created to represent beaver pond marshes of the Southern Blue Ridge. Other associations, such as *Juncus effusus* Marsh (CEGL004112); *Scirpus cyperinus* Southern Ruderal Marsh (CEGL003866); and *Typha (angustifolia, latifolia) - (Schoenoplectus* spp.) Eastern Marsh (CEGL006153), have been attributed to North Carolina and could conceivably be interpreted as applying to a few examples or patches of the Montane Marsh Subtype, but they should not be used. *Sparganium americanum - (Sparganium erectum ssp. stoloniferum) - Epilobium leptophyllum* Seep (CEGL004510) is another association attributed to North Carolina. It represents diverse marshy vegetation dominated by *Sparganium* spp. in states to the north. Examples of our Montane Marsh and Piedmont Marsh Subtypes often have small patches of nearly pure *Sparganium americanum* associated with rivulets, but none large enough to merit recognition as a distinct subtype.

The treatment of this community as a ruderal marsh in the NVC is problematic. It is a natural community that should be a conservation priority.

Rare species:
Vascular plants – *Stellaria alsine* and *Thalictrum macrostylum*.

Vertebrate animals – *Glyptemys muhlenbergii, Pseudacris collinsorum*, and *Vermivora chrysoptera.*

PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT (PIEDMONT MARSH SUBTYPE)

Concept: Piedmont/Mountain Semipermanent Impoundments are portions of Piedmont and Mountain floodplains affected by impoundment by beaver dams, along with rare small man-made ponds that resemble them. This includes drained beaver ponds that are still distinguishable from pre-impoundment conditions. The Piedmont Marsh Subtype covers portions of Piedmont examples with emergent or nonaquatic herbaceous vegetation predominating.

Distinguishing Features: Semipermanent Impoundment communities are distinguished by vegetation and hydrology affected by impoundment by beavers. Small manmade impoundments are included if they produce a similar environment and vegetation, a situation that commonly occurs in the Coastal Plain but that is rare in the Piedmont or Mountains. Both small man-made ponds and larger reservoirs in the Piedmont and Mountains tend to bear little resemblance to natural beaver ponds and should not be treated as natural communities.

The Piedmont Marsh Subtype is distinguished by dominance by emergent or dense nonwoody vegetation with vegetation and flora characteristic of the Piedmont region, sometimes with species more typical of the Coastal Plain. The Piedmont Marsh Subtype tends to be dominated by large graminoids, with zones of coarse forbs, and has less of the smaller forbs and boggy species of the Montane Marsh Subtype. Species with high constancy or dominant in Piedmont Marsh and scarce or absent in Montane Marsh include *Carex comosa*, *Carex stipata*, *Persicaria hydropiperoides*, *P. punctata*, other *Persicaria* species other than the tearthumbs, *Echinodorus cordifolius*, *Erianthus giganteus*, *Alisma subcordata*, *Saururus cernuus*, *Pontederia cordata*, *Scirpus polyphyllus*, *Hydrocotyle ranunculoides*, *Hypericum mutilum*, *Onoclea sensibilis*, *Woodwardia areolata*, and *Pluchea camphorata*.

Marshy beaver ponds in the upper Piedmont and foothills should be classified as the subtype their vegetation best resembles (Montane or Piedmont).

Crosswalks: *Polygonum (hydropiperoides, punctatum) - Leersia* spp. Shoreline Wet Meadow (CEGL004290).
G756 Eastern North American Wet Shoreline Vegetation Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).

Sites: Piedmont/Mountain Semipermanent Impoundments occur on floodplains of streams or rivers. Beavers generally prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. Ponds are also common on large river floodplains, where beavers dam sloughs or tributary streams. Beavers strongly prefer low gradient streams, and many Piedmont streams are probably too swift for them.

Within beaver ponds, the Piedmont Marsh Subtype typically occurs as a zone at the upper end or on the edges, or it fills the bed of a drained pond. Beavers sometimes build small dams within entrenched channels, where open water is confined to the channel itself, and in these cases, marsh created by the raised water table may occupy a broad part of the floodplain.

Soils: Piedmont/Mountain Semipermanent Impoundments can occur on any floodplain soil, though impoundment modifies the preexisting soil if the pond lasts very long. Besides saturation, depletion of oxygen, and chemical reduction, the still water of ponds traps sediment, and may allow deposition of relatively pure clay or organic matter over sizeable areas. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam was breached, sediment stored elsewhere in floodplains might remain in place for centuries.

Hydrology: The Piedmont Marsh Subtype may be permanently or seasonally flooded with shallow water or may be unflooded but permanently saturated.

Vegetation: Piedmont Marsh Subtype vegetation is dominated by herbaceous plants. Woody plants may be present with sparse to moderate cover, either as surviving trees, shrubs, and small trees established on edges and on stumps, or young trees and shrubs beginning to invade drained ponds. The herbaceous vegetation tends to be extremely variable among sites and is usually very patchy and heterogeneous within sites. Descriptions often note several plant species that dominate patches, and though these sometimes may be large areas of near-monoculture, more often the patches are only a few square meters or the dominance is weak. Sizeable areas may have diverse herbaceous vegetation with no obvious dominant. The community as a whole may be quite rich in species in mature sites.

Plant species that frequently dominate patches include *Typha latifolia*, *Juncus effusus*, *Peltandra virginica*, *Scirpus cyperinus*, *Sparganium americanum*, *Impatiens capensis*, *Leersia oryzoides*, and increasingly, *Murdannia keisak* and *Microstegium vimineum*. *Sparganium americanum* often dominates in drowned channels that have deeper water than most of the marsh but may occasionally dominate larger expanses. *Carex* spp. and *Persicaria* spp. also often reported as dominant at a generic level. These include *Carex crinita, comosa*, *stipata*, and other species, and *Persicaria arifolia*, *densiflora*, *hydropiperoides*, *punctata*, and other species. A wide variety of other species have rarely, often only once, been reported as dominating patches: *Decodon verticillatus*, *Echinodorus cordifolius*, *Erianthus giganteus*, *Glyceria septentrionalis*, *Gratiola viscidula*, *Pontederia cordata*, *Sagittaria latifolia*, *Scirpus polyphyllus*, and even *Zizaniopsis miliacea*. Additional herbaceous species with fairly high frequency include *Saururus cernuus*, *Carex lupulina*, *Boehmeria cylindrica*, *Dulichium arundinaceum*, *Ludwigia leptocarpa*, *Ludwigia palustris*, *Lycopus virginicus*, *Penthorum sedoides*, *Sagittaria latifolia*, and *Alisma cordata*. Many more species are fairly frequent, including *Bidens discoidea*, *Bidens laevis*, *Glyceria striata*, *Hydrocotyle ranunculoides*, *Hypericum mutilum*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Pilea pumila*, *Pluchea camphorata*, and *Woodwardia areolata*. The most typical woody species, on edges and on stumps, are *Alnus serrulata*, *Cephalanthus occidentalis*, *Salix nigra*, *Swida* (*Cornus*) *amomum*, *Rosa palustris*, and *Hibiscus moscheutos*. *Fraxinus pennsylvanica* and *Acer rubrum* are the most likely tree species to have survived impoundment and are quick to begin establishing in drained ponds. *Betula nigra*, *Platanus occidentalis*, and *Liquidambar styraciflua* also may occur in drained ponds. Drained pond beds may also have a number of more ruderal species and may become dominated by *Cyperus* spp., *Murdannia keisak,* and *Microstegium vimineum*.

A diverse community of animals may use the ponds, including frogs and toads, lizards, turtles, snakes, and birds that are not common in the surrounding forest (Metts et al. 2001).

Range and Abundance: Ranked G4?. This subtype may occur throughout the Piedmont. No examples have been described in the foothills region, and it is unclear where the transition from Piedmont Marsh to Montane Marsh might occur. This subtype presumably occurs in South Carolina, and potentially in Virginia, Georgia, and more distant states. Because the crosswalked NVC association is a poor fit, its range is not a good indication of the range of this subtype as conceived in North Carolina.

Associations and Patterns: This subtype may occur as single or multiple zones within a complex of other subtypes or may be the only subtype present in recently drained ponds. In ponds where the dam is confined within the stream channel, a Piedmont Marsh Subtype community with a high water table but no standing water may dominate much of the floodplain. This subtype likely borders some other floodplain community, or an upland, on at least one side.

Variation: This subtype is extremely variable among sites and often extremely heterogeneous within sites. Although patches strongly dominated by a single species are common, large areas are not strongly dominated. Rather than name variants by fine-scale patches/zones, it seems to more reasonable to seek patterns in total flora or ecology. While more vegetational patterns may eventually be recognized, including perhaps examples that have flora with more or less Coastal Plain affinity, for now two variants based on dynamics are recognized:

1. Marsh Zone Variant forms part of a complex in active ponds and is expected to last as long as the pond, or to succeed only slowly to other communities.

2. Successional Marsh Variant occupies the former bed of a drained pond and is expected to quickly succeed to other communities. It typically has a more ruderal flora that can include less water-tolerant species.

Krues and Bason (2015) described a physical typology of beaver ponds that may be useful in describing their variation. The main pond forms are described as: inundating (filling the floodplain), channel (flooding the channel only), and discontinuous (flooding part of floodplain and channel but with high ground on levees or rises). This may be helpful, though additional categories would perhaps be needed for sloughs and for backswamps in large floodplains. The typology of cluster configurations described by the same authors also appears useful: pioneer (single pond), disjunct serial (several ponds nearby), and stair step serial (ponds running together). All three are frequent.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

The Piedmont Marsh Subtype, as defined, has variable dynamics, with some examples being fairly stable zones and others being short-lived natural successional communities. Marsh vegetation may develop quickly when a pond is created or when a pond is drained and exposes formerly flooded area. It will continue to develop and change over time, as additional species colonize and as the environment evolves. Marsh vegetation may also develop gradually from the Open Water Subtype, as sediment fills an older pond. Conversely, the marsh may be slowly or quickly colonized by shrubs or tree saplings and develop into the Shrub Subtype. Very little is known about the duration of these successional stages within the life of a pond.

Comments: As defined, this is an extremely variable and heterogeneous community. The NVC synonymized to it does not fit much of our vegetation well and has a very broad geographic range, but it is defined as a beaver pond community. Other associations, such as *Juncus effusus* Marsh (CEGL004112); *Scirpus cyperinus* Southern Ruderal Marsh (CEGL003866); and *Typha (angustifolia, latifolia) - (Schoenoplectus* spp.) Eastern Marsh (CEGL006153), have been attributed to North Carolina and could conceivably be interpreted as applying to a few examples or patches of the Piedmont Marsh Subtype, but they should not be used. If we were to attempt to name the vegetation patches within this community as separate associations based on their dominants, vastly more associations would be needed. In fact, most of our marshes have more mixed vegetation at the typical scale of measurement. However, they vary substantially from one part to another, as well as from one marsh to another, and the variation is not well characterized. It seems best to treat our Semipermanent Impoundments with a small set of subtypes based on structure and the regional floristic differences. *Sparganium americanum - (Sparganium erectum ssp. stoloniferum) - Epilobium leptophyllum* Seep (CEGL004510) is another association attributed to North Carolina. It represents diverse marshy vegetation dominated by *Sparganium* spp. in states to the north. Examples of our Montane Marsh and Piedmont Marsh Subtypes often have small patches of nearly pure *Sparganium americanum* associated with rivulets, but none large enough to merit recognition as a distinct subtype.

Rare species: No rare species are known to be specifically associated with this community.

PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT (SHRUB SUBTYPE)

Concept: Piedmont/Mountain Semipermanent Impoundments are portions of Piedmont and Mountain floodplains affected by impoundment by beaver dams, along with rare small man-made ponds that resemble them. They include drained beaver ponds that are still distinguishable from pre-impoundment conditions. The Shrub Subtype encompasses all Piedmont and Mountain examples with substantial shrub and young tree vegetation, including shallow water zones of mature ponds and natural successional vegetation of abandoned ponds.

Distinguishing Features: Semipermanent Impoundment communities are distinguished by vegetation and hydrology affected by impoundment by beavers. Small manmade impoundments are included if they produce a similar environment and vegetation, a situation that commonly occurs in the Coastal Plain but that is rare in the Piedmont or Mountains. Both small man-made ponds and larger reservoirs in the Piedmont and Mountains tend to bear little resemblance to natural beaver ponds and should not be treated as natural communities.

The Shrub Subtype is distinguished by the dominance of shrubs or small trees, most often *Alnus serrulata, Salix* spp., or *Acer rubrum*, but potentially *Viburnum, Cephalanthus, Fraxinus*, or other species. It is distinguished from floodplain communities that would otherwise occupy the site by having different vegetation, usually more uniform and wetter, with a more depauperate herb layer or with an herb layer composed of shade-intolerant species remaining from the pond rather than typical floodplain forest species.

Crosswalks: *Alnus serrulata* Southeastern Shrub Swamp (CEGL008474).
G599 Central Interior Wet Meadow & Shrub Swamp.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
Southern Piedmont Small Floodplain and Riparian Forest Ecological System (CES202.323).
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: Piedmont/Mountain Semipermanent Impoundments occur on floodplains of streams or rivers. Beavers generally prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. Ponds are also common on large river floodplains, where beavers dam sloughs or tributary streams. Beavers strongly prefer low gradient streams, and many Piedmont and especially Mountain streams are probably too swift for them. Within beaver ponds, the Shrub Subtype typically occurs as a zone on the edges, at the upper end, or fills the bed of drained ponds.

Soils: Piedmont/Mountain Semipermanent Impoundments can occur on any floodplain or valley bottom soil, though impoundment modifies the preexisting soil if the pond lasts very long. Besides saturation, depletion of oxygen, and chemical reduction, the still water of ponds traps sediment; this may allow deposition of relatively pure clay or organic matter over sizeable areas. In at least one example in South Carolina, the author has observed a floating mat with the shrubs rooted in it, and this may develop in older ponds in North Carolina too. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam is breached, sediment stored in other parts of floodplains might remain in place for centuries.

Hydrology: The Shrub Subtype may be permanently or seasonally flooded with shallow water, but more often is unflooded but saturated.

Vegetation: Vegetation of the Shrub Subtype is dominated by woody species, which may range from dense to fairly open. Most frequently dominant are *Alnus serrulata* and *Salix nigra; Cephalanthus occidentalis* is also often dominant. Water tolerant species of trees, such as *Acer rubrum* and *Fraxinus pennsylvanica*, may or may not be abundant. Herbaceous plants may be present, beneath the shrubs or on stumps and tree bases. Any of the species listed for the Piedmont Marsh Subtype or Montane Marsh Subtype may occur.

Range and Abundance: Ranked G4. The Shrub Subtype may occur throughout the Piedmont and Mountains. It likely occurs in all adjacent states and probably ranges farther. The characteristic species are wide-ranging, so this community could potentially be recognized over a very large range. However, the associated herbaceous species, though not well known, would potentially distinguish more narrowly defined floristic types.

Associations and Patterns: This subtype may occur as single or multiple zones within a complex of other subtypes or may be the only subtype present in recently drained ponds. This subtype likely borders some other floodplain community, or an upland, on at least one side.

Variation: Though not well described, two axes of variation can readily be defined in this subtype. Some examples are successional, occurring in drained ponds, containing invading trees and expected to have a short lifespan, while others are long-term zonal communities dominated by open wetland shrubs and expected to last as long as the pond lasts. The differences between Piedmont and Mountain biogeography, enough to define separate subtypes for the marsh communities, are less well marked but presumably can be recognized as variants. Thus, we can define four variants that should prove useful, though their floristic differences are not well known:
1. Montane Shrub Zone Variant.
2. Montane Successional Variant.
3. Piedmont Shrub Zone Variant.
4. Piedmont Successional Variant.

Dynamics: See the more extensive discussion of general beaver pond dynamics under the Open Water Subtype.

The Shrub Subtype, as defined, has variable dynamics, with some being fairly stable zones and others being short-lived natural successional communities. The Shrub Subtype generally develops from one of the marsh subtypes. This may occur simply because it takes longer for the woody plants to establish and grow to dominance when a pond forms or is drained. It may also occur slowly, as sediment gradually fills in parts of a long-lasting pond and creates shallower water. Within the Shrub Subtype, shrubs may quickly give way to young trees in drained ponds.

Comments: This subtype as defined covers both Piedmont and Mountain examples. The lower diversity among the woody species (and poorly known herbaceous component) suggests less variation than among the marshes.

The NVC association synonymized with this subtype is problematic, in that it is very broadly defined and covers both natural and artificial vegetation, and includes sites very different from beaver ponds.

Rare species:
Vascular plants – *Ilex collina*.

ROCKY BAR AND SHORE (ALDER-YELLOWROOT SUBTYPE)

Concept: Rocky Bar and Shore communities represent shrub, herbaceous, or sparse mixed vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Alder-Yellowroot Subtype covers shrubby examples of medium size Mountain and upper Piedmont rivers. They may be on bedrock, boulders, or cobble bars. Vegetation and floristic composition often varies widely among sites.

Distinguishing Features: The Rocky Bar and Shore type is distinguished from streamside forest communities such as Montane Alluvial Forest and Piedmont Alluvial Forest by the lack of a well-developed tree canopy, though some trees may be present. It is distinguished from Spray Cliffs by the absence of regular spray from falling water and the corresponding general lack of bryophytes. It is distinguished from other nonforested wetland communities by occurring along streams or rivers, in areas subject to flooding and scouring. The boundary between bedrock Rocky Bar and Shore communities and upland Montane Cliff communities is potentially difficult in steep gorges. The boundary should be placed where flood scouring appears to cease being a significant (though still infrequent) influence.

The Alder-Yellowroot Subtype is distinguished from most subtypes by having a substantial (though still often sparse) shrub presence, with *Alnus serrulata* or *Xanthorhiza simplicissima* generally most abundant. The other subtype with substantial woody plant presence, the Mixed Bar Subtype, has a more mixed composition and structure that may include more trees as well as additional shrub species or, conversely, at times may lack either trees or shrubs.

Crosswalks: *Alnus serrulata - Xanthorhiza simplicissima* Wet Shrubland (CEGL003895).
G978 Eastern North American Riverine Sand-Gravel Bar Group.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The Alder-Yellowroot Subtype occurs on rocky or sandy bars or on scoured bedrock with crevices. This community often is on smaller rivers or large creeks but can occur on large rivers.

Soils: No well-developed soil is present. The substrate is recently deposited alluvial material or accumulations of material in crevices and pockets in bedrock.

Hydrology: The Alder-Yellowroot Subtype is frequently flooded and is generally a relatively short distance above normal water levels.

Vegetation: The Alder-Yellowroot Subtype consists of a heterogeneous mix of vegetation that has a substantial shrub component and limited tree or herb cover. Both *Alnus serrulata* and *Xanthorhiza simplicissima* are highly constant and usually have some of the highest cover. Other shrubs that are frequent and sometimes have high cover in CVS and Brown (2011) plots, and often are mentioned in site descriptions and local studies such as Newell (1997), Cooper and Hardin (1970), Dumond (1969), include *Rhododendron maximum, Leucothoe fontanesiana, Swida* (*Cornus*) *amomum, Hamamelis virginiana, Rhododendron arborescens*, *Rhododendron minus*, and *Viburnum cassinoides*. *Arundinaria gigantea* may also occur. Most of the tree species typical of Montane Alluvial Forest may be present in small numbers. *Acer rubrum, Tsuga canadensis, Nyssa sylvatica, Pinus strobus*, *Platanus occidentalis, Carpinus caroliniana, Liriodendron tulipifera*, *Betula lenta*, and *Liquidambar styraciflua* are present at moderate frequency, though some may represent overhanging cover from adjacent forests. Only a few herbs occur with moderate frequency and significant cover: *Dichanthelium clandestinum, Boykinia aconitifolia, Solidago rugosa, Apios americana*, and the exotic *Microstegium vimineum*. A large number of additional herbs occur with moderate frequency but lower cover in plot data, including *Lycopus virginicus, Rudbeckia laciniata, Eurybia divaricata, Houstonia serpyllifolia, Impatiens capensis, Athyrium asplenioides, Bidens* sp., *Polystichum acrostichoides, Viola sororia, Carex torta, Dichanthelium dichotomum* var. *ramulosum, Hypericum mutilum, Amphicarpaea bracteata, Oxalis stricta, Rubus flagellaris, Eutrochium fistulosum, Eutrochium purpureum, Juncus tenuis, Amauropelta* (*Parathelypteris*) *noveboracensis, Persicaria longiseta, Rumex crispus, Trautvetteria caroliniensis*, and *Viola primulifolia*. Several exotic species are also fairly frequent, including *Holcus lanatus,* and *Reynoutria japonica (Polygonum cuspidatum*), but some examples have little or no exotic plant presence.

Range and Abundance: Ranked G3G4. This subtype is scattered in the Mountains, with a few examples in the Piedmont. It probably is overlooked in reports and may occur in areas without other intact natural communities, so it may be more common than records suggest. The equivalent NVC association ranges from Virginia to Alabama and westward to Kentucky and Tennessee.

Associations and Patterns: The Alder-Yellowroot Subtype is a small patch community, with most patches just a few meters wide. It may potentially be associated with other subtypes, especially the Twisted Sedge Subtype. It typically occurs adjacent to Montane Alluvial Forest (Small River Subtype) or to Rich Cove Forest or Acidic Cove Forest but may occur with Montane Alluvial Forest (Large River Subtype).

Variation: This subtype is highly variable, but variation has not been clarified. Variation occurs with some examples conceptually transitional to other subtypes, especially the Mixed Bar Subtype and Twisted Sedge Subtype. Some of the apparent variation among site descriptions may come from incorrect classification.

Dynamics: As with other Rocky Bar and Shore subtypes, the Alder-Yellowroot Subtype is frequently flooded and subject to strong currents which can disturb the vegetation. However, it is dominated by long-lived shrubs, suggesting truly catastrophic disturbance is not common.

Comments: The conceptual distinction between the Alder-Yellowroot Subtype and Mixed Bar Subtype needs further clarification.

Rare species:
Vascular plants – *Glyceria laxa, Palustricodon* (*Campanula*) *aparinoides* var. *aparinoides,* and *Spiraea virginiana*.

ROCKY BAR AND SHORE (TWISTED SEDGE SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Twisted Sedge Subtype encompasses examples dominated by *Carex torta* or similar shade-intolerant, tough-rooted grass-like herbs. They generally occur on low cobble or gravel bars that are submerged by flowing water much of the time. They are often associated with the Alder-Yellowwood Subtype. All North Carolina examples are in the Mountains or upper Piedmont.

Distinguishing Features: The Twisted Sedge Subtype is distinguished from other subtypes by the dominance of *Carex torta* or other similar perennial graminoid herbs.

Crosswalks: *Carex torta* Riverbed Vegetation (CEGL004103).
G977 Eastern North American Riverbed Group.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The Twisted Sedge Subtype usually occurs in shallow flowing water along large creeks or small rivers with substantial current. Most are probably 3rd to 5th order streams. The substrate generally is gravel or cobbles, but it may occur on bedrock with fractures.

Soils: No developed soil is present. Some sand is trapped beneath the gravel.

Hydrology: The Twisted Sedge Subtype occurs around the typical water level, often in shallow flowing water much of the year.

Vegetation: The vegetation is strongly dominated by *Carex torta*, which may be sparse or fairly dense. Often no other vascular plants are present, but a few individuals of *Boykinia aconitifolia, Trautvetteria caroliniensis, Lobelia cardinalis, Xanthorhiza simplicissima*, or other species of other subtypes may be present.

Range and Abundance: Ranked G3G4. In North Carolina, this community is scattered through the Mountain Region. Examples have not been documented in the foothills, but they could occur there. The equivalent NVC association is widespread in the southern and central Appalachian region, ranging from Georgia to Pennsylvania, and including Kentucky and Tennessee.

Associations and Patterns: The Twisted Sedge Subtype occurs as a small patch community. Individual patches are often just a few meters in length and width, but complexes of patches may add up to larger areas. The true area of the larger complexes is poorly known.

Variation: Variation appears to consist primarily of the addition of other plants in the gradation to other subtypes of Rocky Bar and Shore.

Dynamics: The Twisted Sedge Subtype is subject to frequent flooding with substantial current. The streams where it occurs have limited fine sediment deposition and most are clear and oligotrophic. This community probably has low nutrient availability, though growth may still be more limited by disturbance and mechanical stress than nutrients. Plants are tough but may be battered or uprooted by swift water or by gravel and cobbles carried as bed load in floods. Occasional flash floods may reconfigure bars, permanently destroying patches or creating new patches where the community can develop.

Rare species: No rare species are known to be specifically associated with this community.

ROCKY BAR AND SHORE (WATER WILLOW SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Water Willow Subtype covers examples dominated by *Justicia americana*, which are generally low cobble or gravel bars, mostly in the Piedmont but occasionally in the Mountains.

Distinguishing Features: The Water Willow Subtype is distinguished from all other communities by the dominance of *Justicia americana* and near or complete absence of other vascular plants.

Crosswalks: *Justicia americana* Riverbed (CEGL004286).
G977 Eastern North American Riverbed Group.
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: The Water Willow Subtype usually occurs in shallow flowing water along small rivers with substantial current. Most are probably 4th to 5th order streams. The substrate generally is cobbles, boulders, or bedrock with trapped sand.

Soils: No developed soil is present.

Hydrology: The Water Willow Subtype occurs within shallow flowing water, generally a few inches to two feet deep at normal water levels.

Vegetation: The Water Willow Subtype normally consists exclusively of *Justicia americana*, in sparse to dense stands. Other plants shared with the Mixed Bar Subtype may be present in small numbers. Matthews, et al. (2011) noted *Boehmeria cylindrica* and the exotic *Murdannia keisak* as associates, as well as noting the possibility of overhanging trees.

Range and Abundance: Ranked G4G5. North Carolina examples are known throughout the eastern and central Piedmont. They probably are overlooked and are more abundant than records indicate. As defined, the NVC association is extremely widespread, ranging as far as Georgia, Arkansas, Pennsylvania, and New Jersey.

Associations and Patterns: The Water Willow Subtype is a small patch community, with individual patches potentially hundreds of meters long and clusters of patches several acres. It may grade into the Mixed Bar, Riverweed, Southern Wild Rice, or potentially other subtypes of Rocky Bar and Shore. Otherwise, this subtype occurs with various Piedmont and potentially Mountain floodplain forests.

Variation: Variation appears to consist primarily of the addition of other plants in the gradation to other subtypes of Rocky Bar and Shore.

Dynamics: The Water Willow Subtype is subject to frequent flooding with substantial current and potentially battering by bed load material and floating debris. Plants are tough but may be battered or uprooted by swift water or reworking of the substrate. Occasional flash floods may reconfigure bars, permanently destroying patches or creating new patches where the community can develop. Given the continuous water flow, nutrient availability may be high. Patches may be degraded by excess deposition of fine sediment, as well as by even shallow impoundment of the river.

Rare species:
Vascular plants – *Harperella nodosa*.

Vertebrate animals – *Notropis mekistocholas*.

ROCKY BAR AND SHORE (MIXED BAR SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Mixed Bar Subtype covers communities of both Piedmont and Mountains that consist of mixtures of short-lived herbs with shrubs and shrub-sized to larger trees, on frequently scoured bars of boulders, cobbles, or mixed sand and rock. This subtype appears to be higher and drier than the other subtypes, at least in the highest parts, and is more associated with larger and lower elevation rivers.

Distinguishing Features: The Rocky Bar and Shore type is distinguished from streamside forest communities such as Montane Alluvial Forest and Piedmont Alluvial Forest by the lack of a well-developed tree canopy, though some trees may be present. The Mixed Bar Subtype is distinguished by vegetation that includes varying amounts and statures of trees such as *Platanus occidentalis, Betula nigra, Fraxinus pennsylvanica*, shrubs in addition to *Alnus serrulata* and *Xanthorhiza simplicissima*, and a diverse mix of mostly short-lived herbs. Herbaceous cover may be sparse to dense and may vary substantially from one bar to the next and from one time to the next. *Dichanthelium clandestinum, Rumex crispus*, and *Festuca subverticillata* are frequent, but a very large number of species may be present, including some typical of floodplain forests, wetlands, upland forests, prairies, native weedy species, and numerous exotic species. These communities are distinguished from Montane Alluvial Forest and the various Piedmont floodplain forests by having limited-to-no tree canopy, as a result of flood disturbance. Generally, the trees that are present are battered, stunted, or chronically young.

Crosswalks: *Platanus occidentalis / Dichanthelium clandestinum - Festuca subverticillata* Floodplain Forest (CEGL004031).
G673 Appalachian-Interior-Northeast Floodplain Forest Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The Mixed Bar Subtype occurs primarily along medium to large rivers in both the Piedmont and Mountains, on sites that may be a mix of silt, sand, gravel, cobbles, and bedrock outcrop. The looser material is newly deposited or frequently reworked. Rivers where it occurs tend to be at lower elevation than most Alder–Yellowroot Subtype occurrences, but bars often stand higher above the river.

Soils: No well-developed soil is present. The substrate is recently deposited alluvial material or accumulations of material in crevices and pockets in bedrock.

Hydrology: The Mixed Bar Subtype is frequently flooded but at least parts of bars may stand fairly high above normal water levels. Because it usually occurs on larger rivers, floods may be of somewhat longer duration than some other subtypes, but nevertheless are short.

Vegetation: The vegetation of the Mixed Bar Subtype is extremely variable in structure and composition, within and among examples, also sometimes at the same site at different times. Trees may be present as a few large individuals, few or many small to medium sized but heavily battered individuals, as seedlings and saplings, or totally absent. Patches may be dominated by shrubs. Herbs may be dense, moderate, or nearly absent, throughout an example or in different patches within it. The most frequent tree species are characteristic species shared with adjacent floodplain forests. In CVS and Brown (2002) plot data, and similarly in mountain site descriptions, these are *Platanus occidentalis, Acer rubrum, Liriodendron tulipifera, Fraxinus pennsylvanica, Robinia pseudo-acacia, Carpinus caroliniana, Liquidambar styraciflua, Salix nigra,* and *Juglans nigra*. Piedmont sites, generally not represented by plots, include most of the same species, with the addition of *Betula nigra, Acer negundo, Tilia americana* var. *caroliniana*, and several others are lower frequency. Shrubs frequent in mountain plots are *Swida* (*Cornus*) *amomum, Alnus serrulata, Lindera benzoin, Physocarpus opulifolius*, *Rubus pensylvanicus*, and the exotic *Rosa multiflora*. Additional species often noted in site reports include *Cephalanthus occidentalis* and *Ligustrum sinense*. Vines are not usually extensive, but *Toxicodendron radicans, Clematis virginiana*, *Parthenocissus quinquefolia*, *Smilax glauca*, and the exotic *Lonicera japonica* are frequent. Herbs include a diverse mix of floodplain species, typically upland species, and both native and exotic weedy species. Weedy and exotic species are abundant and diverse even in examples without overt alteration. In mountain plot data, *Dichanthelium clandestinum, Festuca subverticillata*, *Verbesina alternifolia*, and the exotic *Microstegium vimineum* are highly constant and sometimes dominant in patches. *Solidago rugosa, Leersia virginica, Amphicarpaea bracteata,* and the exotic *Phalaris arundinacea* and *Reynoutria japonica* (*Polygonum cuspidatum*) occur fairly frequently and may dominate. Other frequent herbs include *Rumex crispus, Oxalis stricta, Viola sororia, Rudbeckia laciniata, Apios americana, Elymus virginicus, Lycopus* spp., *Boehmeria cylindrica, Impatiens capensis, Geum canadense, Juncus tenuis, Persicaria longiseta, Oenothera biennis, Hypericum mutilum, Verbesina occidentalis, Ambrosia artemisiifolia, Persicaria sagittata, Achillea borealis, Elymus riparius, Persicaria virginiana, Carex lurida, Cryptotaenia canadensis, Eurybia divaricata, Hypericum punctatum, Eupatorium perfoliatum, Galium triflorum, Acalypha rhomboidea*, *Ambrosia trifida, Persicaria punctata, Solidago gigantea, Bidens frondosa, Dichanthelium acuminatum* var. *fasciculatum, Juncus effusus, Potentilla canadensis, Eutrochium purpureum, Helenium autumnale, Mimulus ringens, Polystichum acrostichoides, Heliopsis helianthoides, Chasmanthium latifolium,, Conyza canadensis, Pilea pumila, Sedum ternatum, Solidago curtisii*, and *Rorippa palustris*. Frequent exotic herbs include *Hesperis matronalis, Artemisia vulgaris, Holcus lanatus, Fallopia scandens, Daucus carota, Trifolium pratense, Glechoma hederacea, Dioscorea polystachya, Saponaria officinalis, Lespedeza cuneata, Arthraxon hispidus, Plantago rugelii, Trifolium repens, Alliaria petiolata*, and *Commelina communis*. A similarly diverse collection of additional species occurs with lower frequency. The pool of herbs in the Piedmont examples largely is within this set. Most of the added species, such as *Saururus cernuus, Elymus hystrix*, and the exotic *Murdannia keisak*, could potentially also occur in the mountains.

Brown (2002) reported these communities have the highest plot-scale species richness values in the Mountain Region, higher than those of Rich Cove Forests and comparable to the most diverse longleaf pine communities.

Range and Abundance: Ranked G4. North Carolina examples are primarily in the Piedmont but also occur in the larger mountain valleys. The overall range of this community is somewhat uncertain. The equivalent NVC association is attributed definitively only to North Carolina and

Tennessee, but questionably to Virginia, South Carolina, and Georgia. It or a closely related association likely is present in these states and in Alabama, and probably other interior states.

Associations and Patterns: The Mixed Bar Subtype is a small patch community. Most patches are less than 1 acre, but complexes of them may be several acres. It occurs most often with Piedmont Alluvial Forest (the Large River Variant) or Piedmont Levee Forest, with Montane Alluvial Forest (Large River subtype), and less often with other floodplain communities. It may also border upland communities.

Variation: The Mixed Bar Subtype is extremely variable – very different among occurrences, heterogeneous within, and sometimes with examples changing drastically with time. For the present, two variants are tentatively recognized. They are expected to differ biogeographically in their flora, but because most of the species can be found throughout the range, it is unclear how distinct they are.

1. Mountain Variant occurs in the Mountain Region and mountainous foothills.

2. Piedmont Variant occurs in most of the Piedmont. It lacks characteristic mountain species such as *Tsuga canadensis* and *Rhododendron maximum*.

Brown's (2002) analysis identified four clusters among the three mountain rivers she studied:

Platanus occidentalis/Cornus amomum (Acalypha rhomboidea, Ambrosia artemisiifolia, Oenothera biennis, Robinia pseudoacacia, Rosa multiflora, Salix nigra, Saponaria officinalis) Shrubland

Platanus occidentalis – Betula nigra (*Alnus serrulata, Anthoxanthum odoratum, Apios americanum, Hypericum mutilum, Microstegium vimineum)* Woodland

Festuca subverticillata – Scirpus expansus – Schoenoplectus tabernaemontani (Carex vulpinoidea, Eupatorium perfoliatum var. perfoliatum, Glyceria striata, Hypericum mutilum) Herbaceous Vegetation

Leersia virginiana – Impatiens capensis – Hypericum muticum – Boehmeria cylindrica Herbaceous Vegetation.

The first accounted for most of the plots (17), but occurred only on the New and Nolichucky Rivers. The other three clusters ranged from one to three plots, and occurred on the Little Tennessee in combination with the other rivers. This may suggest a potential subdivision of the Mountain Variant, but it is unclear if it is based on biogeography or on other characteristics of these rivers confounded with geography. This warrants further study, as it is presently unclear how to apply these groupings to bars on other rivers.

Dynamics: As with other Rocky Bar and Shore subtypes, the Mixed Bar Subtype is frequently flooded and subject to strong currents which can severely disturb the vegetation. The large portion of the vegetation that consists of weedy and short-lived species, along with the often battered appearance of the longer-lived woody plants, attest to the intensity of natural disturbance. High fertility, limited chance for competitive exclusion by larger plants, and high input of propagules from a large source area contribute to both the high diversity and the abundance of weedy species. Brown (2002) and Brown and Peet (2003) concluded that propagule pressure and the predominance of immigration processes over extinction processes were the primary driver of species richness. They found that number of native and exotic species was positively correlated, except at the finest scales of plots where direct competition for space was most important.

Comments: *Platanus occidentalis - Betula nigra - Salix (caroliniana, nigra)* Floodplain Forest (CEGL003896) and *Platanus occidentalis - Betula nigra / Cornus amomum / (Andropogon gerardii, Chasmanthium latifolium)* Floodplain Forest (CEGL003725) are related associations in the Central Appalachians and northern Piedmont.

Rare species:
Vascular plants – *Cyperus subsquarrosus, Helianthus occidentalis* ssp. *occidentalis, Plantago cordata,* and *Spiraea virginiana*.

ROCKY BAR AND SHORE (MOUNTAIN BEDROCK SCOUR SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Mountain Bedrock Scour Subtype encompasses flood-scoured bedrock areas with sparse vegetation consisting of herbaceous and woody plants rooted in bedrock crevices and in small soil pockets.

Distinguishing Features: The Mountain Bedrock Scour Subtype is distinguished from most other Piedmont and Mountain Floodplain Forests communities by having the predominant substrate of stable bedrock rather than loose material that is reworked by flooding. Any comparable scour communities found in the upper Piedmont should also be classified as this subtype. The Yadkin Falls Bedrock Scour Subtype is distinguished from it by the presence of *Solidago plumosa* as well as by its central Piedmont location. If other bedrock scour communities are found in the eastern Piedmont, a new subtype will likely be needed for them. Other Rocky Bar and Shore subtypes may include some rock outcrops but loose material predominates and is the substrate for most individual plants.

This subtype may grade into a Montane Cliff or other upland rock outcrop community. The boundary is conceptually where flood scouring ceases to be a significant influence, but this may be difficult to discern precisely.

Crosswalks: Southern Appalachian Bedrock Riverscour Vegetation (CEGL004033).
G753 Central Interior-Appalachian Riverscour Barrens & Prairie Group.
South-Central Interior Large Floodplain Ecological System (CES202.705).

Sites: The Mountain Bedrock Scour Subtype may occur along large to small rivers, primarily in narrow gorges or confined reaches.

Soils: No well-developed soil is present. Plants root in small soil pockets and crevices in rock outcrops or in small deposits of loose sediment.

Hydrology: The Mountain Bedrock Scour Subtype is intermittently flooded for brief periods, ranging from high to low frequency.

Vegetation: Vegetation of this subtype is sparse, consisting of low cover of plants rooted in the limited suitable microsites. The range of potential vegetational variation is not well known, but examples will generally have a mix of long-lived herb, shrub, and tree species along with the short-lived and weedy species typical of most other bar communities. In the only well-documented example, three plots in the Nolichucky River gorge, no plant species has as much as 10% cover. The largest covers, mostly 2-5%, include the woody species *Salix nigra*, *Ulmus alata, Platanus occidentalis, Rosa palustris*, *Ilex verticillata*, and *Toxicodendron radicans*, but also a variety of herbs. The more extensive herbs include *Persicaria longiseta, Andropogon virginicus* var. *virginicus, Ipomoea pandurata, Juncus marginatus, Justicia americana, Dichanthelium acuminatum* var. *fasciculatum*, and the exotic *Reynoutria japonica* (*Polygonum cuspidatum*). Other herbs with high frequency include species shared with the Mixed Bar Subtype, such as

Dichanthelium clandestinum, Rumex crispus ssp. *crispus*, *Mimulus ringens* var. *ringens*, *Acalypha rhomboidea, Bidens frondosa, Boehmeria cylindrica, Conyza canadensis, Eupatorium perfoliatum, Eutrochium maculatum* var. *maculatum, Eutrochium purpureum, Festuca subverticillata*, *Hypericum mutilum* var. *mutilum*, *Lycopus virginicus*, *Oenothera biennis, Oxalis stricta*, and *Solidago juncea*. A few upland species such as *Ionactis linariifolia* are also present. As in the Mixed Bar Subtype, exotic species are numerous. *Microstegium vimineum* is constant, and *Artemisia vulgaris, Arthraxon hispidus* var. *hispidus*, *Dioscorea polystachya, Dysphania ambrosioides, Kummerowia stipulacea, Lespedeza cuneata, Leucanthemum vulgare, Mollugo verticillata*, and *Trifolium repens* occur in at least two of the three plots. A few other woody species are frequent, though as small individuals, including *Acer rubrum, Liriodendron tulipifera, Physocarpus opulifolius* var. *opulifolius, Parthenocissus quinquefolia,* and *Clematis virginiana*. Other examples may be expected to have a different but similarly diverse collection of species.

Range and Abundance: Ranked G3 but probably rarer. Some examples may be overlooked or unreported, but only a single well-developed site is known in North Carolina, in the Nolichucky River gorge. The NVC association is also questionably attributed to Tennessee and Georgia. More examples are likely to be found, but this appears to be a very rare community. The final impression of abundance may depend on the degree of acceptance of very small examples.

Associations and Patterns: The Mountain Bedrock Scour Subtype is a small patch community, occurring in patches well less than an acre in extent.

Variation: As with many small patch communities and likely more so, the Mountain Bedrock Scour Subtype is likely to be extremely variable among examples. Among three plots, analysis by Brown (2002) identified two clusters, named as *Salix nigra – Ilex verticillata – Polygonum cuspidatum (Andropogon virginiana, Ionactis linariifolia, Ipomea pandurata, Toxicodendron radicans)* Sparse Vegetation and *Ulmus alata – Platanus occidentalis – Rosa palustris /Juncus marginalis – Equisetum arvense (Andropogon virginicus, Dichanthelium acuminatum var. fasciculatum, Justicia americana)* Sparse Vegetation.

Dynamics: Unlike most other bar communities, only limited parts of this subtype are subject to reworking or substantial new deposition of sediment. It is subject to occasional natural scouring by floods but likely is stable for periods of years between floods. Flood scouring may kill some plants, but plants rooted in deeper crevices may well survive to resprout. Nevertheless, the diverse flora rich in weedy species shows that, in addition to inhibiting soil development on the rock, flooding is important in bringing in propagules and disturbing established plants. Natural flood disturbance may be frequent on the lower parts but rare on the upper parts, suggesting a gradient of dynamics approaching those of upland rock outcrops on the higher parts.

Comments: The NVC contains several associations for bedrock river scour communities in adjacent states. Most contain a substantial component of prairie grasses such as *Andropogon gerardii* and *Schizachyrium scoparium*, which seem to be lacking in North Carolina's examples.

Rare species:
Vascular plants – *Agrostis mertensii, Dicentra eximia, Diervilla rivularis, Helianthus occidentalis* ssp. *occidentalis,* and *Lysimachia fraseri*.

ROCKY BAR AND SHORE (YADKIN FALLS BEDROCK SCOUR SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Yadkin Falls Bedrock Scour Subtype covers the extremely rare examples in which *Solidago plumosa* is a prominent component, known only from the Falls of the Yadkin River in the Uwharrie Mountains. It consists of very open communities on bedrock along river shorelines, kept bare of soil by flood scouring but not flooded for significant periods.

Distinguishing Features: The Yadkin Falls Bedrock Scour Subtype differs from the other Piedmont subtypes in having a substrate of hard bedrock, with plants rooted in crevices or limited soil pockets, in combination with a flooding regime that includes some flooding but not for appreciable periods of time. Vegetation thus is dominated by perennial herbs and is fairly stable. This is in contrast to the loose boulder, cobble, or gravel substrate and unstable vegetation of the other Piedmont subtypes. It is distinguished from the Mountain Bedrock Scour Subtype by geographic location and corresponding biogeographic differences. At present, the presence of *Solidago plumosa* is sufficient to distinguish it. No other bedrock scour communities are known in the Piedmont. If any are found, at least in the central or eastern Piedmont, they may be placed here, but likely will call for a new subtype.

Crosswalks: *Schizachyrium scoparium - Solidago plumosa* Riverscour Wet Meadow (CEGL004459).
G753 Central Interior-Appalachian Riverscour Barrens & Prairie Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: The Yadkin Falls Bedrock Scour Subtype is known from a single site, in the gorge of the Yadkin River where it crosses the Uwharrie Mountains. It occurs on bedrock outcrops along the riverbank, which apparently are kept free of soil development and forest vegetation by scouring flood waters. It likely was extensive in the gorge but is now confined to the small areas that are not submerged by waters behind Badin Dam and Falls Dam.

Soils: No well-developed soil is present. Plants root in small soil pockets and crevices in rock outcrops or in small deposits of loose sediment.

Hydrology: The Yadkin Falls Bedrock Scour Subtype is intermittently flooded for brief periods. Prior to dam construction, the river likely rose rapidly during floods because of its limited floodplain in the gorge and had rapid flow capable of substantial corrasion. Even with the dams, brief, intense flooding likely occurs occasionally, and probably remains important in maintaining the community. Most of the time, available moisture may be quite limited in shallow soil pockets, but a bit more available in deeper crevices.

Vegetation: This subtype has sparse, patchy vegetation, limited to plants rooted in crevices and small pockets of soil. Most of the plants are herbaceous, but a few shrubs, vines, and small trees are present. The flora is a mix of species shared with other bar subtypes, with rock outcrop communities, and with communities of basic upland communities, as well as ruderal species.

Schizachyrium scoparium and *Solidago plumosa* are among the most abundant species. Other herbaceous species include *Dichanthelium* sp., *Eurybia pilosa*, *Allium cernuum*, *Agave* (*Manfreda*) *virginica*, *Muhlenbergia capillaris*, *Phemeranthus teretifolius*, *Hypericum gentianoides*, *Oenothera humifusa*, *Tragia urticifolia, Sporobolus clandestinus,* and *Symphyotrichum dumosum*. Woody species include *Platanus occidentalis, Liquidambar styraciflua, Diospyros virginiana, Ulmus alata, Hypericum prolificum*, *Swida* (*Cornus*) *stricta, Cephalanthus occidentalis, Ilex decidua, Amorpha schwerinii, Gelsemium sempervirens, Campsis radicans,* and *Muscadinia rotundifolia*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina, and only one or two sites remain.

Associations and Patterns: The Yadkin Falls Bedrock Scour Subtype is a small patch community, though it once was probably more extensive in the Yadkin River falls area. It grades to Piedmont Alluvial Forest and Basic Mesic Forest.

Variation: Only a single example is known, but if any more Piedmont bedrock scour communities are found, they potentially could be very different and likely would warrant a different subtype.

Dynamics: Unlike most other bar communities, this subtype is not subject to reworking or substantial new deposition of sediment. It is subject to occasional natural scouring by floods but likely is stable for periods of years between floods. Flood scouring may kill some plants, but plants rooted in deeper crevices may well survive to resprout. Substrate condition created by flood scouring is the most important aspect of being in the floodplain. Natural flood disturbance may be frequent on the lower parts but rare on the upper parts, suggesting a gradient of dynamics approaching those of upland rock outcrops on the higher parts. Floods also bring nutrients and seed input, but these communities are not significantly affected by wetness.

Comments: This subtype appears to be conceptually intermediate between river bar and rock outcrop communities. At the one example, floodplain forest on well-developed soil occurs at similar elevations to the higher parts of this community, suggesting that the rock outcrop as well as the flood scouring is necessary for its occurrence.

Rare species:
Vascular plants – *Baptisia alba, Helenium brevifolium,* and *Solidago plumosa*.

ROCKY BAR AND SHORE (RIVERWEED SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Riverweed Subtype covers largely submerged riffles where *Podostemum ceratophyllum* dominates, generally in nearly monospecific stands. Sparse emergent vegetation may be present.

Distinguishing Features: The Riverweed Subtype is distinguished from all other communities by the dominance of *Podostemum ceratophyllum*.

Crosswalks: *Podostemum ceratophyllum* Aquatic Vegetation (CEGL004331).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).
South-Central Interior Large Floodplain Ecological System (CES202.705).
South-Central Interior Small Stream and Riparian Ecological System (CES202.706).

Sites: The Riverweed Subtype is thought to occur primarily on small rivers, in areas with boulder or bedrock streambed.

Soils: No developed soil is present.

Hydrology: The Riverweed Subtype is generally permanently submerged in shallow, fairly swift-flowing water.

Vegetation: The Riverweed Subtype consists of beds of *Podostemum ceratophyllum* attached to rocks. Generally no other vascular plants are present, but sparse stems of *Justicia americana* or other species may occur.

Range and Abundance: Ranked G3G5. The distribution and abundance of this subtype in North Carolina is very poorly known. It is usually overlooked in site reports. The description in the NVC notes that it has drastically declined, mentioning specifically the upper Neuse River basin as a place where it has been lost from most of the places it occurred. The NVC association as defined is extremely widespread. It is attributed as far away as Arkansas, Oklahoma, Maine, and potentially Quebec.

Associations and Patterns: It is not known how large natural patches of this subtype are. It likely is best regarded as a small patch community, with patches limited by reaches of appropriate substrate, but it could potentially run for long distances along rivers.

Variation: Nothing is known of variation.

Dynamics: Little is known about dynamics. The flowing water presumably provides a steady source of nutrients. Patches may be scoured in floods or may be disturbed by rocks moving as bed load. This subtype is extremely sensitive to excess sediment input. It presumably disappears if soft sediment buries its rocky substrate.

Comments: This community is more aquatic than the other subtypes and may warrant a separate community type. Its distribution and abundance are particularly poorly known.

Rare species: No rare species are known to be specifically associated with this community.

ROCKY BAR AND SHORE (SOUTHERN WILD RICE SUBTYPE)

Concept: Rocky Bar and Shore communities represent sparse, herbaceous, or shrub vegetation of bedrock, cobble, and gravel areas in or along steam channels, where forest vegetation is prevented from developing by flood scouring or reworking of the substrate. The Southern Wild Rice Subtype covers areas dominated by *Zizaniopsis miliacea* on rocky river bars.

Distinguishing Features: The Southern Wild Rice Subtype is distinguished from all other communities by dominance of *Zizaniopsis miliacea* in a rocky Piedmont river setting.

Crosswalks: *Zizaniopsis miliacea* Coastal Plain Slough Marsh (CEGL004139).
G188 South Atlantic & Gulf Coast Marsh & Wet Meadow Group.
Southern Piedmont Large Floodplain Forest Ecological System (CES202.324).

Sites: The Southern Wild Rice Subtype occurs on low bars of cobbles, gravel, and sand, close to normal low water levels. Known examples are along medium to large rivers.

Soils: The soil consists of recent deposits of sand and gravel.

Hydrology: The Southern Wild Rice Subtype is frequently flooded. Floods may be of somewhat longer duration than some other subtypes, but nevertheless are brief.

Vegetation: The Southern Wild Rice Subtype consists of dense or patchy vegetation dominated by *Zizaniopsis miliacea*. Associated vegetation is not well known. *Justicia americana* may occur in patches, especially near the edge. Small amounts of *Salix nigra, Platanus occidentalis, Betula nigra, Alnus serrulata*, or other trees and shrubs of the Mixed Bar Subtype may be present. A variety of herbs shared with the Mixed Bar Subtype may also be present.

Range and Abundance: Ranked G4?. This community is known in limited portions of the Cape Fear, PeeDee and potentially Neuse rivers, all near the Fall Zone. The association is also attributed to South Carolina and Virginia. The relationship of North Carolina's subtype to NVC association concepts is unclear. See comments below. It is unclear if any of the other states with this association have it as a Piedmont river bar community.

Associations and Patterns: The Southern Wild Rice Subtype is a small patch community. It may occur in association with our bar subtypes, especially the Water Willow or Mixed Bar Subtype. It may border Piedmont Levee Forest or Piedmont Alluvial Forest on the riverbank.

Variation: Examples vary with the gradation to other communities.

Dynamics: Dynamics of this subtype are poorly known but must be similar to other Rocky Bar and Shore communities in most ways. As with most bar communities, the Southern Wild Rice Subtype is subject to disturbance by flooding, including reworking of the substrate, scouring, battering by floating debris, and new deposition. Because it exists in similar settings to the Mixed Bar Subtype and drier edges of the Water Willow Subtype, it may bear a successional relationship to them. The dense vegetation would require time and stability to develop and might depend on a period free of severe flood disturbance. Once established, the dense root mat of *Zizaniopsis* probably stabilizes the bar and allows this subtype to persist with less change than most other subtypes. Known examples appear to have withstood record-setting floods in the last few years without obvious major change.

There is some question whether the Southern Wild Rice Subtype is a natural community at all, or if it may represent a recent invasion of the Piedmont by this species which otherwise is confined to tidal rivers and estuaries in North Carolina. Discussion in the botanical community indicates varying beliefs. It is retained for now because the evidence for it being a recent development is not compelling. Spread of *Zizaniopsis* has been noted at the confluence of the Deep and Rocky Rivers, where it overran a rare plant reintroduction site in a place it had not occurred before. Elsewhere there is no clear memory if *Zizaniopsis* was dominant in the past in places where it occurs now. It is unclear what alteration would be responsible for its invasion if it was not previously abundant in the region, though increased sediment loads and altered flood regimes in rivers are two possibilities. The large stand on the Pee Dee River is at a place called Grassy Islands, but the site has been heavily altered by a reservoir and it is not known if this is the eponymous grass. However, the Rocky and Deep Rivers, where recent spread has specifically been noted, are not appreciably controlled by dams and are less loaded with sediment than many Piedmont rivers.

Comments: The crosswalked NVC association is problematic, and it may be that it would be better to have no crosswalk. The association was defined as a Coastal Plain slough marsh, a community that does not occur in North Carolina in non-tidal settings. It was provisionally expanded to cover a Piedmont occurrence in South Carolina and, on that basis, applied to North Carolina's Piedmont community. However, our small patch communities of rocky river bars probably bear little relationship to the large patch slough community of South Carolina. *Zizaniopsis miliacea* Rocky Riverbed Vegetation may be a more analogous community, but it is defined only for Arkansas and Oklahoma.

It is notable that North Carolina does not have any inland *Zizaniopsis* wetlands in the Coastal Plain. Other than tidally influenced area, it is apparently confined to Fall Zone rapids on a few Piedmont Rivers. The species would appear to be capable of establishing in beaver ponds, in both the Piedmont and Coastal Plain, but is not known to have done so in North Carolina.

This subtype apparently is not described in any published literature, at least in North Carolina. Only a single CVS plot contains *Zizaniopsis* in the Piedmont, and it appears to be intermediate, with the species abundant but with *Justicia* dominating.

Rare species: No rare species are known to be specifically associated with this community.

MOUNTAIN BOGS AND FENS THEME

Concept: Mountain Bogs and Fens are wetlands of the Mountain Region and nearby Piedmont foothill valleys. They have permanently saturated soils, lack regular floodwater input, and have high soil organic content and very low nutrient availability. They have a flora with numerous distinctive herbaceous species shared with bogs and fens in other regions as well as endemic relatives of them. In most of the communities, tree cover is limited or absent; even in the substantially forested Swamp Forest—Bog Complex communities, there are openings where wetness excludes trees.

Distinguishing Features: Mountain Bogs and Fens generally most closely resemble Upland Seepages and Spray Cliffs, which also have saturated soils and general lack of stream flooding. Seeps may also have mucky soils, though many have mineral soil, gravel, or bedrock; their soils are higher in nutrient status. Bogs and seeps are best distinguished by the flora. Bogs usually have *Sphagnum* and often have carnivorous plants, while seeps generally have little or none of either. The pool of characteristic bog and fen species not generally found in seeps is fairly large; frequent ones include *Carex folliculata, C. collinsii, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. In wetlands, *Pinus rigida*, *Nyssa sylvatica*, and *Picea rubens* are characteristic of bogs and fens. Species requiring more minerotrophic (though still acidic) conditions are rarely found in bogs. These include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Some other wetland species may be abundant in either group of saturated wetlands, including *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus*.

The High Elevation Boggy Seep community is an exception to many of these distinguishing features because it is intermediate between the two themes. It can have many of the characteristic species of Mountain Bogs and Fens though it is placed in the Upland Seepages and Spray Cliffs theme. It is nevertheless distinguished from bogs by having a substantial slope and more obvious water flow. It occurs at higher elevation than most Mountain Bogs and Fens.

Swamp Forest–Bog Complexes, part of this theme, may resemble Acidic Cove Forests, but are distinguished by having interspersed boggy areas with *Sphagnum* and bog or general saturated wetland species.

Sites: Most Mountain Bogs and Fens occur in flat areas in stream bottoms or valleys, at the base of upland slopes, and in sloughs or relict channels but separated from creeks or rivers. A few occur on gentle slopes or in perched upland areas. In almost all cases, there is an uphill source of seepage, though it may not be obvious, and there is some microtopography that blocks or slows drainage. Detailed descriptions of several sites are included in Moorhead et al. (2000).

Soils: Soils are rich in organic matter, usually with a distinct layer of soft muck, though most are not deep enough to be classified as Histosols. Soils may be heterogeneous, with greatly varying depth of organic matter. Underlying material is usually alluvium, and layers of sand or gravel are common in lower horizons. Most soils are extremely acidic and low in nutrients, though the few richer fens may have circumneutral pH and high levels of calcium. In some bogs, there is development of hummock and hollow microtopography, and this may have been more common before widespread grazing.

Hydrology: Soils are saturated most of the time in the wetter parts of Mountain Bogs and Fens. Water comes from groundwater seepage as well as rainfall, and some limitation of drainage appears to be an important contributor to the saturation. See the comments below about the use of terminology of bogs versus fens. All closely examined examples of all the communities in this theme have significant ground water input. Moisture conditions are often very heterogeneous within sites, with higher and lower areas; visible areas of water input, rivulets, and areas where water flows or accumulates; local areas of higher or lower topography; and sometimes hummock and hollow structure in the organic substrate. Ongoing studies by Jeff Wilcox of University of North Carolina at Asheville have demonstrated areas of groundwater input by using an infrared camera to look at water temperatures in several of these wetlands; ground water input was identifiable as cool areas in summer and warm areas in winter. Where ground water dynamics have been studied, they track current weather fairly closely, suggesting a shallow source. Moorhead (2003) noted at one site that water tables were clearly affected by transpiration, that the water table was near the surface during winter and spring, dropped to 35 cm in late summer in a normal year, and dropped to 80 cm in a dry year. Most water came from the adjacent slope, but he noted that during the drought the alluvium in the adjacent floodplain would also have been a source of water. Given their bottomland location, flooding must naturally occur in some bogs at least occasionally, and gravel beds embedded in organic soils give evidence of it in the past. However, no flooding of bogs was noted in the extensive extreme flooding caused by multiple hurricanes in 2004. Flooding at any frequency would presumably bring in nutrients that would eliminate the nutrient-limited character of bogs.

Vegetation: Vegetation in this theme varies in structure, with all characteristically being at least somewhat more open than forests. Most of the communities are naturally herbaceous or have a complex zoned or patchy structure of herb and shrub dominance with scattered trees. The Swamp Forest–Bog Complex communities are predominantly forested but have numerous small openings with herbaceous vegetation. The vegetation in most communities is a mix of general saturated wetland species with specialists largely confined to boggy wetlands. Both sets of species represent fairly large pools from which a small to moderate number may be present in any given example. Examples are notoriously variable among sites. General wetland species that often are abundant include *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus*. Characteristic bog specialists include *Sphagnum* spp., *Drosera rotundifolia*, *Sarracenia* spp., *Carex folliculata, C. collinsii, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Among trees, *Pinus rigida*, *Nyssa sylvatica*, and *Picea rubens* often join *Acer rubrum, Liriodendron tulipifera*, and *Tsuga canadensis*.

Dynamics: The dynamics of Mountain Bogs and Fens are complex, not fully understood, and somewhat controversial. A nearly universal history of past use for livestock grazing, coupled generally with occurrence in valleys and watersheds with long settlement and land use, may have left no examples without substantial alteration. Within examples valued for conservation, a tradition of intensive, if episodic, management over decades makes discernment of spontaneous dynamics difficult. Much can be surmised from the behavior of bogs and fens in other regions, where they are more numerous and less heavily altered, but it is not clear how readily the lessons apply in our region. However, enough plant species are shared with northern bogs and fens to suggest similar conditions. The most crucial characteristics for the dynamics of Mountain Bogs and Fens are that they are naturally poor in available plant nutrients, thanks to immobilization in undecomposed organic matter, and that their most distinctive plant species are conservative, not generally dispersing readily.

The number of plant species largely confined to bogs suggests bogs have existed in our region for a long period. They probably were more extensive and widespread in the wetter and cooler conditions of the Pleistocene; they have been a small part of the landscape since the modern climate was established, and likely were even less extensive during the warmer, drier Hypsithermal period. The occurrence of conservative flora suggests that bogs are not ephemeral communities and did not appear and disappear widely across the landscape, but that they have long occurred where they are found. Most appear tied to rare site configurations where water input and drainage are appropriate. Few bogs have been studied to determine an age, but McDonald (2010) found organic deposits extending back to 14,934 years ago in one site, and Shafer (1986) found organic material back to 3300 years. Even these may not be full ages, but instead may be the time since the organic layer was last disturbed or contaminated with newer carbon. As with High Elevation Rocky Summits, the most distinctive species may once have occurred in a more widespread landscape of alpine tundra during the colder parts of the Pleistocene.

As with bogs and fens in other regions, our communities appear to result from a process of paludification, where saturation and anaerobic soils lead to inhibited decomposition and organic matter buildup, organic matter buildup enhances saturation, limited recycling of nutrients promotes bog vegetation, and bog vegetation produces nutrient-poor refractory litter that further contributes to organic matter buildup. *Sphagnum* in particular is widely known to acidify soil, compete successfully for nutrients with other plants, and to be slow to decompose. This process is most pronounced in ombrotrophic bogs, without groundwater input, but similar processes happen even in rich fens, where cations may be abundant but nitrogen and phosphorous are still scarce.

In boreal mires, there is a general belief in a succession from fen to bog hydrology and vegetation as organic matter buildup raises the surface above groundwater discharge (e.g., Zobel 1988). Change is greater in fens, while, when bog vegetation prevails, vegetation is likely to be more stable (Pedrotti et al. 2014). Many sites show mosaics, with hummocks supporting bog vegetation while hollows and water tracks continue to support fen vegetation for a longer time. The transition appears to be driven by proliferation and widening of the hummocks, whose tops are out of reach of the ground water table. This transition is considered autogenic and slow, a kind of primary succession that followed deglaciation. However, there is also evidence that it can reverse or take different courses if ground water levels change naturally or artificially (e.g., Hughes and Dumyme-Peaty 2002) and that it can sometimes happen rapidly (Tahvanainen 2011) with altered hydrology.

This version of primary succession appears more applicable to Southern Appalachian systems than is the often-cited succession in glacial ponds. However, succession from open water may have occurred in a few cases, in abandoned stream channel segments or in short-lived Pleistocene lakes.

It is unclear how similar wetland development in this theme is to either scenario. The course of paludification in Mountain Bogs and Fens is less extreme than in the pocosins of the Coastal Plain and in boreal sites, where it has led to the spread of large peatlands. However, McDonald (2010) found evidence of it in his site, where organic matter accumulated first in stream channel segments, then spread over the adjacent area, and ultimately produced a surface having no relationship with the underlying alluvial topography. If paludification is less extreme in mountain bogs, it may be because natural disturbances have interrupted it. Although bog sites do not regularly flood, McDonald (2010) found evidence of episodes of alluvial deposition that suggest river flooding, with gaps in the peat record. Many sites also occur in settings where beaver ponds can flood them. It may be noted that most of these potential natural disturbances, including stream flooding, beavers, fire, and native grazing animals, are likely to have also occurred in the Coastal Plain and that much deeper organic deposits and extensive peatlands were still able to develop. However, the lower topographic gradients may have been important there.

Regardless of their past development, of greatest concern for the dynamics of Mountain Bogs and Fens is the present ecological instability of the vegetation. Many of the communities show a tendency for rapid proliferation of native shrubs and trees, and woody cover can increase to a density that threatens the survival of characteristic herbaceous species, sometimes in the space of only a few years. The most distinctive bog species do not survive in heavy shade. What is regarded as the most characteristic bog animal, *Glyptemys muhlenbergii*, also requires open herbaceous vegetation. Communities that appear to have persisted for thousands of years at a site appear ready to disappear in the space of a few decades or less. Many of the most highly regarded conservation sites have been maintained by cutting of shrubs and trees, sometimes for many years, with sprouting and re-seeding beginning again immediately. Communities that appear most analogous, such as northern bogs and fens, do not show this tendency. They exclude native forest and shrubland vegetation, apparently by a combination of wetness, low nutrient levels, and likely competitiveness of the established vegetation.

This ecological instability has generated several views on the nature of bogs. Most focus on disturbance, either viewing open bogs as shifting ephemeral communities or believing that some kind of periodic or chronic disturbance once "reset succession" by removing invading woody plants and thus maintained the open vegetation. The most common kind of shifting ephemeral community hypothesis is that bogs represent a stage of succession following drainage of beaver ponds. However, no ephemeral community hypothesis accords with the conservative flora nor with the tie of bogs to distinctive sites with groundwater discharge. Beavers, once extirpated in the region, have returned and numerous beaver ponds are now being created and abandoned, yet there is no known case of a bog developing where it did not exist before.

The other category of disturbance hypotheses, that of maintenance in their particular sites by periodic or chronic disturbance, could also involve beavers. Other ideas include large herbivores and fire.

A diverse fauna of large grazing and browsing animals was present until the end of the Pleistocene and may well have affected the landscape then, but only elk and bison persisted into the current climate that shaped our present bogs. These species could have had important effects on bogs until they were extirpated early in European settlement. The habitats and behavior of the local races of elk and bison are not well known. Bogs were too small a part of the recent landscape to have been a major food source for them, but a visit by a herd could be a major physical disturbance. It is unclear if either species would choose to frequent bogs. They don't appear to favor mires in regions where they still occur. Bogs have abundant grassy food, but hampered movement in the wet ground would have increased their risk of attack by predators. The native large herbivore well adapted to wetlands, moose, was not present in this region. Bison also disturbed areas by wallowing; however, if bison wallows in tallgrass prairie farther west are an indication, they chose upland flats rather than wetlands. It should be noted that domestic livestock are not native to the region and that their behavior is very different from native large herbivores.

Fire is known to have been abundant in the region since the Pleistocene, both before and after a widespread human presence. However, the setting of bogs, at the base of slopes and near streams, surrounded by mesic vegetation, would limit natural fire spread into them. It appears that most bog vegetation is not very flammable; graminoids are sometimes abundant, but forbs, bryophytes, and saturated litter would limit fire spread and intensity.

Beavers have flooded a number of bogs in recent years, as their populations continue to recover in the region, and the majority of known bogs appear to have potential for being flooded. Bog vegetation can survive on the edges of ponds, and for a time under very shallow water, but dies out in deeper water. Crucial aspects of natural beaver dynamics in the region — duration of ponds, frequency of return to former ponds, and how much of the floodplain landscape was affected by ponds over time — are completely unknown. Several bogs that have been impounded by beaver ponds or artificial lakes and subsequently drained can be observed to have well-developed bog vegetation in the former lake bed. All that the author has carefully observed have bog vegetation extending beyond the pond edge, generally clearly older outside of the pond, indicating that the plants spread from a local source rather than recolonizing from a different site or persisting in the standing water.

It is unclear how often bogs would naturally have been subject to disturbances, and whether those disturbances functioned to maintain their character or disrupted it until they recovered. Very frequent, low-intensity disturbances to which the biota were resilient, such as was the role of fire in many upland communities, do not appear to have been likely for any of the processes under consideration. Additional important evidence for the effect of disturbance comes from vegetation analysis by Wichmann (2009). She found a distinct type of vegetation that was associated with disturbed bogs across the full range of bog environments, while less disturbed bogs were differentiated into several distinct communities associated with particular location, elevation, and environment. This suggests that the disturbances, including impoundment, grazing, and even heavy shrub clearing (or heavy cover by shrubs before clearing), were replacing the characteristic vegetation of several communities with a homogenized successional vegetation of more generalist plants. It suggests that such disturbances are not processes that maintain bogs, but rather are disruptions that the community has to recover from. Such disruptions would be detrimental if they occur too frequently. Additional evidence comes from a study of seed banks in a bog, which found seeds with limited diversity and primarily consisting of generalist and ruderal species rather than the most characteristic bog species. It thus appears that the bog flora is not adapted to surviving catastrophic disturbance in a seed bank.

A more likely alternative hypothesis for the instability of bogs is that they, like their northern counterparts, were naturally maintained by harsh site conditions and competitiveness of vegetation, and that these conditions have been disrupted. As noted above, changes in ground water levels can change the presence of bog or fen conditions in northern mires. Many remaining examples of mountain bogs, including some of the most intact, have had drainage ditches dug in the past. At many, the nearest stream has been channelized or has become entrenched as a result of land use in its watershed. Given the low levels of available nutrients, bogs are very sensitive to addition of nutrients. Artificial drainage, input of surface runoff or sediment, and physical disturbance of the soil increase nutrient levels, either by direct input or by increasing decomposition. This presumably is part of why many kinds of disturbances lead to homogenized vegetation and dominance by generalist species. Additional possible enrichment of nutrients may have come from atmospheric deposition. Nitrates have been an important component of acid rain in the region, and though their levels have been reduced, much input has already occurred. Atmospheric nitrogen enrichment in boreal bogs is considered a potential disruptor, one that must be accounted for before studying other drivers (e.g., Schultheis et al. 2010; Tahvanainen 2011; Pedrotti et al. 2014). The effects of added nitrogen can be complex rather than straightforward (e.g. Wieder et al. 2019). They found that it was partly compensated for by reduction of nitrogen fixing. They also found that it stimulated growth in some species but not others, and that expected increases in herb and moss production did not occur, apparently because of increased growth of shrubs and trees.

A history of such disturbances in the last century may be the cause of the present instability of many bogs and the invasion by woody plants. Grazing within the bogs may have been particularly important. While cattle help eliminate seedlings of trees and shrubs, they also disrupt *Sphagnum* mats, destroy any hummock structure that existed, enhance decomposition by breaking up and stirring organic matter, more directly increase nutrient levels by concentrating them in their excretions, and create bare sites where seedlings of ruderal species, both herbaceous and woody, could establish. Clearing of adjacent areas for pasture or cultivation also increase runoff of surface water, sediment, and nutrients into bogs, while soil compaction would also reduce infiltration. Nearby clearings can increase the seed rain of ruderal and generalist species into the bog. The few bogs that apparently did not have substantial grazing appear to not show as substantial woody invasion, but this question needs further study. The fact that woody invasion did not become evident until the cessation of grazing does not make it less likely that the alteration caused by the grazing is contributing to the current instability.

While a definitive answer to any of these views of bog dynamics is lacking, the question is extremely important for determining appropriate management for bogs. It is unclear whether arrival of beavers at a given bog is beneficial or harmful. Otherwise, current management is usually based on maintaining a general vegetation structure, with a focus on the needs of particular species. Extensive experience and a growing literature exist on using cattle grazing to create conditions optimal to bog turtles (e.g., Travis et al. 2018). Such management maintains the homogenized vegetation of disturbed bogs, and it is not a plausible return to natural conditions even if the hypothesis of maintenance by native large herbivores is accepted. Bogs that are managed with a focus on plants generally are managed by periodic hand cutting of shrubs and trees. This too is not an analogue of any natural process, though it is less generally disruptive to the ecosystem. Sites where heavy cutting has followed heavy woody cover contain the homogenized vegetation of disturbed bogs, at least at first. Nevertheless, cutting is believed to have been the only thing that has prevented the elimination of rare species and herbaceous flora from some sites in the last several decades. Sites with ongoing maintenance by cutting do have characteristic herbaceous flora and support rare plants.

True restoration of bogs will be particularly difficult if nutrient enrichment or hydrologic alteration are important factors. Once present, nutrients are retained and cycled on the site, and there is no quick way to remove them. Reversal of artificial drainage has been tried at a few sites, sometimes with apparent success, but without knowledge of pre-alteration baseline conditions. The literature on the reversible succession from fens to bogs in boreal settings suggests the possibility of unexpected consequences: making the site wetter, if it raises the water table close enough to the surface, will increase nutrient levels and bring a return to fen conditions. While less attention has been paid to nutrients, it is plausible that, if nutrient addition is stopped, removal of biomass in the form of woody vegetation will slowly reduce levels. It is plausible that, if the soil and herbaceous layer are left undisturbed, growth of *Sphagnum* and accumulation of organic matter will sequester nutrients and create less favorable conditions for trees and shrubs, making the system more stable over time. However, this has not been documented to date.

The effect of anticipated changes in the climate are also of concern for mountain bogs, with much uncertainty about what to expect. The greater prevalence of bogs in northern climates suggests that warming is not likely to be beneficial. Processes reviewed for West Virginia bogs by Schultheis et al. (2010) likely also apply to North Carolina bogs. A warming climate would lead to increased *Sphagnum* growth to a point, increasing nutrient stress on other plants, but this would only occur if precipitation remained high enough to maintain saturation. It would also only occur if increased woody growth did not prevent it. Increased drought would harm *Sphagnum*, increase decomposition and nutrient levels, and exacerbate woody invasion. Conversely, an increase in extreme rainfall and flooding could bring more overland runoff, stream flooding, and sediment input which would be detrimental.

Comments: The classification of mires into bogs or fens based on the role of ground water does not appear to work as well in the Southern Appalachians as it does in northern latitudes. Additionally, the intermixture of bog and fen conditions in so many northern mires may occur at a scale too fine to separate in the smaller patches of our mountain wetlands. By the standard classification of mires, all the communities in this theme are fens, because all have significant ground water input. However, most do not show the minerotrophic character expected of fens, and their vegetation more closely resembles bogs than fens. The ground water emerging from acidic igneous and metamorphic rocks subject to millions of years of chemical weathering and leaching remains acidic and low in cations, much more so than groundwater from even acidic glacial till. Given the lack of fit of flora and vegetation to fens in other regions, the 4th Approximation retains the Southern Appalachian tradition of calling most of these communities bogs, using the name fen only for the very rare examples that have higher pH, base-rich ground water.

Mountain Bogs and Fens are difficult to study with standard plot methods such as those used by CVS because of their structural and vegetational heterogeneity, as well as because even the least altered examples have been affected by woody encroachment and variable recent management, as well as being affected by past grazing. Bogs are most often sampled with 10x10 meter plots, and this is most often appropriate. However, Swamp Forest–Bog Complex communities are not well represented by 10x10 meter plots. Boggy openings are smaller than this, but plots centered on them look deceptively much more open than the community as a whole. Conversely, 10x10 meter plots placed in edges or in tree patches in open Southern Appalachian Bogs appear deceptively forested, and analysis often places them with Swamp Forest–Bog Complex plots. Quantitative analysis conducted without being cognizant of these structural issues can give misleading results.

The NVC association names for communities in this theme have long been problematic. They suggest that some should be more strongly herbaceous, others shrublands or woodlands, when the natural range of vegetation structure in them all is apparently similar. More recent name changes have added the word "seepage" to most of the names, an unfortunate move that obscures their distinctness from the Low Elevation Seeps and other non-boggy associations.

KEY TO MOUNTAIN BOGS AND FENS

1. Community predominantly forested in natural condition, generally a mosaic of open saturated wetland patches in a mesic to wet forested matrix; wetland patches individually less than 1 acre in size; bog flora in wetland patches generally limited in diversity.

2. Forest matrix containing abundant *Picea rubens*, sometimes in combination with abundant *Tsuga canadensis* or *Tsuga caroliniana*; occurring at higher elevation, generally above 3500 feet.. **Swamp Forest–Bog Complex (Spruce Subtype)**

2. Forest matrix not containing appreciable *Picea rubens*, dominated by *Tsuga canadensis, Acer rubrum, Liriodendron tulipifera*, or other mesophytic species; potentially occurring at elevations somewhat above 3500 feet but usually lower...**Swamp Forest–Bog Complex (Typic Subtype)**

1. Community vegetation structure not as above, either predominantly herbaceous or a mosaic of herb, shrub, and tree patches or zones.

3. Community a rich fen, fed by groundwater rich in calcium and magnesium, containing abundant calciphilic species such as *Muhlenbergia glomerata, Cladium mariscoides, Triantha glutinosa*, *Parnassia grandifolia,* and *Sphagnum subsecundum*; extremely rare community associated with seepage from mafic or ultramafic rock; occurring in Ashe or Alleghany County.

4. Extremely rare community known only at Bluff Mountain; vegetation with zones dominated by *Muhlenbergia glomerata* and *Cladium mariscoides*.. **Southern Appalachian Fen (Bluff Mountain Subtype)**

4. Extremely rare community known only at The Glades, known only in degraded form in North Carolina; vegetation including abundant *Schizachyrium scoparium* and *Panicum virgatum*, as well as *Muhlenbergia glomerata* and several *Rhynchospora* spp.. **Southern Appalachian Fen (Glades Subtype)**

3. Community a poor fen, fed by acidic groundwater low in base cations; vegetation consisting primarily of acid-tolerant species, though small numbers of more calciphilic species may occasionally be present; underlying rock various but rarely mafic or ultramafic; potentially occurring anywhere in the Mountains.

5. Community on a distinct slope, with saturated subsoil but seldom saturated at the surface; flora containing a distinctive set of species of Coastal Plain affinities shared with fire-maintained savannas, including *Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius, Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus,* and *Eupatorium pilosum*; extremely rare community known only in Clay County.............**Low Mountain Seepage Bog**

5. Community generally flat or nearly so, on a stream bottom or very gentle slope; if species of Coastal Plain affinities are present, they are a different suite; potentially occurring throughout the Mountains.

6. Community containing a distinct suite of species, many of Coastal Plain affinities, including *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Anchistea virginica*, *Lorinseria areolata, Myrica gale, Chamaedaphne calyculata, Gaylussacia orocola*, and *Sarracenia jonesii*; very rare community known only from the upper French Broad River valley around Hendersonville and Cedar Mountain... **French Broad Valley Bog**

6. Community lacking the above suite of species, but distinguished by a different suite of bog species, many with northern affinities, such as *Carex trisperma, Carex buxbaumii,*

Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris (Thelypteris) simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Ilex collina, Picea rubens, Vaccinium macrocarpon, and *Micranthes* (*Saxifraga) pensylvanica*; collectively widespread in the Mountains and potentially present in the foothills.

7. Very rare community occurring in high elevation valleys, above 4000 feet, in Ashe and Watauga County; characterized by a suite of species that includes *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*. ....**Southern Appalachian Bog (Long Hope Valley Subtype)**

7. Community generally at middle or lower elevations, or if rarely at elevations above 4000 feet, lacking the above suite of species.

8. Community at middle or rarely higher elevations, above 3000 feet; characterized by a suite of species that includes *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*, and often having zones dominated by *Carex echinata*..…………………………………………**Southern Appalachian Bog (Typic Subtype)**

8. Community at lower elevations, below 3500 feet; largely lacking the above species and instead characterized by species such as *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*, and often having zones dominated by *Carex atlantica*.

9. Community with abundant *Symplocarpus foetidus* and containing *Toxicodendron vernix*, potentially containing *Kalmia carolina* or *Viburnum nudum* (but lacking the other characteristic species of French Broad Valley Bogs); extremely rare community known from Alleghany County……………………………………………… .... **Southern Appalachian Bog (Skunk Cabbage Subtype)**

9. Community lacking *Symplocarpus foetidus, Toxicodendron vernix, Kalmia carolina,* and *Viburnum nudum*; potentially anywhere in the Mountains or foothills ....**Southern Appalachian Bog (Low Elevation Subtype)**

SWAMP FOREST–BOG COMPLEX (TYPIC SUBTYPE)

Concept: Swamp Forests–Bog Complexes are stream bottom mosaics of mesic to wet forest with small, wetter, bog-like open areas, or occasionally uniformly wet forests. The ground surface is usually irregular, so that wetness varies substantially on a fine scale, but occasionally is uniformly flat. Herb-dominated boggy openings are usually a minority of the area, in a matrix of closed or open tree canopy, usually with a dense shrub layer. The Typic Subtype covers most North Carolina examples, at low to moderate elevations, excluding only higher elevation examples that have significant *Picea rubens* in the canopy.

Distinguishing Features: Swamp Forest–Bog Complexes are distinguished from other Mountain Bogs and Fens communities by the combination of a well-developed canopy with small boggy openings containing wetland plants characteristic of bogs, such as *Sphagnum*, *Carex folliculata,* and *Osmundastrum cinnamomeum*. Boggy openings are small and floristically depauperate compared to Southern Appalachian Bog and French Broad Valley Bog communities. Openings as large as one acre, or smaller openings that have a diverse and characteristic bog flora, should be classified as an embedded bog community. Forested wetlands that represent invasion of open bogs, and forest patches on edges or within open bogs should not be classified as Swamp Forest–Bog Complex but should be treated as part of the open bog mosaic, unless they are notably more extensive than the open bog. Floodplain Pools may be distinguished by the composition of the herbaceous vegetation, which does not include most of the characteristic bog species.

The matrix of Swamp Forest–Bog Complexes may be indistinguishable from Acidic Cove Forest, with only the presence of numerous boggy openings distinguishing it. Often, however, the canopy contains at least some individuals of species not typical of Acidic Cove Forest, such as *Pinus rigida* or *Nyssa sylvatica*. Some also contain wetland shrubs such as *Viburnum cassinoides* or *Alnus serrulata* in the matrix as well as in the boggy openings.

The Typic Subtype is distinguished from the Spruce Subtype by lacking *Picea rubens* as a significant component.

Crosswalks: *Tsuga canadensis - Acer rubrum - (Nyssa sylvatica) / Rhododendron maximum / Sphagnum* spp. Seep Forest (CEGL007565). G902 Central Appalachian-Northeast Acidic Swamp Group. Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).
Forest Gap Bog Complex (Gaddy 1981).

Sites: Swamp Forest–Bog Complexes occur on bottomlands of medium to large streams or rivers, or occasionally on flats at heads of valleys. They generally have substantial microtopography consisting of ridges and swales or a flat with numerous small depressions. Most of the microtopography appears to be relict stream channels and alluvial features, but a few sites have features of unknown origin. As with other bogs, some sites have small amphitheater-like basins on the upland edge, apparently resulting from sapping by groundwater discharge, and some have mucky rivulets flowing through parts. Most examples are at elevations of 2000-3000 feet, but occurrences may range down to near 1000 feet or to 4500 feet or higher.

Soils: Swamp Forest–Bog Complexes have alluvial soils with local or frequent saturated inclusions. They are generally Inceptisols and Entisols with indicators of wetness (Fluvaquents, Humaquepts, Fluvaquentic Dystrochrepts, or Humic Haplumbrepts). Frequently mapped series are Nikwasi, Toxaway, Hatboro, Codorus, Hatboro, and Rosman.

Hydrology: Boggy openings are permanently or semipermanently saturated, occasionally holding shallow surface water. The forest matrix usually is visibly higher and at least moderately well drained, but occasionally is saturated throughout. The overall community may be flooded in large flood events but not routinely. Seepage may be evident locally, but most openings appear to be kept wet only by rainwater and a high water table.

Vegetation: Swamp Forest–Bog Complexes usually have a typical dense forest canopy over most of their extent, with open areas frequent but small. Most of the typical canopy trees are shared with Acidic Cove Forest. Analysis of plots by Wichmann (2009) found *Acer rubrum*, *Pinus strobus*, *Nyssa sylvatica*, *Quercus alba*, *Tsuga canadensis*, *Quercus rubra*, and *Pinus rigida* the most frequent canopy species, in that order of abundance. Also frequent in other site descriptions are *Liriodendron tulipifera* and *Betula lenta*. The understory is usually not extensive, and consists of the canopy species, though *Amelanchier arborea* was frequent in plots. The shrub layer is usually dense. The most frequent shrubs in plots are *Kalmia latifolia*, *Viburnum cassinoides*, *Rhododendron maximum*, *Alnus serrulata*, *Ilex verticillata*, *Vaccinium corymbosum*, *Aronia arbutifolia*, and *Lyonia ligustrina*. *Leucothoe fontanesiana* has also been observed to dominate sizeable areas. The wetland shrubs generally are confined to in or near the boggy openings in most examples, while *Rhododendron*, *Kalmia*, and *Leucothoe* are widespread in the forest matrix. The herb layer in boggy openings consists of species common to many boggy wetlands, though with fewer species. Frequent species reported by Wichmann (2009) in plots and observed to be frequent elsewhere are *Osmundastrum cinnamomeum*, *Carex folliculata*, *Amauropelta* (*Parathelypteris*) *noveboracensis, Galium tinctorium*, *Impatiens capensis*, *Lycopus virginicus*, *Mitchella repens*, *Carex intumescens*, *Houstonia serpyllifolia*, and *Viola cucullata*. *Dalibarda repens* and *Symplocarpus foetidus* were also frequent in the plots but not as widespread in other occurrences. Other species frequent in site descriptions include *Carex gynandra*, *Carex leptalea*, *Osmunda spectabilis, Glyceria melicaria*, *Oxypolis rigidior*, *Symphyotrichum puniceum*, and *Solidago patula*. *Sarracenia purpurea* var. *montana* and *Drosera rotundifolia* occur occasionally. Herbs in the forest matrix are sparse or patchy. Frequent species include *Galax urceolata*, *Athyrium asplenioides*, *Polystichum acrostichoides*, *Hexastylis heterophylla*, *Hexastylis rhombiformis*, *Medeola virginiana*, and *Maianthemum canadense*.

Range and Abundance: Ranked G2. The equivalent association is described with a range from Georgia to Kentucky. This may represent an overly broadly defined association. If defined that broadly, it probably is not as rare as G2. North Carolina alone has 50 good to fair quality occurrences, scattered throughout the Mountain region. However, the distinctive mosaic wetland sites are inherently uncommon. Their occurrence in accessible, low elevation sites that have long been subject to draining, impoundment, and clearing for pasture, has made them increasingly rare. Many occurrences of “meadow bogs”, disturbed boggy wetlands in pastures, are believed to have been Swamp Forest–Bog Complex areas that were cleared, but this is somewhat uncertain.

Associations and Patterns: Swamp Forest–Bog Complexes are large patch communities, with natural occurrences often 10-50 acres, though many others are only a few acres. This community typically grades to Acidic Cove Forests on adjacent bottomlands, less commonly to Rich Cove Forest. It may contain embedded patches of Southern Appalachian Bog or French Broad Valley Bog. Various upland oak forests may border it on adjacent slopes.

Variation: The Typic Subtype is variable from site to site, but the variation is not well enough sorted out to recognize distinct variants. Most distinctive are the few examples in the upper French Broad valley that are uniformly wet rather than with boggy openings. They may represent a distinct community type of such large valleys, but the few examples are too altered and too little studied to be sure what they represent. Otherwise, examples vary in canopy composition and shrub layer, but the significance of such variation is unknown. Wichmann (2009) linked her equivalent grouping to three other NVC associations rather than the one synonymized here, and she noted the variability but noted the need for more data to sort the variation.

Dynamics: Dynamics of Swamp Forest–Bog Complexes are different from Mountain Bogs and Fens. Their structure appears to be stable, with boggy openings generally not showing a tendency to be invaded by shrubs or trees. Boggy openings are tied to stable microsites and appear unlikely to shift, but it is possible that some could be created by wind throw and tip up pits. While Swamp Forest—Bog Complex communities are sometimes equated with an end point of the invasion of trees into open Southern Appalachian Bogs, this is unlikely; most sites are distinctly different.

With their substantial tree canopy, gap processes similar to those in most forests are important in a way they are not in other Mountain Bogs and Fens. Most canopy trees regenerate in small to medium size gaps created by wind, lightning, or disease. It may be that the variable canopy composition represents variable time since disturbance, with *Liriodendron* and *Pinus* giving way to *Tsuga* over time, but this is far from clear. Examples with abundant *Tsuga* have recently suffered extensive mortality caused by hemlock woolly adelgid. The dense shrub layer in most examples raises questions of how canopy trees can regenerate in their shade, but, as with Acidic Cove Forests, examples do not appear to be losing canopy density.

Environmental factors that lead to formation of Swamp Forest–Bog Complex, rather than to the Acidic Cove Forest, Rich Cove Forest, or Montane Alluvial Forest in similar sites, need further study. A high water table, combined with microtopography, would appear to be necessary. Other communities likely have a deeper water table, perhaps because of greater depth to an impermeable layer or less subsurface ground water flow from adjacent uplands. Gaddy (1981), apparently the first to recognize this community, suggested the boggy openings were caused by paludification following tree blowdown or logging in wet alluvial forests. However, boggy openings do not resemble wind throw pits, and sites do not appear more widely windthrown nor more recently logged than those of other communities. Canopy gaps away from boggy openings appear to have normal tree regeneration. Additionally, regrowth and maturation of the forest does not appear to lead to drying and closure of the boggy openings. Though not clearly documented, they may be vulnerable to actions such as ditching, stream channelization, or extensive development in the watershed, which would lower water tables or reduce groundwater recharge.

The frequency and role of flooding in these communities is not known. They usually occur on alluvial soils with microtopography created by flood scouring or channel movement. However, these features likely are relict from the Pleistocene, as none show evidence of recent reworking. Major floods must inundate sites, but their effects may be short lived. No significant alterations of examples were reported after extensive major flooding caused by multiple hurricanes in 2004. Boggy vegetation in the sloughs would not be expected to survive frequent flooding. More frequent flooding can be expected to result in vegetation as seen in Floodplain Pools.

Fire dynamics likely are similar to those in Acidic Cove Forests. Fire may penetrate these communities, but at low intensity and generally without much effect. The boggy openings would not burn and might inhibit fire spread, but are not usually continuous enough to be a significant fire barrier.

Comments: Swamp Forest–Bog Complexes illustrate a conceptual difficulty of addressing spatial scale in community classification. They could be regarded as a mosaic of two communities. However, because of the small size of boggy openings compared to free-standing community types, and because openings are usually widely distributed, they have been treated as a single complex community throughout the history of North Carolina community classification. The concept was described in an early Natural Heritage Program inventory of bogs (Gaddy 1981), where they were called forest gap bog complex. They are difficult to study with typical vegetation plot approaches because of their mosaic structure. Standard 1/10 hectare plots are wider than typical boggy openings, though openings may be longer. Small plots centered on openings give a false impression of openness, while randomly located plots, may miss openings entirely.

Besides Wichmann (2009), there is at least one published study of an example of this community (Warren et al. 2004). Numerous whole-site descriptions provide good background on its characteristics.

Wichmann's (2009) Low Elevation Saturated Forests (*Acer rubrum var. rubrum / Viburnum cassinoides / Osmunda cinnamomea var. cinnamomea*) type fits this well, but she synonymized it also with CEGL008438 and two other associations not reported from North Carolina. She also noted that it is heterogeneous and might be subdivided with more data. *Glyceria striata - Carex gynandra - Chelone glabra - Symphyotrichum puniceum / Sphagnum* spp. Herbaceous Seep (CEGL008438), a "poorly developed bog" has been attributed to North Carolina and synonymized to Swamp Forest–Bog Complex. Its concept as it might occur in North Carolina appears confused. It may represent the vegetation of boggy openings, separated from the matrix.

Rare species:
Vascular plants – *Carex bullata, Carex cristatella, Caltha palustris, Chelone obliqua* var. *erwiniae, Chelone obliqua* var. *obliqua, Coptis trifolia, Dalibarda repens, Filipendula rubra, Glyceria laxa, Helenium brevifolium, Helonias bullata, Hexastylis rhombiformis, Palustricodon* (*Campanula*) *aparinoides, Platanthera integrilabia, Platanthera peramoena, Poa paludigena, Rhododendron vaseyi, Sagittaria fasciculata, Sarracenia purpurea* var. *montana, Sceptridium oneidense, Thalictrum macrostylum,* and *Torreyochloa pallida*.

Vertebrate animals – *Glyptemys muhlenbergii*.

SWAMP FOREST–BOG COMPLEX (SPRUCE SUBTYPE)

Concept: Swamp Forests–Bog Complexes are stream bottom complexes of mesic to wet forest with small, wetter, bog-like open areas, or less often, uniformly wet forested areas. The ground surface is usually irregular, so that wetness varies substantially on a fine scale, but occasionally is uniformly wet. Herb-dominated boggy openings are usually a minority of the area, in a matrix of closed or open tree canopy, usually with a dense shrub layer. The Spruce Subtype covers the rare examples that have *Picea rubens* dominant or codominant. They generally have a larger component of northern species and a minimal component of species shared with the Coastal Plain.

Distinguishing Features: Swamp Forest–Bog Complexes are distinguished from other Mountain Bogs and Fens communities by the combination of a well-developed canopy with small boggy openings containing wetland plants characteristic of bogs, such as *Sphagnum*, *Carex folliculata,* and *Osmundastrum cinnamomeum*. Boggy openings are small and floristically depauperate compared to Southern Appalachian Bog and French Broad Valley Bog communities. Openings as large as one acre, or smaller openings that have a diverse and characteristic bog flora, should be classified as an embedded bog community. Forested wetlands that represent invasion of open bogs, and forest patches on edges or within open bogs, should not be classified as Swamp Forest–Bog Complex but should be treated as part of the open bog mosaic, unless they are notably more extensive than the open bog.

The Spruce Subtype is distinguished from the Typic Subtype by having *Picea rubens* as a canopy dominant or codominant. Some examples have additional distinctive species of northern affinities, such as *Taxus canadensis*. The combination of *Picea rubens* canopy with wetland conditions in a flat setting distinguishes the Spruce Subtype from all other communities. Though at higher elevation than the Typic Subtype, this subtype usually is at lower elevation than most subtypes of Red Spruce–Fraser Fir Forest.

Crosswalks: *Picea rubens - (Tsuga canadensis) / Rhododendron maximum* Swamp Forest (CEGL006277).
G045 Acadian-Appalachian Red Spruce Acidic Swamp Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: The Spruce Subtype occurs on bottomlands of medium to large streams on flats at heads of valleys. The sites are unusually flat for their elevation, and often appear as "hanging valleys" (though they are not the glacial valleys the term is generally used for). Cold air drainage and pooling appear to be important influences in this community. Elevations range from 3600 to 5400 feet. A few sites are uniformly flat and wet, but most have substantial microtopography. This sometimes appears to be fluvial features such as sloughs or abandoned channels, but elsewhere consists of a series of small parallel channels and intervening small ridges. Given the small size and limited watershed of most examples, the substantial microrelief is surprising. As with other bogs, some sites have small amphitheater-like basins on parts of the upland edge, apparently resulting from sapping by groundwater discharge, and some have mucky rivulets flowing through them.

Soils: Soils of the Spruce Subtype are variable or not well understood. Each occurrence is mapped as a different series of Dystrochrepts, Humaquepts, or Hapludults.

Hydrology: Boggy openings are permanently or semipermanently saturated, occasionally holding shallow surface water. The forest matrix usually is visibly higher and at least moderately well drained, but occasionally is saturated throughout. The overall community may be flooded in large flood events but not routinely. Seepage may be evident locally, but most openings appear to be kept wet only by rainwater and a high water table.

Vegetation: The canopy of the Spruce Subtype is dominated or codominated by *Picea rubens*. It may have full forest density or may be more open. Codominant trees are *Acer rubrum, Tsuga canadensis*, or in one case, *Tsuga caroliniana*. Often associated is *Betula alleghaniensis*, while *Betula lenta* and other species shared with the Typic Subtype are occasional. The sparse understory consists primarily of the same species but may include *Amelanchier arborea/laevis*. The shrub layer is generally dense, most often with *Rhododendron maximum* dominant. *Kalmia latifolia* is frequent. Other wetland and high elevation shrubs may occur in boggy openings or scattered through the matrix. Frequent species include *Viburnum cassinoides, Sambucus canadensis, Aronia melanocarpa, Clethra acuminata, Ilex verticillata*, while less frequent but notable species include *Ilex collina, Taxus canadensis, Sambucus racemosa* var. *pubens, Rhododendron catawbiense, Viburnum lantanoides*, *Vaccinium corymbosum*, and *Lyonia ligustrina*. *Sphagnum* spp. dominates patches, at least in boggy openings and often elsewhere. The only herbs frequent in site descriptions are *Osmundastrum cinnamomeum, Glyceria melicaria, Osmunda spectabilis, Solidago patula,* and *Viola* sp. A variety of additional species may be present at low frequency, including *Carex* spp., *Chelone glabra, Chelone lyonii, Juncus gymnocarpus, Symphyotrichum puniceum, Trillium undulatum, Dryopteris cristata, Platanthera psycodes, Platanthera peramoena*, and *Neottia (Listera) smallii*.

Range and Abundance: Ranked G2? This community is very rare in North Carolina, with only seven examples scattered throughout the Mountain Region. Its range is notable in that it represents the southernmost occurrence of native *Picea rubens* as well as most of the lowest elevation occurrences of the species in the Southern Appalachians. The flat valley bottoms in which they occur are inherently rare at appropriate elevations. The synonymized NVC association is defined as ranging from New York southward to North Carolina. It may be too broadly defined. If the community is as wide-ranging as it implies, it is probably more common than the G2 rank would imply.

Associations and Patterns: The Spruce Subtype may occur as either a large patch or small patch community. Large examples are 20 to perhaps more than 100 acres, but some are naturally bounded in areas of only a few acres. Though examples tend to be at higher elevations than the Typic Subtype, they are typically below the elevation of the extensive spruce-fir zone and are controlled by different environmental factors. Red Spruce—Fraser Fir Forest (Low Rhododendron Subtype) sometimes occurs in association. Otherwise, the Spruce Subtype is generally surrounded by Northern Hardwood Forest but could be associated with Acidic Cove Forest, especially the High Elevation Subtype. The largest example has embedded Southern Appalachian Bog (Long Hope Valley Subtype) patches.

Variation: Examples vary in the canopy species associated with the spruce, with some examples having little else, some having *Tsuga canadensis*, and one example having *Tsuga caroliniana*. No variants are formally recognized.

Dynamics: Regeneration patterns and dynamics are little known in this community. However, Collins, et al. (2010) found that at Alarka Laurel, spruce had recruited steadily for at least the last 100 years. Several examples have had extensive mortality of *Picea* caused by an anomalous southern pine beetle attack and do not seem to show significant tree regeneration after 10-20 years. Examples with abundant *Tsuga* have suffered widespread canopy mortality in recent years, caused by hemlock woolly adelgid, and their future is unclear. At least one other example has only sparse trees, for reasons that are unknown. The dense evergreen shrub layer may inhibit tree regeneration, but given the shade tolerance of *Picea*, this seems unlikely given that examples of the Typic Subtype retain dense canopies. The climate at the elevation of occurrence, marginal for the species, may be important.

The occurrence of *Picea rubens* in the Spruce Subtype is presumably relictual from a time in the Pleistocene when the species was widespread at lower elevation. It is notable that the southernmost as well as the lowest elevation populations of *Picea rubens* occur in this community rather than in Red Spruce–Fraser Fir Forest, and that others are disjunct some distance from larger populations. Their future in a warmer climate is unclear. They are already surviving outside of the typical climatic envelope for the species. However, they also apparently survived warmer climatic periods since the end of the Ice Age. Collins, et al. (2010) reported that growth declined during the severe droughts of the 1930s but did not decline during other droughts. They noted that some northern studies also found this community buffered from climatic variation that affected mountain top spruce stands.

Comments: Most of the comments about the Typic Subtype also apply to the Spruce Subtype. This subtype is very little studied in North Carolina. Wichmann (2009) appears to be the only formal study to address them. Her study illustrates the difficulties of plot data analysis in Mountain Bogs and Fens. In the grouping that represented this subtype, small plots in woody portions of Southern Appalachian Bogs greatly outnumbered Swamp Forest–Bog Complex plots, resulting in misleading summary data. For this reason, the vegetation description above is based more on site reports.

Rare species:
Vascular plants – *Arethusa bulbosa, Carex trisperma, Chelone cuthbertii, Filipendula rubra, Ilex collina, Lilium grayi, Menyanthes trifoliata, Rhododendron vaseyi,* and *Taxus canadensis*.

Nonvascular plants – *Aneura sharpii*.

SOUTHERN APPALACHIAN BOG (TYPIC SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, usually, extensive *Sphagnum* cover. Though traditionally known as bogs, examples studied in detail appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Typic Subtype covers Southern Appalachian Bogs that occur at middle elevations, generally above 3000 feet, containing many species of northern affinities but lacking the distinctive flora of the Long Hope Valley Subtype. They are thus in the middle of the elevational range of North Carolina's mountain bogs.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora. Bogs generally, though not always, have extensive *Sphagnum* and, often, carnivorous plants, while these are uncommon in most other wetlands. Species typical of bogs and not of other wetlands include *Carex folliculata, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Species of less acidic wetlands and not typical of bogs include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Many additional species, such as *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus* are often abundant in bogs, sometimes more if they are altered, but also occur in other kinds of saturated wetlands.

High Elevation Boggy Seeps may share bog flora with Southern Appalachian Bogs. They are distinguished by structural and floristic differences: seeps are moderately to steeply sloped and have a mixture of plants of bogs and of more fertile wetlands. They may, however, contain extensive cover of *Sphagnum* and populations of *Vaccinium macrocarpon*.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex communities by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species largely or completely lacking in Southern Appalachian Bogs but present in these other communities, many of them shared with Coastal Plain wetlands, include *Sarracenia* spp., *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Anchistea virginica, Lorinseria areolata, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*. Species typical of Southern Appalachian Bogs and generally lacking in the other bogs, many of them northern species, include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris* (*Thelypteris*) *simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Picea rubens, Vaccinium macrocarpon*, and *Micranthes (Saxifraga) pensylvanica*.

Southern Appalachian Fens are distinguished from Southern Appalachian Bogs by containing species needing higher pH and base saturation, such as *Muhlenbergia glomerata, Triantha (Tofieldia) glutinosa*, and *Sphagnum subsecundum*. Only a single Southern Appalachian Fen is known in North Carolina, at Bluff Mountain.

The Typic Subtype of Southern Appalachian Bog is distinguished from the Low Elevation Subtype by occurrence at higher elevation, generally above 3000 feet north of Asheville, somewhat higher farther south. This is accompanied by floristic differences that include a greater number and abundance of northern species. Species Wichmann (2009) found more abundant in the Typic Subtype than in the Low Elevation Subtype include *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*. *Carex echinata*, while present in both, often is dominant in the Typic Subtype but not in the Low Elevation Subtype. Species more common in the Low Elevation Subtype include *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*. The Skunk Cabbage Subtype also occurs at elevations below 3000 feet, and contains abundant *Symplocarpus foetidus*, as well as containing *Toxicodendron vernix*.

The Typic Subtype is distinguished from the Long Hope Valley Subtype by having a smaller component of northern species and by the absence of characteristic species such as *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*. All but one example are in Long Hope Valley, but not all bogs in lower Long Hope Valley may represent that subtype.

Crosswalks: *Carex atlantica - Solidago patula var. patula - Lilium grayi / Sphagnum bartlettianum* Herbaceous Seep (CEGL004158).
G184 Central & Southern Appalachian Seep & Seepage Bog Group

Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).
Acidic Bog – *Lyonia ligustrina* var. *ligustrina* – *Viburnum cassinoides* / *Carex echinata* var. *echinata* – *Scirpus expansus* / *Sphagnum* spp. (2.3); High Elevation Mosaic Bog – *Vaccinium simulatum* / *Osmunda cinnamomea* var. *cinnamomea* – *Oclemena acuminata* / *Sphagnum* spp. – *Polytrichum* spp. (2.4); Mosaic bog – *Salix sericea* / *Osmunda cinnamomea* var. *cinnamomea* – *Carex echinata* ssp. *echinata* / *Sphagnum* spp. (2.5) (Wichmann 2009).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped areas near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. They are generally above 3000 feet in elevation, somewhat higher in the southern part of the state.

Soils: Mountain bog soils are generally saturated and high in organic matter but rarely are true Histosols. They often include layers of gravel or other alluvial material at the base, sometimes also embedded within the organic-rich material. The Typic Subtype is often mapped as Nikwasi (Cumulic Humaquept), sometime as Toxaway (Cumulic Humaquept), Cullowhee (Fluvaquentic Humadept), or Rosman (Fluventic Humadept).

Hydrology: Southern Appalachian Bogs are permanently saturated. In hydrologic classifications of mires they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site also appears to be needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: Southern Appalachian Bog vegetation is extremely variable in structure and dominance, among examples, within sites, and, at least in recent decades, over time. The natural structure is not known in detail, though it is clear that it characteristically has a dense herbaceous layer and only partial woody cover. In the least altered examples, trees are sparse or confined to the edges, while shrubs are patchy or scattered in the interior and may form a dense edge zone. Trees are often small and appear stunted. Characteristic tree species include *Acer rubrum*, *Tsuga canadensis, Picea rubens*, *Betula alleghaniensis*, and *Pinus strobus*. Shrub zones and patches are most often dominated by *Rhododendron maximum* or *Alnus serrulata*, but may also be dominated by *Kalmia latifolia, Spiraea alba, Spiraea tomentosa, Salix sericea*, or other species. Other highly constant or frequent shrubs include *Lyonia ligustrina, Hypericum densiflorum, Viburnum cassinoides, Vaccinium corymbosum, Aronia melanocarpa, Rosa palustris, Kalmia carolina*, and *Xanthorhiza simplicissima*. *Rubus hispidus* or *trivialis* is sometimes abundant on the ground.

The herb layer is generally patchy, with much fine-scale variation. Beds of *Sphagnum* spp. are often present, at least in part of the bog. Species that are highly constant and dominate patches in plots (Wichmann 2009) are *Carex echinata* var. *echinata, Osmundastrum cinnamomeum,* and *Solidago patula*. Other frequent species that dominate patches include *Carex leptalea* var. *leptalea*, *Carex atlantica, Carex gynandra, Scirpus expansus,* and *Lycopus uniflorus.* Less frequent in plots but sometimes dominant are *Vaccinium macrocarpon, Thelypteris palustris,* and *Chelone glabra*. In bogs that have been disturbed, *Persicaria sagittata, Persicaria hastata, Juncus effusus, Eupatorium perfoliatum*, or other species may dominate. Few species are highly constant, but many are frequent in plots, including *Galium tinctorium, Drosera rotundifolia, Houstonia serpyllifolia, Symphyotrichum puniceum* var. *puniceum*, *Platanthera clavellata, Carex lurida, Hypericum punctatum, Hypericum mutilum, Oxypolis rigidior, Viola cucullata, Glyceria striata, Sphenopholis pensylvanica, Rhynchospora capitellata,* and *Lycopus virginicus*. Species less frequent in plots but characteristic in the Typic Subtype include *Carex baileyi, Dryopteris cristata, Rhynchospora alba, Impatiens capensis, Impatiens pallida, Glyceria melicaria, Juncus gymnocarpus, Eleocharis tenuis, Lilium grayi*, and *Chamaenerion* (*Epilobium*) *angustifolium*.

Range and Abundance: Ranked G1. There are about 25 occurrences in North Carolina, scattered throughout the interior of the Mountain region. It is unclear if this community occurs in any other state. The NVC association is questionably attributed to Virginia and Tennessee. Given the lower elevations in Tennessee, any bog communities shared with North Carolina there are likely to be the Low Elevation Subtype. The number of occurrences would suggest a G rank of G2, but the many threats to this community may warrant G1.

Associations and Patterns: Southern Appalachian Bogs are small patch communities. Most occurrences are a few acres in size, some only one acre. They are sometimes associated with Swamp Forest–Bog Complex communities but more often are bordered by Acidic Cove Forest within the bottomland and on the adjacent slopes.

Variation: The Typic Subtype is one of the mountain bog communities that is notorious for its variability. Variation includes different dominants and different collections of species in different bogs, different parts of the same bog, and, apparently, at different times. Bogs exhibit a tendency common to many small patch communities with conservative flora, that each site appears unique, presumably because of limited dispersal of species. Additionally, some of the larger bogs have several separate patches that differ substantially in dominant vegetation and total flora. The author has repeatedly had the experience of visiting a bog several times and forming drastically different impressions because a different portion was visited or because the aspect of the vegetation had changed.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Typic Subtype well in all their complexity.

Comments: Southern Appalachian Bogs are among the most difficult communities to classify. Part of this is due to the extreme variability of their vegetation, as described above. Both site descriptions and plots can give a limited picture of a complex site. Plots are more difficult to interpret than in most kinds of vegetation. Plots are generally small, usually 100 square meters rather than 1000, because of small size of open patches and of homogeneous vegetation. This gives different impressions of constancy of species and of species richness. Plot placement is generally biased toward the most open part of bogs. Nevertheless, because of the strongly zoned or patchy vegetation, small differences in plot location, deliberate or accidental, can result in very different data on species cover. Understanding of bog vegetation is also complicated by the nearly universal history of alteration that is greater than in the reference examples of most communities.

Though bogs have been of great interest to the conservation community and the Natural Heritage Program throughout its existence, there is very little published literature on their vegetation. Moorehead et al., (2000) describe several sites briefly. Wichmann (2009) conducted the only thorough quantitative study on a broad set of bog communities. She found the most distinctive vegetation groupings to be those associated with alteration. Vegetation disturbed by clearing, grazing, and beaver impoundment, vegetation heavily dominated by shrubs, once-open bogs now dominated by trees, and a depauperate herbaceous type formed strong groups that were not well associated with differences in environment or biogeography. The large number of plots in these categories left a much smaller set to identify underlying characteristic natural patterns that would be more appropriate for classification for conservation purposes. However, groups that are equivalent to the three subtypes recognized here also emerged, and these are the basis for much of the description of vegetation and floristic distinctions in the 4th Approximation. These subtypes also correspond fairly well to those recognized in Weakley and Schafale (1994).

Earlier drafts of the 4th approximation, and the NVC, recognized separate herbaceous and shrub subtypes within what is now treated as the Typic Subtype. These were conceived as zones. Given the reality of the variation and rapid change in shrub cover, this distinction is problematic, impossible to apply meaningfully, and potentially misleading for conservation action. It has been dropped. *Alnus serrulata - Kalmia carolina - Rhododendron catawbiense / Carex folliculata - Lilium grayi* Seepage Shrubland (CEGL003915) and *Rhododendron maximum / Sphagnum* spp. Seepage Shrubland (CEGL003849) were the shrub-dominated typic bog associations. Both remain in the NVC but it does not appear useful to use them for Natural Heritage purposes.

As noted in the theme description, the move to add the word "seep" to the names of our bog associations and alliance, and putting them in a general seep group, is misleading and unfortunate.

Carex (atlantica, echinata, leptalea, lurida) - Solidago patula Herbaceous Seep (CEGL004156) is a broadly defined, apparently more depauperate bog association attributed to all of the states neighboring North Carolina. Its concept may overlap several North Carolina subtypes, but it is not considered to occur here.

Rare species:
Vascular plants – *Arethusa bulbosa, Calamagrostis canadensis* var. *canadensis, Caltha palustris* var. *palustris, Carex baileyi, Carex buxbaumii, Carex conoidea, Carex trisperma, Carex vesicaria, Chamerion angustifolium* var. *circumvagum, Chelone cuthbertii, Chelone obliqua* var. *erwiniae, Chelone obliqua* var. *obliqua, Coryphopteris* (*Thelypteris*) *simulata, Epilobium ciliatum* var. *ciliatum, Geum aleppicum, Geum laciniatum, Glyceria laxa, Helenium brevifolium, Helonias bullata, Lilium grayi, Lilium canadense, Lonicera canadensis, Lycopodiella inundata, Oenothera perennis, Packera crawfordii, Palustricodon* (*Campanula*) *aparinoides, Parnassia grandifolia, Platanthera herbiola, Poa paludigena, Poa palustris, Solidago uliginosa* var. *uliginosa, Sparganium acaule, Stachys eplingii, Stenanthium gramineum* var. *robustum, Thalictrum macrostylum, Triadenum* (*Hypericum*) *fraseri, Utricularia cornuta, Vaccinium macrocarpon,* and *Veronica americana*.

Nonvascular plants – *Dicranum undulatum, Hypnum pratense, Sphagnum angustifolium, Sphagnum capillifolium, Sphagnum fallax, Sphagnum subsecundum, Sphagnum warnstorfii,* and *Splachnum pensylvanicum*.

Vertebrate animals – *Empidonax alnorum, Glyptemys muhlenbergii,* and *Mustela nivalis*.

Invertebrate animals – *Polites mystic* and *Somatochlora elongata.*

SOUTHERN APPALACHIAN BOG (LOW ELEVATION SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, generally, extensive *Sphagnum* cover. Though traditionally known as bogs, these wetlands generally appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Low Elevation Subtype covers bogs of lower elevations, generally below 3000 feet, with relatively few species of northern affinities.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora. Bogs generally, though not always, have extensive *Sphagnum* and, often, carnivorous plants, while these are uncommon in most other wetlands. Other species typical of bogs and not of other wetlands include *Carex folliculata, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Species of less acidic wetlands and not typical of bogs include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Many additional species, such as *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus* are often abundant in bogs, sometimes more if they are altered, but also occur in other kinds of saturated wetlands.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species largely or completely lacking in Southern Appalachian Bogs but present in these other communities, many of them shared with Coastal Plain wetlands, include *Sarracenia* spp., *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Helonias bullata,* *Anchistea virginica, Lorinseria areolata, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*. Species typical of Southern Appalachian Bogs and generally lacking in the other bogs, many of them northern species, include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris* (*Thelypteris*) *simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Picea rubens, Vaccinium macrocarpon*, and *Micranthes (Saxifraga) pensylvanica*.

The Low Elevation Subtype is distinguished from the Typic Subtype by occurrence at lower elevations, generally below 3500 feet, and by floristic differences that include a smaller number and abundance of northern species. Species Wichmann (2009) found more abundant in the Typic Subtype than in the Low Elevation Subtype include *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*. Species more common in the Low Elevation Subtype include *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*. *Carex atlantica* is often dominant in patches. *Carex echinata*, while present in both, often is dominant in the Typic Subtype but not in the Low Elevation Subtype. The Skunk Cabbage Subtype also occurs at elevations below 3000 feet, and contains abundant *Symplocarpus foetidus*, as well as containing *Toxicodendron vernix*.

Crosswalks: *Alnus serrulata - Rhododendron viscosum - Rhododendron maximum / Juncus gymnocarpus - Chelone cuthbertii* Seepage Shrubland (CEGL003916).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).
Southern Appalachian Bog (Southern Floodplain Variant), (Southern Appalachian Bog (Low Elevation Variant) (Third Approximation).
Low Elevation Bog – *Lyonia ligustrina* var. *ligustrina – Aronia arbutifolia* / *Eriophorum virginicum – Solidago patula* var. *patula / Sphagnum spp.* (2.7) (Wichmann 2009).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped areas near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. The Low Elevation Subtype generally occurs below 3500 feet elevation, reaching somewhat higher in the southern part of the state.

Soils: Mountain bog soils are generally saturated and high in organic matter but rarely are true Histosols. They often include layers of gravel or other alluvial material at the base, sometimes also embedded within the organic-rich material. The Low Elevation Subtype is often mapped as Rosman (Fluventic Humadept), Nikwasi (Cumulic Humaquept), or Toxaway (Cumulic Humaquept).

Hydrology: Southern Appalachian Bogs are permanently saturated. In hydrologic classifications of mires they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site also appears to be needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: Southern Appalachian Bog vegetation is extremely variable in structure and dominance, among examples, within sites, and, at least in recent decades, over time. The natural structure is not known in detail, though it is clear that it characteristically has a dense herbaceous layer and only partial woody cover. In the least altered examples, trees are sparse or confined to the edges, while shrubs are patchy or scattered in the interior and may form a dense edge zone. Trees are often small and appear stunted. Characteristic trees species include *Acer rubrum, Tsuga canadensis, Pinus strobus*, *Liriodendron tulipifera*, and *Oxydendrum arboreum*. Shrub zones and patches are most often dominated by *Rhododendron maximum* or *Alnus serrulata*. Other frequent shrubs include *Rosa palustris, Aronia arbutifolia, Aronia melanocarpa, Spiraea tomentosa, Rhododendron viscosum*, *Kalmia latifolia, Ilex verticillata, Vaccinium corymbosum*, and *Kalmia carolina*. *Rubus hispidus* or *trivialis* is highly constant and sometimes dominates patches.

The herb layer is generally patchy, with much fine-scale variation. Beds of *Sphagnum* spp. are often present, at least in part of the bog. In CVS plots (Wichmann 2009), there are no highly constant herbs that dominate. Frequent species that may dominate patches include *Carex leptalea* var. *leptalea, Carex echinata* ssp. *echinata*, *Carex atlantica, Osmundastrum cinnamomeum, Rhynchospora capitellata, Andropogon glomeratus, Juncus effusus*, and *Vaccinium macrocarpon*. In disturbed bogs, *Persicaria sagittata, Persicaria hastata, Juncus effusus, Eupatorium perfoliatum*, *Scirpus cyperinus*, or other species may dominate. Though less dominant, highly constant species in plots include *Eriophorum virginicum, Solidago patula*, *Juncus* sp., *Vernonia noveboracensis, Dichanthelium lucidum,* and *Drosera rotundifolia*. Other frequent species include *Viola primulifolia, Viola pallens, Scirpus expansus, Eriocaulon decangulare, Pogonia ophioglossoides, Platanthera clavellata, Symphyotrichum puniceum* var. *puniceum, Lycopus uniflora, Oxypolis rigidior, Carex folliculata, Carex buxbaumii, Chelone cuthbertii, Eleocharis tenuis, Galium tinctorium, Linum striatum, Packera crawfordii, Polygala sanguinea, Schizachyrium scoparium, Carex intumescens, Eutrochium fistulosum, Hypericum canadense, Rhynchospora alba, Rhynchospora gracilenta, Eupatorium rotundifolium, Juncus biflorus,* and *Solidago speciosa*. Less frequent species that are characteristic include *Carex ruthii, Lysimachia terrestris, Pteridium latiusculum, Sanguisorba canadensis,* and *Calopogon tuberosus*.

Range and Abundance: Ranked G1G2 but perhaps appropriately G2. More than 40 occurrences are known, but, even more than most bogs, a substantial number of them are in poor condition and threats are high. They are scattered through the interior of the Mountain region with a few also occurring in the foothills. This community apparently also occurs in South Carolina, Georgia, and Tennessee.

Associations and Patterns: Southern Appalachian Bogs are small patch communities. Most occurrences are a few acres in size, some only one acre. They are sometimes associated with

Swamp Forest–Bog Complex communities but more often are bordered by Acidic Cove Forest within the bottomland and on the adjacent slopes.

Variation: The Low Elevation Subtype, like the Typic Subtype, is one of the mountain bog communities that is notorious for its variability. Variation includes different dominants and different collections of species in different bogs, different parts of the same bog, and also, apparently, at different times. Bogs exhibit a tendency common to many small patch communities with conservative flora, that each site appears unique, presumably because of limited dispersal of species. Additionally, some of the larger bogs have several separate patches which differ substantially in dominant vegetation and total flora.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Low Elevation Subtype well in all their complexity.

Comments: The extreme difficulty of classifying bog vegetation, discussed for the Typic Subtype, applies equally well to the Low Elevation Subtype, which is similarly variable and often even more altered by land use in and near the bog.

Published literature is equally scarce. McLeod (1983) and McLeod and Croom (1983) describe the floristics and vegetation zones of one example, and some of the examples described by Moorhead et al. (2000) are of the Low Elevation Subtype.

Weakley and Schafale (1994) recognized a Southern Floodplain subtype. It is not recognized in the 4th approximation. Wichmann (2009) did not find a grouping corresponding to it. Because all southern bogs she sampled fell into one of the categories of altered vegetation, this is not definitive. However, examination of whole-site floristics failed to find any differences related to biogeography or distinctive environmental factors. Almost all southern bogs are at lower elevations and those not treated as French Broad Valley Bogs fit this subtype. However, the substantial distance and moderate disjunction of the southern examples makes it possible that biogeographic differences will be found that warrant a distinct subtype.

Earlier drafts of the 4th approximation, and the NVC, recognized separate herbaceous and shrub subtypes within what is now treated as the Typic Subtype. These were conceived as zones, but ones that might be associated with several different bog subtypes. Given the reality of the variation and rapid change in shrub cover, this distinction is problematic, impossible to apply meaningfully, and potentially misleading for conservation action. It has been dropped. *Alnus serrulata - Kalmia carolina - Rhododendron catawbiense - Spiraea alba / Carex folliculata - Lilium grayi* Shrubland (CEGL003915) and *Rhododendron maximum / Sphagnum* spp. Shrubland (CEGL003849) were the shrub-dominated typic bog associations.

The name of the corresponding NVC association is particularly misleading in being called a shrubland as well as a seep. As with other mountain bog communities, shrubs are a part of it and can become unduly dense, but the presence of conservative herbaceous plants that need full sun indicates that they are not inherently dominated by shrubs.

Carex (atlantica, echinata, leptalea, lurida) - Solidago patula Herbaceous Vegetation (CEGL004156) is a broadly defined, apparently more depauperate bog association attributed to all of the states neighboring North Carolina. Its concept may overlap several North Carolina subtypes, probably most extensively the Low Elevation Subtype, but it is not considered to occur here.

Rare species:
Vascular plants – *Arethusa bulbosa, Calamagrostis canadensis, Carex buxbaumii, Carex utriculata, Carex vesicaria, Chelone cuthbertii, Chelone obliqua* var. *erwiniae, Coryphopteris simulata, Cuscuta cephalanthi, Dalibarda repens, Epilobium ciliatum* var. *ciliatum, Filipendula rubra, Glyceria laxa, Helenium brevifolium, Helonias bullata, Hexastylis rhombiformis, Hierochloe hirta, Lilium grayi, Liparis loeselii, Menyanthes trifoliata, Oenothera perennis, Packera crawfordii, Palustricodon* (*Campanula*) *aparinoides, Pedicularis lanceolata, Platanthera herbiola, Platanthera grandiflora, Poa palustris, Rhynchospora alba, Sarracenia purpurea* var. *montana, Solidago uliginosa* var. *uliginosa, Sparganium acaule, Spiraea alba, Thalictrum macrostylum, Vaccinium macrocarpon,* and *Veronica americana*.

Nonvascular plants – *Entodon sullivantii, Hypnum pratense, Sphagnum angustifolium, Sphagnum capillifolium, Sphagnum fallax*, *Sphagnum flexuosum,* and *Sphagnum fuscum*.

Vertebrate animals – *Glyptemys muhlenbergii*.

Invertebrate animals – *Euphydryas phaeton, Ladonia julia,* and *Somatochlora elongata*.

SOUTHERN APPALACHIAN BOG (LONG HOPE VALLEY SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, generally, extensive *Sphagnum* cover. Though traditionally known as bogs, these wetlands generally appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Long Hope Valley Subtype covers bogs of Long Hope Valley and related high elevation bogs, with a distinctive set of northern disjunct flora that includes species such as *Menyanthes trifoliata, Ilex collina,* and *Taxus canadensis* in addition to the larger set of species of northern affinities shared with the Typic Subtype.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora.

The Long Hope Valley Subtype is distinguished from other subtypes by a characteristic set of northern disjunct plant species, including *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*, as well as many of the broader set of species with northern affinities. It lacks many species of mid to lower elevations.

Crosswalks: *Carex atlantica - Rhynchospora alba - Parnassia asarifolia / Sphagnum warnstorfii* Herbaceous Seep (CEGL004157).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).
High Elevation Valley Fen – *Lyonia ligustrina* var. *ligustrina – Aronia arbutifolia* / *Eriophorum virginicum – Solidago patula* var. *patula / Sphagnum spp.* (2.8) (Wichmann 2009).

Sites: The primary location for the Long Hope Valley Subtype is a distinctive high elevation, low-gradient valley, at around 3900-4600 feet. A cold microclimate produced by sheltering, slope aspect, and cold air drainage may be an important part of the setting, as the valley is surrounded by high peaks and runs northward. The bogs are in discrete spots scattered through the valley, with some on gentle lower slopes and side valleys. The only other known example is in a smaller valley at 4100 feet.

Soils: Soils in the primary occurrence of the Long Hope Valley Subtype are mapped broadly as a newer series called Longhope (Terric Haplohemist with a frigid temperature regime). This suggests a deeper organic layer than most examples of other subtypes, but soils may be more heterogeneous than this implies. The other known example is mapped as Nikwasi (Cumulic Humaquept).

Hydrology: The Long Hope Valley Subtype occurs in permanently saturated sites with groundwater seepage, similar to other subtypes.

Vegetation: As with other Southern Appalachian Bogs, the Long Hope Valley Subtype is variable in vegetation structure and dominance. Some bogs there seem less altered than any Southern Appalachian Bogs elsewhere. These have a dense herb layer with only sparse shrubs and small trees in the interior, with a zone of dense shrubs and sparse trees on the edge. *Picea rubens* is the primary tree. Shrubs include *Rhododendron maximum, Salix sericea, Ilex collina*, and *Rosa palustris*. Other trees and shrubs frequent in CVS and Wichmann (2009) data include *Acer rubrum, Lyonia ligustrina, Aronia melanocarpa, Viburnum cassinoides*, and *Lonicera dioica*. Highly constant and sometimes dominant herb layer species in Wichmann (2009) are *Sphagnum* spp., *Carex echinata* var. *echinata, Schizachyrium scoparium, Houstonia serpyllifolia, Solidago patula,* and *Vaccinium macrocarpon*. Other species that are less constant but sometimes locally dominant in plots include *Rhynchospora alba, Rhynchospora capitellata, Carex leptalea* spp. *leptalea, Carex buxbaumii, Scirpus expansus*, and *Juncus* sp. Several less dominant species are highly constant in plots: *Packera aurea, Drosera rotundifolia, Juncus effusus,* and *Oxypolis rigidior*. Other frequent species in plot data include: *Eriophorum virginicum, Parnassia asarifolia, Thelypteris palustris, Pogonia ophioglossoides, Viola cucullata, Galium asprellum, Epilobium leptophyllum, Linum striatum, Eleocharis tenuis, Hypericum mutilum, Luzula echinata, Platanthera lacera, Viola pallens, Osmundastrum cinnamomeum, Lycopodioides apodum, Cirsium muticum*, and *Rubus hispidus* or *trivialis*. Also notable as distinct to this subtype is *Menyanthes trifoliata*.

Range and Abundance: Ranked G1. The Long Hope Valley Subtype is a narrow endemic community, confined to one large and one small site in Watauga and Ashe County.

Associations and Patterns: The Long Hope Valley Subtype is a small patch community, with individual patches each a few acres or less. Many patches are associated with Swamp Forest–Bog Complex (Spruce Subtype). Others are surrounded by upland communities, including Northern Hardwood Forest and unusual lower slope stands of *Picea rubens*. Though not well known, it appears that some bog patches in the lower part Long Hope Valley represent the Typic Subtype rather than the Long Hope Valley Subtype.

Variation: Little is known about the variation among the few examples.

Dynamics: Dynamics of the Long Hope Valley Subtype are presumed to be generally similar to those of other Southern Appalachian Bog Subtypes. However, some of the bogs in upper Long Hope Valley appear not to show rapid invasion by shrubs and trees, and perhaps are more stable. This area is remote from the pastures in the site and may not have been grazed. This needs further study. The other occurrence of the Long Hope Valley Subtype is also notable for its dynamic setting. Most of the bog was inundated by an artificial lake, which was later drained. It is clear that bog vegetation persisted above the level of the lake, and that it spread into nearby parts of the drained lake bed. More recently, beavers have impounded part of the bog within the lake bed.

Comments: The Long Hope Valley Subtype conceptually represents a higher elevation equivalent to the Low Elevation and Typic subtypes, with the effects of its elevation perhaps enhanced by its occurrence in a "hanging" valley where cold air drainage and accumulation may be important. However, some other aspects of its vegetation, such as the importance of *Schizachyrium scoparium*, are less explicable. Additionally, though Long Hope Valley is higher than most Southern Appalachian Bogs, at least a couple occur at similar elevations but better resemble the Typic Subtype.

The bogs of Long Hope Valley have long been regarded as unique, and this subtype has been assumed to be confined to that site. However, analysis by Wichmann (2009) showed that one other bog was similar, and that some of the bogs in lower Long Hope Valley were more like the Typic Subtype.

Earlier drafts of the 4th approximation, and the NVC, recognized separate herb and shrub subtypes for Long Hope Valley bogs. These have been combined in both the 4th Approximation and the NVC. The communities appear to be naturally patchy and there is no benefit in distinguishing small, closely intermixed shrub and herb patches. The concept of the association crosswalked to the Long Hope Valley Subtype has been broadened in the NVC to include both herb and shrub zones. The association treated as the Long Hope Valley Shrub Subtype, *Rhododendron (maximum, catawbiense) - Ilex collina - Salix sericea / Carex trisperma - Eriophorum virginicum* Seepage Shrubland (CEGL003913), has been narrowed to represent communities of even higher elevation in southern Virginia and no longer is treated as occurring in North Carolina.

Rare species:
Vascular plants – *Carex baileyi, Carex buxbaumii, Carex lasiocarpa, Carex oligosperma, Carex trisperma, Hierochloe hirta, Ilex collina, Lilium grayi, Lonicera canadensis, Menyanthes trifoliata, Micranthes pensylvanica, Oenothera perennis, Pycnanthemum virginianum, Rhynchospora alba, Taxus canadensis, Utricularia cornuta,* and *Vaccinium macrocarpon*.

Nonvascular plants – *Sphagnum angustifolium, Sphagnum capillifolium, Sphagnum contortum, Sphagnum fallax, Sphagnum flexuosum, Sphagnum fuscum, Sphagnum russowii, Sphagnum subsecundum,* and *Sphagnum warnstorfii*

Vertebrate animals – *Glyptemys muhlenbergii.*

SOUTHERN APPALACHIAN BOG (SKUNK CABBAGE SUBTYPE)

Concept: The Skunk Cabbage Subtype is a very rare bog community resembling the Low Elevation Subtype but with floristic vegetational differences that include abundant *Symplocarpus foetidus* and the presence of several other species not found in the Low Elevation Subtype.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora. Though *Symplocarpus foetidus* is sometimes found in Low Elevation Seep communities, the Skunk Cabbage Subtype of Southern Appalachian Bog can be distinguished from them by the abundance of characteristic Southern Appalachian Bog species such as *Carex baileyi, Carex folliculata, Carex atlantica*, and *Carex echinata*.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species listed as distinguishing features for the Typic and Low Elevation subtypes also apply to the Skunk Cabbage Subtype, except that this subtype shares at least one species, *Toxicodendron vernix,* with French Broad Valley Bogs but not with other subtypes of Southern Appalachian Bog.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish. This is particularly problematic in the few examples of the Skunk Cabbage Subtype.

The Skunk Cabbage Subtype is distinguished from other subtypes by having *Symplocarpus foetidus* present in more than trivial amounts. This subtype is extremely rare, with only several examples known in North Carolina. The examples are more forested than most Southern Appalachian Bogs, but their flora is more bog-like than a typical Swamp Forest–Bog Complex.

Crosswalks: *Pinus rigida / Toxicodendron vernix / Gaylussacia baccata / Symplocarpus foetidus* Seep Woodland (CEGL003667).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped areas near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. The known examples of the Skunk Cabbage Subtype occur around 2600-2700 feet elevation.

Soils: The soils of the Skunk Cabbage Subtype are similar to other subtypes in being saturated and high in organic matter. The known examples are mapped simply as "alluvial land – wet" but presumably belong to a series such as Nikwasi (Cumulic Humaquept), Toxaway (Cumulic Humaquept), or Cullowhee (Fluvaquentic Humadept),

Hydrology: Southern Appalachian Bogs are permanently saturated. In hydrologic classifications of mires they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Some limitation on drainage of water away from the site also appears needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: The natural vegetation structure and dominance of the Skunk Cabbage Subtype is even more uncertain than most Southern Appalachian Bogs. Both Wichmann (2009) and the NVC description emphasized a tendency to have substantial tree cover. The couple of known examples are dominated by *Pinus rigida* and *Acer rubrum* in an open but substantial canopy, with *Pinus strobus* and *Nyssa sylvatica* also having substantial cover. Constant or frequent shrubs with high cover in CVS plot data include *Alnus serrulata, Ilex verticillata, Lyonia ligustrina, Rhododendron maximum, Kalmia carolina,* and reportedly, *Viburnum nudum* as well as *Viburnum cassinoides*. Less abundant in plots but highly constant are *Aronia arbutifolia* and *Vaccinium corymbosum*, while *Toxicodendron vernix, Viburnum cassinoides, Aronia melanocarpa*, *Hypericum densiflorum, Hypericum prolificum, Kalmia latifolia, Rosa palustris, Spiraea tomentosa, Vaccinium fuscatum, Swida* (*Cornus*) *amomum, Gaylussacia baccata, Sambucus canadensis,* and *Lindera benzoin* are also frequent. With the denser woody cover, the herb layer is patchy. Frequent herbs that sometimes dominate patches in CVS plots include *Carex baileyi, Osmundastrum cinnamomeum, Glyceria striata, Glyceria laxa, Carex stricta,* and *Coryphopteris (Thelypteris*) *simulata*. Other frequent herbs in plots include *Carex folliculata, Viola pallens, Viola cucullata, Impatiens capensis, Carex atlantica, Carex intumescens, Carex echinata* spp. *echinata, Chelone cuthbertii, Houstonia serpyllifolia, Lycopus virginicus, Rubus (Dalibarda) repens, Symphyotrichum puniceum* var. *puniceum, Symphyotrichum dumosum, Bartonia virginica, Juncus effusus, Juncus subcaudatus, Dichanthelium lucidum, Hypericum mutilum,* and *Persicaria sagittata*.

Range and Abundance: Ranked G1. The Skunk Cabbage Subtype is known in North Carolina only in two closely associated sites in Alleghany County. The NVC association is also attributed to Georgia. However, *Symplocarpus foetidus* does not occur in or near Georgia, and it is unclear if the community there is really similar.

Associations and Patterns: The Skunk Cabbage Subtype is a small patch community, with the known occurrences covering at most a few acres. It is associated with Swamp Forest–Bog Complex (Typic Subtype) and may be associated with Southern Appalachian Bog (Low Elevation Subtype). The surrounding uplands are heavily altered, but examples likely were surrounded by Acidic Cove Forest.

Variation: Little is known about the range of natural variation. The known examples are similar to other bogs in being extremely heterogeneous and in having a history of clearing that makes the natural vegetation structure uncertain.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Skunk Cabbage Subtype well in all their complexity. The factors that lead to the formation of this subtype rather than the Low Elevation Subtype are not well known. *Symplocarpus foetidus* is at the southern limit of its large contiguous range where this subtype occurs. *Toxicodendron vernix* has a widely scattered range, with a small cluster of counties of occurrences in the vicinity but with species not tending to be present in other bogs in the area.

Comments: The Skunk Cabbage Subtype is accepted provisionally but much uncertainty remains about its natural character and distinctiveness. It is also unclear where it best fits within the 4th Approximation. Because only a couple of examples are known and they are substantially altered, it is less clear than usual which aspects of the vegetation result from alteration and which are part of the natural character. All descriptions have emphasized the amount of tree cover, which may be greater than indicated in the plots that were placed in the most open areas. Wichmann's (2009) analysis grouped it with Swamp Forest–Bog Complex sites. It is treated as a subtype of Southern Appalachian Bog instead because it includes a diverse herbaceous flora more typical of that type. Given the number of tree stems that have been cut out of the most highly regarded examples of the Typic Subtype and Low Elevation Subtype in recent decades to maintain open conditions, it is unclear how much weight to give tree cover. Nevertheless, it must be noted that the *Pinus rigida* trees that dominate in the primary example of the Skunk Cabbage Subtype are large and appear to be old.

It is also unclear what interpretation to give to *Symplocarpus foetidus*, the most abundant species distinct to this subtype. The species does not extend further south in North Carolina, at least in mountain bogs. In states to the north, it occurs in a wide range of wetlands and is not characteristic of bogs. Most of its habitat is more similar to Low Elevation Seeps. Its abundance in this community may be coincidental. Nevertheless, the vegetation of the Skunk Cabbage Subtype differs from the Low Elevation Subtype in containing abundant *Toxicodendron vernix*, *Kalmia carolina*, and perhaps *Viburnum nudum*, species that are shared with French Broad Valley Bogs as well as with wetlands outside the mountains but not with other Southern Appalachian Bog subtypes. At the same time, its range is distant from that of the French Broad Valley Bogs and it lacks most of the other distinctive flora of that community.

Rare species:
Vascular plants – *Carex buxbaumii, Carex trichocarpa, Carex vesicaria, Coryphopteris* (*Thelypteris*) *simulata, Dalibarda repens, Glyceria laxa, Helenium brevifolium, Lilium grayi, Platanthera grandifolia, Poa palustris,* and *Vaccinium macrocarpon*.

Vertebrate animals – *Empidonax alnorum* and *Glyptemys muhlenbergii*.

FRENCH BROAD VALLEY BOG

Concept: French Broad Valley Bogs are open herb- and shrub-rich acidic wetlands of flat stream bottoms or gentle slopes, containing a distinctive flora that includes species shared with Southern Appalachian Bog, species of Coastal Plain affinities, and some additional species that are scarce or absent in the Southern Appalachian Bog and Low Mountain Seepage Bog types. Such bogs are known only from the upper French Broad River valley in the vicinity of Hendersonville, but do not include all bogs in the French Broad basin. They are generally not forested but contain trees on edges, in patches, and where trees have invaded formerly open areas.

Distinguishing Features: The French Broad Valley Bog community is distinguished from Southern Appalachian Bog by floristic differences. The suite of species present in French Broad Valley Bogs but rarely or never in other bogs includes a number of species typical of the Coastal Plain but also some endemic and northern disjunct species. Distinctive species include *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Anchistea virginica*, *Lorinseria areolata, Myrica gale, Chamaedaphne calyculata, Gaylussacia orocola* (*dumosa var. bigeloviana)*, and *Sarracenia jonesii*. Plants present in Southern Appalachian Bogs but not in French Broad Valley Bogs include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris (Thelypteris) simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Ilex collina, Picea rubens, Vaccinium macrocarpon*, and *Micranthes* (*Saxifraga) pensylvanica*.

French Broad Valley Bogs are distinguished from the Low Mountain Seepage Bog by floristic differences as well as by differences in environment and biogeography. Both contain a number of species of Coastal Plain affinities, but the suite of species is quite different. Besides the species mentioned above that are distinct only to French Broad Valley Bogs, the following species occur only in Low Mountain Seepage Bogs: *Sarracenia oreophila, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*.

Crosswalks: *Alnus serrulata - Viburnum nudum var. nudum - Chamaedaphne calyculata / Woodwardia areolata - Sarracenia rubra ssp. jonesii* Seepage Shrubland (CEGL003918).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: French Broad Valley Bogs occur in flat or gently sloping bottoms of small to large streams, at the base of upland slopes where seepage water can be discharged. Elevations are around 2000-3000 feet.

Soils: Mapped series are Hatboro (Typic Fluvaquent), Tate (Typic Hapludult), and Toxaway (Cumulic Humaquept). The bogs presumably represent inclusions in all of these units except possibly Toxaway.

Hydrology: French Broad Valley Bogs, like Southern Appalachian Bogs, are permanently saturated. In hydrologic classifications of mires they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site also appears needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: The natural vegetation structure of French Broad Valley Bogs is not known because of a universal history of clearing and grazing. They likely existed as mosaics of shrub and herb dominance with scattered trees, as is observed in the least altered examples. Characteristic trees are *Nyssa sylvatica*, *Pinus rigida*, *Pinus strobus,* and *Acer rubrum*. A tremendous variety of shrubs may be present. Most frequent are *Alnus serrulata, Rhododendron maximum, Toxicodendron vernix, Rosa palustris, Rhododendron viscosum, Swida* (*Cornus*) *amomum, and Gaylussacia orocola*. Other fairly frequent shrubs include *Lyonia ligustrina, Aronia arbutifolia, Aronia melanocarpa, Viburnum nudum, Viburnum cassinoides, Ilex verticillata, Viburnum dentatum*, and *Leucothoe fontanesiana*, along with *Smilax laurifolia*. Though not frequent, notable disjunct shrub species, including *Chamaedaphne calyculata*, *Kalmia carolina*, and *Gale palustris,* occur in some examples. The herb layer is characteristically dense and is usually dominated by sedges or ferns. *Osmundastrum cinnamomeum* and sometimes *Lorinseria areolata* are abundant. *Sphagnum* forms a dense layer beneath the herbs in sizeable patches. A variety of sedges has been found in these bogs, differing substantially among examples. *Carex folliculata*, *C. collinsii*, *C. intumescens, C. radiata*, and *Carex schweinitzii* have been found in multiple bogs, and many more species are known only in one. *Rhynchospora* spp., *Eleocharis* spp., and *Scirpus* spp. increase the sedge diversity. *Juncus effusus, Juncus gymnocarpus, and Calamagrostis coarctata (cinnoides)* also occur in multiple examples. Frequent among forbs are *Sarracenia purpurea* var. *montana*, *Sarracenia jonesii*, *Chelone cuthbertii, Persicaria sagittata, Eupatorium fistulosum*, and *Eupatorium perfoliatum*. Other notable herbs found in a few examples include *Xerophyllum asphodeloides, Rhexia* sp., *Epilobium ciliatum, Helonias bullata*, *Arethusa bulbosa,* and *Juncus caesariensis*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina. All remaining examples are in Henderson and nearby Transylvania County. Numerous examples are believed to have been destroyed in the area around Hendersonville, but this community is unlikely to have ranged much beyond its current range.

Associations and Patterns: French Broad Valley Bogs are small patch communities. Most examples are now surrounded by heavily altered lands. Naturally, they likely were bordered by Acidic Cove Forests, occasionally by oak forests.

Variation: No variants are recognized, but each remaining example is somewhat different in flora and structure.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general appear to fit French Broad Valley Bogs, to the extent they are known. The French Broad Valley Bogs probably differ from the Southern Appalachian Bogs primarily due to biogeography, rather than to a difference in environment or dynamics. The southern location and occurrence in a large valley that once had more extensive bogs probably are the crucial factors.

Comments: The concept of French Broad Valley Bog has been narrowed from that in early drafts of the 4^{th} Approximation and that implied in Weakley and Schafale (1994). Bogs in the Mills River drainage and most bogs upstream of the Hendersonville valley share some limited flora but are floristically more similar to Southern Appalachian Bog (Low Elevation Subtype), so they are now treated as that community.

French Broad Valley Bogs were not recognized in Wichmann (2009). This appears to be a result of inadequate sampling rather than evidence that they are not distinct. The only plots from a French Broad Valley Bog (under the new, narrowed definition) were classified in the altered vegetation types and included few of the distinctive plants.

As in other mountain bog associations, the NVC name of "seepage shrubland" is misleading. In all mountain bogs, shrubs are a natural component but are dominant only in local patches or zones.

Rare species:
Vascular plants – *Arethusa bulbosa, Carex buxbaumii, Carex utriculata, Chelone cuthbertii, Chelone obliqua* var. *erwiniae, Chelone obliqua* var. *obliqua, Dalibarda repens, Epilobium ciliatum* ssp. *ciliatum, Gaylussacia orocola, Glyceria laxa, Helonias bullata, Hexastylis rhombiformis, Juncus caesariensis, Lilium canadense, Myrica gale, Narthecium montanum, Neottia australis, Platanthera integrilabia, Prunus susquehanae, Sagittaria fasciculata, Sarracenia jonesii, Sarracenia purpurea* var. *montana, Stachys eplingii,* and *Thalictrum macrostylum.*

Vertebrate animals – *Glyptemys muhlenbergii*.

LOW MOUNTAIN SEEPAGE BOG

Concept: The Low Mountain Seepage Bog community type is a nonforested, shrub- or herb-dominated acidic wetland of low elevation, gentle, seepage-fed slopes, containing a distinct suite of plants that includes numerous Coastal Plain disjuncts but is floristically different from the French Broad Valley Bog type.

Distinguishing Features: The Low Mountain Seepage Bog is distinguished from French Broad Valley Bogs and Southern Appalachian Bogs by substantial floristic differences. Low Mountain Seepage Bogs contain a suite of primarily Coastal Plain disjunct species not found in other mountain wetlands. These include *Sarracenia oreophila, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius, Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*.

Crosswalks: *Alnus serrulata - Rhododendron arborescens / Sarracenia oreophila - Rhynchospora rariflora* Seepage Shrubland (CEGL003914).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: The Low Mountain Seepage Bog community occurs on gentle slopes with seepage at low elevation — about 1900 feet. A shallow rock ledge may be important in producing the seepage.

Soils: Soils are mapped as Dillard (Aquic Hapludult) and Nikwasi (Cumulic Humaquept).

Hydrology: A hydrologic study of the most intact example (Wilcox et al. 2020) described it as a hypocrene spring-fed fen, where ground water frequently approaches the surface but rarely reaches it. Ground water is perched atop bedrock and a dense sloping clay layer. The authors believed that evapotranspiration was important to keeping ground water levels lower than the surface and noted that after at least one fire, which substantially reduced woody vegetation, ground water levels rose more than observed with similar rainfall in other years.

Vegetation: All examples are substantially altered, so that it is difficult to know the natural vegetation structure. The most intact remaining example is a mix of shrub and herb zones, blending into a cleared pasture. Shrubs include *Alnus serrulata, Lyonia ligustrina, Aronia arbutifolia, Aronia melanocarpa, Rhododendron arborescens, Rosa palustris,* and *Sambucus canadensis*. Abundant herb species include *Osmundastrum cinnamomeum, Rhynchospora rariflora, Sarracenia oreophila, Eriocaulon decangulare, Amauropelta* (*Parathelypteris*) *noveboracensis, Sagittaria latifolia, Eupatorium perfoliatum, Eupatorium pilosum, Eupatorium fistulosum, Rhexia virginica, Rhexia mariana, Eryngium integrifolium, Helianthus angustifolia, Eriophorum virginicum, Sanguisorba canadensis*, and *Juncus caesariensis*.

Range and Abundance: Ranked G1. Low Mountain Seepage Bog is one of the rarest of natural communities in North Carolina, with only one remaining fair quality example, itself significantly altered. Another, more altered example is present in nearby Georgia, and historical examples were present nearby. The equivalent association is also attributed to Tennessee and Georgia.

Associations and Patterns: Low Mountain Seepage Bog is a small patch community. Natural surroundings are uncertain. The occurrence in a low elevation valley makes it likely that it was naturally surrounded by a dry oak forest or perhaps Low Mountain Pine Forest.

Variation: Natural variation among examples is uncertain.

Dynamics: This community shares with many Mountain Bogs and Fens communities the tendency for shrubs to invade and to threaten the distinctive herbaceous flora. Otherwise, the dynamics of this community appear different from most communities in the theme. Fire appears to be an important ecological process in this community, with its occurrence in a dry, low-elevation valley and its tendency for the soil surface to be dry. Recent prescribed burning appears to have reduced the invading woody vegetation and benefitted *Sarracenia*, though it is unclear what fire regime is natural or is most beneficial to the community as a whole.

Comments: This community was not treated by Wichmann (2009) because of a lack of sufficient plot data. This community is different enough from other Mountain Bogs and Fens that its inclusion in this theme is provisional. It shares some characteristics with Low Elevation Seeps and even with Sandhill Seeps but an important portion of its flora is of bog affinities.

Rare species:
Vascular plants – *Juncus caesariensis* and *Sarracenia oreophila*.

SOUTHERN APPALACHIAN FEN (BLUFF MOUNTAIN SUBTYPE)

Concept: Southern Appalachian Fens are herb-dominated wetlands fed by base-rich waters seeping from amphibolite or ultramafic rocks. The Bluff Mountain Subtype covers the floristically distinct example known only from Bluff Mountain.

Distinguishing Features: Southern Appalachian Fens are distinguished by the presence or abundance of a suite of calciphilic species of northern affinities, such as *Muhlenbergia glomerata, Cladium mariscoides, Triantha (Tofieldia) glutinosa*, and *Sphagnum subsecundum,* which are absent or scare in more acidic mountain herbaceous or shrubby wetlands. The Bluff Mountain Subtype is distinguished from the Glades Subtype by floristic differences and by its higher elevation. While many species are shared, *Cladium mariscoides*, *Carex torta*, and *Triantha glutinosa* are abundant and frequent in the Bluff Mountain Subtype and are scarce or absent in the Glades Subtype, and *Thelypteris palustris, Glyceria striata, Helenium brevifolium*, and a number of shrubs are among the many species in the Glades Subtype but absent at Bluff Mountain.

Crosswalks: *Cladium mariscoides - Sanguisorba canadensis / Sphagnum subsecundum* Herbaceous Seep (CEGL004167).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: The one example occurs in a small, high elevation, low-gradient "perched" valley at about 4300 feet elevation. The underlying rock is amphibolite.

Soils: The soil is a shallow muck overlying amphibolite bedrock. It is mapped as the Toxaway series, a Cumulic Humaquept.

Hydrology: The fen is permanently saturated by ground water seeping from amphibolite. Unlike the Southern Appalachian Bogs, it is high in dissolved cations such as calcium and magnesium and has a circumneutral pH.

Vegetation: The vegetation is a complex of herbaceous zones responding to soil depth and wetness. Species dominant in zones include *Rhynchospora alba, Rhynchospora capitellata, Juncus subcaudatus, Cladium mariscoides, Carex stricta, Helenium autumnale, Schizachyrium scoparium, Sanguisorba canadensis, Solidago uliginosa* var. *uliginosa*, and *Osmunda spectabilis*. Other characteristic species include *Huperzia appalachiana, Eriophorum virginicum, Houstonia cerulea, Utricularia cornuta, Osmundastrum cinnamomeum, Liatris aspera, Muhlenbergia glomerata, Triantha glutinosa, Carex conoidea, Carex buxbaumii*, and *Parnassia grandiflora* (Weakley and Schafale 1994). Other species found in the plot reported by Wichmann (2009) include *Drosera rotundifolia* var. *rotundifolia*, *Carex atlantica, Linum striatum, Lycopus uniflorus, Xyris torta, Carex leptalea* var. *leptalea*, *Houstonia serpyllifolia*, *Viola cucullata*, *Packera aurea*, and *Eleocharis tenuis*. A suite of characteristic bryophytes is also present, including *Sphagnum subsecundum, Rhytidium rugosum, Hypnum pratense, Campylium stellatum, Calliergon cordifolium*, and *Calliergonella cuspidata*.

Range and Abundance: Ranked G1. Only a single occurrence is known. No more are likely to be found, as the site is unique.

Associations and Patterns: The fen is closely associated with the High Elevation Mafic Glade (Bluff Mountain Subtype) community and is otherwise largely surrounded by Montane Oak–Hickory Forest (Basic Subtype).

Variation: Only a single site exists.

Dynamics: The fen is apparently maintained by the saturated and shallow soil and shows little sign of the encroachment by woody plants seen in most Mountain Bogs and Fens.

Comments: In broader classifications of mires in glaciated regions farther north, this type would likely be considered an intermediate, possibly a rich, fen, while Southern Appalachian Bog and French Broad Valley Bog, which appear to be fed by acidic ground water, would be considered poor fens.

Rare species:
Vascular plants – *Bromus ciliatus, Calamagrostis canadensis* var. *canadensis, Carex aquatilis* var. *substricta, Carex buxbaumii, Carex conoidea, Crocanthemum bicknellii, Crocanthemum propinquum, Gentianopsis crinita, Huperzia appalachiana, Lilium grayi, Muhlenbergia glomerata, Oenothera perennis, Parnassia grandifolia, Rhynchospora alba, Solidago uliginosa* var. *uliginosa, Spiranthes lucida, Stachys appalachiana, Stenanthium leimanthoides, Symphyotrichum laeve, Thalictrum macrostylum, Triantha glutinosa,* and *Utricularia cornuta*.

Nonvascular plants – *Campylium stellatum, Cephaloziella hampeana, Cladonia psoromica,* and *Sphagnum subsecundum*.

Vertebrate animals – *Glyptemys muhlenbergii*.

SOUTHERN APPALACHIAN FEN (GLADES SUBTYPE)

Concept: Southern Appalachian Fens are herb-dominated wetlands fed by base-rich waters seeping from amphibolite or ultramafic rocks. The Glades Subtype covers the floristically distinct examples from The Glades in Virginia, and adjacent areas in Alleghany County. Only a very altered area possibly representing this subtype occurs in North Carolina, and more intact examples are unlikely to be found, but a potential remains for restoration.

Distinguishing Features: With no intact remnants in North Carolina and the only remnants in Virginia substantially altered, details of the floristic differences between this subtype and the Bluff Mountain Subtype are sparse. It could be distinguished by the presence of rich fen species such as *Muhlenbergia glomerata*, *Parnassia grandiflora*, and *Xyris torta*, with species not found in the Bluff Mountain Subtype and suggestive of lower elevation, such as *Panicum virgatum* and *Osmunda spectabilis*.

Crosswalks: *Alnus serrulata / Sanguisorba canadensis - Parnassia grandifolia - Helenium brevifolium* Seepage Shrubland (CEGL003917). *Alnus serrulata / Sanguisorba canadensis - Calamagrostis canadensis* Seepage Shrubland (CEGL004252).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).

Sites: Examples occur on nearly flat areas where seepage emerges from hornblende gneiss or amphibolite, at 2400-3500 feet in elevation.

Soils: No details are known about the soil, but it likely would be classified as the Toxaway series, a Cumulic Humaquept.

Hydrology: The fen is permanently saturated by ground water seeping from amphibolite.

Vegetation: No intact examples are known in North Carolina. In the Virginia occurrence (as described in the NVC), the community is a mosaic of herb and shrub zones, with only sparse trees such as *Pinus strobus* and *Acer rubrum*. Predominant shrubs are *Alnus serrulata, Spiraea latifolia, Spiraea tomentosa*, and *Lyonia ligustrina* var. *ligustrina*. Herb species include *Glyceria striata, Juncus subcaudatus, Osmunda spectabilis, Oxypolis rigidior, Viola cucullata, Eleocharis tenuis, Cirsium muticum, Dichanthelium dichotomum, Houstonia caerulea, Oenothera perennis, Sanguisorba canadensis, Parnassia grandifolia, Symphyotrichum novi-belgii, Carex atlantica, Helenium brevifolium, Solidago uliginosa, Calopogon tuberosus, Muhlenbergia glomerata, Schizachyrium scoparium, Xyris torta, Panicum virgatum, Rhynchospora capitellata, Rhynchospora alba*, and *Lycopodioides (Selaginella*) *apodum*

Range and Abundance: Ranked G1. Only one uncertain example, too highly altered to be certain, is known from North Carolina. A small number of well-developed examples occur in Virginia within a few miles of the state line.

Associations and Patterns: The Glades Subtype is a small patch community. It probably naturally graded to Montane Oak–Hickory Forest (Basic Subtype) or Rich Cove Forest (Montane Rich Subtype).

Variation: Two NVC associations appears to be equivalent to this concept in adjacent Virginia. If both are found in North Carolina, they might be found to be distinct enough to treat as separate subtypes but probably would serve better as variants.

Dynamics: Little is known of the natural dynamics of this subtype. It is unclear to what extent the shrubbiness of the current vegetation is a result of shrub encroachment, as happens in most Mountain Bogs and Fens.

Comments: This subtype is perhaps best regarded as an extirpated community in North Carolina. However, the possibility remains of an attempt at restoring it.

Rare species: No rare species are known to be specifically associated with this community.

UPLAND SEEPAGES AND SPRAY CLIFFS THEME

Concept: Upland Seepages and Spray Cliffs are small patch wetlands that are saturated for long periods by seepage of shallow or deep groundwater or by spray from waterfalls, with limited or no surface flooding or ponding of water, and which lack the characteristic flora and vegetation of Mountain Bogs and Fens, Streamhead Pocosins, Wet Pine Savannas, or other themes. A few may occur in floodplains or along stream courses but have their hydrology more affected by long-term saturation than by flooding.

Distinguishing Features: Upland Seepages are distinguished by their saturated hydrology and by a flora consisting of broadly tolerant wetland species without the concentration of specialized extreme acid-tolerant flora of bogs, the calciphilic flora of Southern Appalachian Fen, or the specialized flora of frequently burned pine savannas. While shrubs typical of pocosins may be present, even outside the Coastal Plain, these seepages lack the dense shrub layer typical of pocosin communities and generally lack *Pinus serotina*. They are also distinguished from minor seepage zones in rock outcrop and upland communities by size. Patches may be only a few meters in size but must be large enough to support a characteristic flora of wetland plants. Spray Cliffs are unique communities distinguished by association with waterfalls and with substantial and long-term spray, though seepage may also be present.

Within this theme, several communities are distinguished from others by a component of bog-related plants, while not having the characteristics of true Mountain Bogs and Fens. This is sometimes a subtle distinction, but more minerotrophic wetland species are always present. Several are distinguished by the influence of flooding as well as seepage and by having a component of alluvial species. Other communities are distinguished by differences in vegetation related to geomorphic setting and biogeographic region.

Sites: Seepages occur on gentle to potentially steep upland slopes, along small headwater streams, or on the edges of larger floodplains at the base of an upland slope. There is sometimes an amphitheater-like landform which presumably is created by sapping by the groundwater flow. The groundwater discharge often is associated with a junction between two kinds of substrates, such as an upland slope and an alluvial floodplain, an impermeable layer with a permeable one, or sloping soil with bedrock, and this is sometimes marked by a change in slope. However, seeps may be associated with fractures in underlying bedrock and show no distinctive landform; some examples are distinguishable only by wetland vegetation in an upland location.

Spray Cliffs occur in association with waterfalls, along streams in areas with high topographic relief and resistant rock. Most of their extent is very steep, though gently sloping or horizonal portions may be present.

Soils: Soils of Upland Seepages and Spray Cliffs may span a broad range, from saturated loams or clays to gravel or bedrock, though they rarely are very sandy. They show the effect of saturation in gray color and often in high levels of organic matter. They may be deep or may be a shallow sheet of material over bedrock. Most are organic-rich, and a few may be true mucks. Soils in some communities can be very heterogeneous, with deep mucky pockets alternating with rocky areas or firm clay. Because these communities are all small patches, soils are seldom if ever recognized in soil mapping, and series may not ever be defined for them.

Hydrology: All Upland Seepages and Spray Cliffs are saturated permanently or at least through much of the growing season. The primary source of wetness is groundwater discharge. Ponded water is absent, very shallow, or limited to small microsites. Flooding by streams or rivers is short-term and is a secondary influence on the environment compared to the long-term saturation. The discharged water moves through the community, through the soil, sometimes in a shallow sheet, sometimes in rivulets with limited development of channels. The downstream edge of the community occurs where the water becomes concentrated in a deeper channel, where it sinks back deeper into the ground, or perhaps simply where it spreads out and its influence is reduced.

Vegetation: Vegetation within the Upland Seepages and Spray Cliffs theme ranges widely, though all communities contain abundant predominantly wetland species. The vegetation structure of many of the communities can be hard to characterize. Most have few or no trees rooted within them but, because patches are small, can have substantial canopy cover from trees rooted in adjacent forests. The NVC names some associations as herbaceous vegetation, some as forests, but with the exception of Low Elevation Seep (Piedmont/Mountain Springhead Subtype), rooted tree basal area is low in all. Shrub cover may be moderate or nearly absent. Most communities have a dense herb layer, though in Spray Cliff, Coastal Plain Seepage Bank, and Low Elevation Seep (Bedrock Subtype) the predominant cover may be bryophytes. Species composition is highly variable. A suite of wetland species with broad tolerance for saturated conditions occurs in multiple communities in this theme. It includes *Osmundastrum cinnamomeum, Osmunda spectabilis (regalis), Lorinseria areolata*, *Arisaema triphyllum, Impatiens capensis, Oxypolis rigidior, Houstonia serpyllifolia, Lycopus virginicus*, and, in the mountains, *Chelone glabra* and *Thalictrum clavatum*. *Carex* as a genus is often present and may be represented by a wide range of species. Shrubs of this theme include *Alnus serrulata, Lindera benzoin, Viburnum nudum, Vaccinium fuscatum, Eubotrys racemosa*, and *Aronia arbutifolia*. Many of these species are shared with Mountain Bogs and Fens, and some more specialized bog species, such as *Drosera rotundifolia* and several *Carex* species, may occasionally occur. However, bog specialist species in Upland Seepages and Spray Cliffs are mostly confined to one or two community types, are generally not abundant in them, and have limited diversity in any given site. Some species shared with floodplain wetlands, such as *Saururus cernuus* and *Lindera benzoin*, are also frequent. If trees are rooted in the community, they tend to be widespread wetland-tolerant species such as *Acer rubrum, Liquidambar styraciflua*, and *Liriodendron tulipifera*.

Dynamics: Upland Seepages and Spray Cliffs receive nutrients from the groundwater. Though the water may be acidic and fairly oligotrophic, they presumably are more fertile than many wetlands, though less so than floodplain communities. However, the stress of long-term saturation limits what plants can occur in these communities and presumably limits productivity.

Mountains Bogs and Fens also receive groundwater input. The reason for their lower nutrient status is not entirely clear, but presumably is primarily due to the chemistry of the water. How rapidly water moves through may also be important.

Most seepages are small enough that few trees are rooted in them. Canopy shade often comes largely from trees rooted in adjacent communities. As in other forests, trees are naturally uneven-aged and regenerate primarily in small gaps. The saturated soil may lead to shallow rooting by the trees that are rooted within the community, and this may make them more sensitive to windthrow than most forests. Because patches are often small, even a small gap can temporarily change the environment over the entire patch.

These communities are generally quite stable. However, wetness may vary in response to rainfall and vegetation may shift in response to climatic cycles. Flood flows may act as a natural disturbance in Spray Cliff and Piedmont Boggy Streamhead communities; a few Low Elevation Seep and Rich Montane Seep occurrences may similarly be affected, but most will not be.

The saturated soil and limited flammability of the vegetation in most Upland Seepages and Spray Cliffs makes fire a limited influence. However, the small size of patches subjects most of them to fire effects from the adjacent communities. Some have natural firebreaks in the form of rock outcrops or large floodplains, but many others are surrounded by flammable upland communities. Fire appears to be more important, perhaps crucial, in Hillside Seepage Bog communities.

In areas with feral pigs, these introduced animals can cause severe disturbance in seeps. Rossell, et al. (2016) documented the effects of their rooting in Rich Montane Seep communities in the Great Smoky Mountains.

Comments: Upland Seepages and Spray Cliffs are among the smallest communities recognized in the 4th Approximation but they usually contrast strongly with the surrounding landscape. Examples can be well developed, with a dozen or more wetland plants not found in the surrounding communities, in patches just a few meters wide. They may be important habitat for smaller animals, supporting a high density of salamanders and distinct species of insects. However, they also can range to patches small enough to not show the community characteristics well, which presumably also are too small to support viable populations of most animals.

Upland Seepages and Spray Cliffs have generally received limited study. They often are not addressed in local quantitative studies of vegetation. However, two focused studies have contributed to understanding of some of them. Seymour (2011) is the primary basis for classifying of the Piedmont wetlands, many of the communities in this theme. Zartman and Pittillo (1998) provide excellent data on Spray Cliffs in part of their range. The small size of many examples of these communities makes it hard to fit standard plots into them but a number of CVS plots exist for some of the communities.

KEY TO UPLAND SEEPAGES AND SPRAY CLIFFS

1. Community kept wet at least partially by spray from a waterfall............................**Spray Cliff**

1. Community not influenced by spray from a waterfall.

  2. Community along a Coastal Plain river or stream, occurring on a very steep bluff of clay wetted by seepage from above; vegetation consisting of bryophytes and sparse vascular plants.. ....**Coastal Plain Seepage Bank**

  2. Community not a steep clay bank along a Coastal Plain river; occurring in any region of the state.

    3. Mountain or foothills community dominated by combinations of *Diphylleia cymosa, Laportea canadensis, Rudbeckia laciniata, Monarda didyma, Impatiens capensis*, or similar species of moderately rich sites………………………………………… **Rich Montane Seep**

    3. Community of any region, dominated by species more tolerant of less rich sites; the above species, if present, very limited in diversity and abundance.

      4. Community at high elevation, usually above 5000 feet, only rarely lower; vegetation fairly bog-like, with extensive *Sphagnum* cover or presence of *Vaccinium macrocarpon* or other characteristic bog species (though with fewer such species than typical Southern Appalachian Bogs); vegetation generally dominated by grasses or *Carex* spp.; flora including species typical of high elevation, such as *Chelone lyonii, Impatiens pallida, Oclemena acuminata*, and *Hypericum graveolens*, along with more widespread species ………………………………………………………………… **High Elevation Boggy Seep**

      4. Community lower than 5000 feet elevation or, if occasionally higher, occurring on bedrock substrate without appreciable soil development; in any region of the state.

        5. Vegetation containing multiple woody Coastal Plain species such as *Smilax laurifolia, Cyrilla racemiflora*, and *Magnolia virginiana* along with other more widespread seep species; occurring in the Piedmont or occasionally in lower elevation Mountains.

          6. Community extending along a headwater stream in the central or eastern Piedmont, subject to brief flooding; containing a mixture of some richer species such as *Lindera benzoin* and upland species such as *Quercus alba*, along with Coastal Plain species and widespread seep species; well-developed canopy of trees rooted in the community usually present, consisting of species such as *Liriodendron tulipifera, Liquidambar styraciflua, Acer rubrum*, and upland species .... **Piedmont Boggy Streamhead**

          6. Community not along a headwater stream channel, though a stream may issue from it and it may contain small rivulets without channel development; community on an upland slope or in an amphitheater-like recess in a slope; trees rooted in the community abundant or not.

            7. Community in the foothills or occasionally in the Mountain Region; generally in a fairly large amphitheater-like basin; generally forming the headwaters of a stream; well-developed tree canopy usually present ..…………………………………………… …………………..**Low Elevation Seep (Piedmont/Mountain Springhead Subtype)**

            7. Community in the central or eastern Piedmont; on an upland slope or in a small basin not along a stream; trees rooted in the community few or none under natural conditions ....**Hillside Seepage Bog**

        5. Community not containing *Smilax laurifolia, Cyrilla racemiflora*, or *Magnolia virginiana* in appreciable amounts, other than in rare seeps in the Coastal Plain.

8. Mountain or rarely foothills community occurring on a substrate of bedrock with few fractures; occurring along a stream side, on the edge of a granitic dome, or on a steep cliff face; vegetation usually with extensive *Sphagnum* or other bryophyte cover. ....**Low Elevation Seep (Bedrock Subtype)**

8. Community not occurring on bedrock substrate; generally with limited bryophyte cover; occurring in any region.

9. Community occurring on the edge of a well-developed floodplain of a river or stream in any region of the state; floodplain species such as *Fraxinus pennsylvanica* and *Acer negundo* usually present; species of wetter sites such as *Peltandra virginica, Saururus cernuus, Leersia oryzoides*, and *Persicaria sagittata* often present, along with more widespread seep species ....**Low Elevation Seep (Floodplain Subtype)**

9. Community not in a floodplain; on an upland slope, along a headwater stream, or in a recess on a slope above a floodplain.

10. Community in the Mountain Region or foothills; vegetation containing characteristic mountain species not typical of the Piedmont, such as *Micranthes micranthidifolia, Houstonia serpyllifolia, Thalictrum clavatum*, and *Chelone glabra* ………………………………………….. **Low Elevation Seep (Montane Subtype)**

10. Community in the Piedmont or rarely in the Coastal Plain; characteristic mountain species lacking. .... **Low Elevation Seep (Typic Subtype)**

SPRAY CLIFF

Concept: Spray Cliffs are communities of rock outcrops kept constantly wet by spray from falling water, sometimes supplemented by seepage. These communities are largely herbaceous but may contain some shrubs and trees. They are often small, sometimes vertical or nearly so, and may be partially shaded by trees rooted in adjacent forests.

Distinguishing Features: Spray Cliffs may be distinguished from all other communities by long-term wetness created by spray from falling water. They generally have well-developed bryophyte cover compared with adjacent dry Montane Cliff communities. The transition to drier cliff may be gradual. They are distinguished from forests by the absence of a closed tree canopy, due to steepness and lack of soil, though they may have substantial shade from trees rooted in adjacent forests. The presence of a well-developed spray zone depends on the configuration of the falls as much as the amount of water and the distance of fall. Some large falls have little or no Spray Cliff present, while relatively small falls can have exemplary ones. Drier cliffs near waterfalls may be wet briefly from spray at times of unusually high stream flow.

Crosswalks: *Vittaria appalachiana – Heuchera parviflora var. parviflora – Houstonia serpyllifolia / Plagiochila* spp. Cliff Vegetation (CEGL004302).
G961 Southern Appalachian Cliff & Rock Vegetation Group.
Southern Appalachian Spray Cliff Ecological System (CES202.288).

Sites: Spray Cliffs occur in association with waterfalls, along streams in areas with high topographic relief and resistant rock. Most of their extent is very steep, but gently sloping or horizonal portions may be present. Many waterfalls also have a grotto or overhanging portion, where light levels are low. Most Spray Cliffs are in narrow gorges, where topography shelters them from drying sun and wind. The exposure to large amounts of water also buffers temperature extremes and keeps humidity high.

Soils: Generally, no developed soil is present other than in small patches and in pockets in crevices.

Hydrology: Spray Cliffs are saturated or at least wet on the surface much or all of the year. Spray is an important and constant source of wetness, but seepage may also contribute to saturation. The high humidity created by falling water, spray, and topographic sheltering also reduces evaporation. Waterfalls are subject to the dynamics of the streams that form them. In times of flood, Spray Cliffs may be disturbed by scouring or movement of debris.

Vegetation: Vegetation of Spray Cliffs is highly variable among sites and is often extremely heterogeneous within a single example. Most portions of most examples have low cover of vascular plants. Rare examples have dense grass or sedge vegetation, and local portions may have high cover from shrubs or trees rooted in crevices. High cover and diversity of bryophytes is often noted. Many examples also are shaded by trees rooted in adjacent upland communities. When present, trees often include *Tsuga canadensis, Acer rubrum, Betula lenta, Liriodendron tulipifera*, or *Amelanchier laevis*, but *Aesculus flava, Tilia americana* var. *heterophylla*, or other species of Rich Cove Forest, as well as various oaks, may be present. *Rhododendron maximum* is by far the most frequent shrub, but a wide variety of species may be present, including *Leucothoe* *fontanesiana, Alnus serrulata, Xanthorhiza simplicissima, Hydrangea arborescens*, and many others. *Parthenocissus quinquefolia, Toxicodendron radicans*, or other vines may drape part of the cliff. Vascular herbs usually include a distinctive combination of species typical of wetlands, upland forests, and rock outcrops. In the Chattooga basin, Zartman and Pittillo (1998) found the most frequent vascular plant species to be *Thalictrum clavatum, Houstonia serpyllifolia, Lobelia amoena, Chelone glabra, Eurybia divaricata, Heuchera villosa, Oxypolis rigidior, Trautvetteria carolinensis, Solidago patula, Lycopodioides (Selaginella) apodum*, *Viola cucullata*, and the exotic *Microstegium vimineum*. Elsewhere, *Thalictrum clavatum* is the most frequent species, and *Micranthes petiolaris* (*Saxifraga michauxii*)*, Micranthes micranthidifolia, Micranthes careyana, Heuchera villosa, Heuchera parviflora, Impatiens capensis*, *Boykinia aconitifolia, Trautvetteria carolinensis*, and the fern gametophytes *Vittaria appalachiana* and *Trichomanes intricatum* are among the most frequently reported species. A great diversity of other species is present at low frequency, including additional wetland species such as *Chelone* spp., *Viola cucullata, Hydrocotyle americana*, and *Drosera rotundifolia*, species of dry rock outcrops, such as *Krigia virginica*, *Houstonia longifolia* var. *glabra,* and *Danthonia spicata*, widespread species such as *Eurybia divaricata* and *Galax urceolata*, and rare habitat specialists such as *Huperzia porophila* and *Phegopteris connectilis*. One unique example contains *Spartina pectinata* and *Andropogon gerardii*. Bryophytes are less often identified, even when their abundance is noted. The few species lists recorded suggest a diverse collection of both mosses and liverworts. Species found frequent in Zartman and Pittillo (1998) on the Chattooga River include *Thuidium delicatulum* to be by far the most frequent species. Other frequent species were *Plagiomnium ciliare, Atrichum oerstediana, Sphagnum lescurii, Scapania nemorosa, Campylium chrysophyllum, Mnium hornum, Philonotis fontana*, and *Dumortiera hirsuta*. Additional species noted repeatedly elsewhere include *Lophocolea* (*Chiloscyphus*) *appalachiana, Bazzania trilobata,* and *Hookeria acutiloba*. Some lichens, such as *Peltigera* (*Hydrotheria*) *venosa* are also characteristic.

Range and Abundance: Ranked G2 but possibly less rare. Spray Cliffs are scattered throughout the Mountain Region and foothills, with well over 50 known. However, their aggregate acreage is very small. Because many are small and can be marginally developed, a different decision on the minimum specifications for occurrence would lead to very different numbers. They are most concentrated in the southern escarpment area. As defined, this is a Southern Appalachian endemic community, occurring in North Carolina, Tennessee, South Carolina, and Georgia.

Associations and Patterns: Spray Cliffs are small patch communities, with no examples more than a couple acres in size. However, size data can be ambiguous because most of their surface is near vertical. They may be associated with Montane Cliffs, where dry open rock exists beyond the spray zone. Otherwise, they usually are surrounded by Acidic Cove Forest, Rich Cove Forest, or Canada Hemlock Forest.

Variation: Individual Spray Cliff occurrences are extremely variable in flora, as indicated by the large number of species with very low constancy. Patterns of variation have not been fully sorted out but three variants are recognized.

1. Typic Variant includes examples in most of the Mountain Region and foothills.

2. Southern Escarpment Variant includes examples in the high-rainfall southern escarpment area, including the Chattooga, Whitewater, Horsepasture, and Toxaway rivers, Panthertown Valley, and nearby creeks. This area has a large number of rare species, among bryophytes and herbs, many of them associated with Spray Cliffs. The narrow range of *Hydrangea cinerea* means it may occur in the variant and is very rarely present in the Typic Variant.

3. Sloughgrass Variant covers the unique example where *Spartina pectinata* is a dominant species, known only at Rainbow Falls.

The possibility of a rich variant should also be investigated. Examples surrounded by Rich Cove Forest share species with that community, which are absent in other examples. At least one extremely rich example is known, where *Ptelea trifoliata* is the most abundant shrub.

Dynamics: Spray Cliffs may have unique dynamics, sharing different aspects with different communities. Like Rocky Bar and Shore, portions of them may be naturally disturbed by floods. Otherwise, they appear to be extremely stable. The sheltered topography and flowing water ameliorate temperature fluctuations, allowing plants of tropical affinities to have persisted through drastic climatic fluctuation. The effects of drought too are ameliorated. Water is abundant and nutrients continually supplemented. Nevertheless, standing biomass and presumably primary productivity are low because of limited rooting space. More than perhaps any other community, lack of sunlight may also limit productivity, especially in grottos.

Comments: The inclusion of Spray Cliff with upland seepages is marginal. They are unique in many ways, but their strongest ecological affinities seem to be to this theme.

Spray Cliffs are seldom the target of deliberate exploitation. Nevertheless, they are variably susceptible to disturbance by human visitation. While portions are vertical and inaccessible, flatter portions and grottos are particularly attractive and susceptible to trampling. Even vertical cliff bases may be heavily disturbed by "hand trampling."

Rare species:
Vascular plants – *Asplenium monanthes, Chelone obliqua, Chenopodium simplex, Didymoglossum petersii, Huperzia porophila, Hymenophyllum tayloriae, Moranopteris* (*Grammitis*) *nimbata, Phegopteris connectilis, Spartina pectinata,* and *Vandenboschia boschiana*.

Nonvascular plants – *Acrobolbus ciliatus, Aneura sharpii, Brachythecium rotaeanum, Bellibarbula recurva, Bryocrumia vivicolor, Bryoerythrophyllum ferruginascens, Bryoxiphium norvegicum, Bryum riparium, Campylium stellatum, Cephaloziella hampeana, Cheilolejeunea evansii, Chiloscyphus muricatus, Cirriphyllum piliferum, Cyrto-hypnum pygmaeum, Dichodontium pellucidum, Didymodon tophaceus, Drepanolejeunea appalachiana, Entodon sullivantii, Ephebe lanata, Fissidens asplenioides, Grimmia longirostris, Gymnoderma lineare, Homalia trichomanoides, Lejeunea blomquistii, Lejeunea cavifolia Lophocolea* (*Chiloscyphus*) *appalachiana, Mylia taylorii, Oxyrrhynchium pringlei, Philonotis cernua, Plagiochila austinii, Plagiochila echinata, Plagiochila sullivantii, Plagiochila virginica* var. *caroliniana, Plagiochila virginica* var. *virginica*, *Plagiomnium carolinianum, Plagiomnium rostratum, Porella wataugensis, Racomitrium aciculare, Radula voluta, Rhytidiadelphus subpinnatus, Rinodina* *chrysomelaena, Sphagnum capillifolium, Sphagnum squarrosum, Taxiphyllum alternans, Taxiphyllum cuspidifolium, Tetrodontium brownianum,* and *Warnstorfia fluitans*.

Invertebrate animals – *Nesticus bishopi*.

HIGH ELEVATION BOGGY SEEP

Concept: High Elevation Boggy Seeps are communities intermediate between Mountain Bogs and Fens and Upland Seepages and Spray Cliffs. They occur in upland locations or along small headwater streams and generally have moderate to substantial slopes. They often have substantial *Sphagnum* cover and share more species with Southern Appalachian Bogs than most seeps do, but they also contain many species not characteristic of bogs. They are generally graminoid-dominated in the center, but some have enough tree or shrub cover to be considered woodlands or shrublands.

Distinguishing Features: High Elevation Boggy Seeps are distinguished from Rich Montane Seeps by having *Sphagnum* present and generally by having graminoid-dominated vegetation that includes characteristic species such as *Carex gynandra*, *Carex ruthii*, *Glyceria striata, Glyceria melicaria, Chelone lyonii*, and *Drosera rotundifolia*. They generally lack *Rudbeckia laciniata, Laportea canadensis, Monarda didyma*, and *Diphylleia cymosa*, though they may share species such as *Circaea alpina, Impatiens pallida, Oxypolis rigidior*, or *Micranthes* (*Saxifraga) micranthidifolia*. High Elevation Boggy Seeps are distinguished from Southern Appalachian Bogs most readily by topography, generally occurring on a pronounced slope at high elevation, also by floristic differences. Most of the same species mentioned above, such as *Carex ruthii* and *Glyceria*, are largely absent in bogs. High Elevation Boggy Seeps are generally at higher elevation than Low Elevation Seep (Montane Subtype), though the ranges may overlap. They share some species, but Low Elevation Seeps rarely have as extensive *Sphagnum*, and they contain low-elevation species such as *Lindera benzoin*.

Crosswalks: *Carex gynandra – Platanthera clavellata – Drosera rotundifolia – Carex ruthii / Sphagnum* spp. Herbaceous Seep (CEGL007697).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern and Central Appalachian Bog and Fen Ecological System (CES202.300).
Southern Appalachian Seepage Wetland Ecological System (CES202.317).
High Elevation Seep (3rd Approximation).

Sites: High Elevation Boggy Seeps occur on upland slopes or along small headwater streams. They usually have a distinct gentle-to-steep slope. Some are in amphitheater-like landforms that may have been formed by the groundwater discharge, and some are at distinct changes in slope that may reflect underlying impermeable layers. Others probably are associated with fractures in underlying bedrock that transport groundwater, but this is not well known. Most examples are above 5000 feet elevation, but some may occur to 4000 feet or possibly a bit lower.

Soils: Soils are usually a heterogeneous mix of loamy material, gravel, and muck, sometimes with boulders or small bedrock outcrops. Patches are too small to be distinguished in soil mapping.

Hydrology: High Elevation Boggy Seeps are saturated permanently, or nearly so, by discharging groundwater. The discharged water moves through the community, through the soil, sometimes in a shallow sheet, sometimes in rivulets with limited development of channels. The downhill edge of the community occurs where the water becomes concentrated in a deeper channel or where it sinks back deeper into the ground.

Vegetation: High Elevation Boggy Seeps have a dense herb layer. Most have few trees or shrubs rooted in the middle, but woody vegetation is common on the edges and may be dispersed throughout with low cover. Many examples are small enough to be shaded by trees rooted in adjacent forest. *Sphagnum* spp. usually forms mats with high cover. The herb layer is usually dominated by graminoid species, with *Carex ruthii, Carex flexuosa, Carex gynandra* or *crinita,* and other species of *Carex* often dominant. No plants other than *Sphagnum* have high constancy either in plot data or in site descriptions. Frequent species in one or both include *Houstonia serpyllifolia, Drosera rotundifolia, Parnassia asarifolia, Solidago patula, Krigia montana, Chelone lyonii, Glyceria melicaria, Thalictrum clavatum, Hypericum graveolens, Solidago glomerata, Danthonia compressa, Oclemena acuminata, Sitobolium* (*Dennstaedtia*) *punctilobulum, Avenella (Deschampsia*) *flexuosa,* and *Carex atlantica*. A large number of wetland species occur at lower frequency, such *as Carex debilis, Carex howei, Carex intumescens, Juncus acuminatus, Osmundastrum cinnamomeum, Platanthera clavellata, Juncus gymnocarpus, Oxypolis rigidior, Calamagrostis coarctata, Rhynchospora capitellata, Micranthes micranthidifolia, Impatiens pallida,* and *Chelone glabra*. Many upland or broadly tolerant species may also be present with low frequency, including *Athyrium asplenioides, Eurybia chlorolepis, Amauropelta* (*Parathelypteris*) *noveboracensis, Mitchella repens, Carex aestivalis, Agrostis perennans, Ageratina roanensis*, *Hypericum mitchellianum*, and *Nabalus* spp. The most constant tree species are *Acer rubrum, Betula alleghaniensis, Betula lenta,* and *Picea rubens*. *Abies fraseri, Sorbus americana, Tsuga canadensis*, and *Amelanchier arborea* are also fairly frequent. *Viburnum cassinoides* is the shrub with the highest frequency. Other fairly frequent species include *Hypericum densiflorum, Vaccinium corymbosum, Vaccinium simulatum, Rhododendron catawbiense, Kalmia latifolia, Diervilla sessilifolia, Vaccinium erythrocarpum*, *Aronia melanocarpa*, and *Lyonia ligustrina* var. *ligustrina*.

Range and Abundance: Ranked G2. Examples are scattered through the higher mountains but are most abundant and extensive in the Great Balsam Mountains. This community is a narrow Southern Appalachian endemic, occurring in Tennessee and possibly Virginia. None are reported in Georgia, but it could occur there.

Associations and Patterns: High Elevation Boggy Seeps are small patch communities. Well-developed patches may be less than 1 acre in size, but some may be several acres. They sometimes occur in clusters that add up to larger acreage. High Elevation Boggy Seeps are naturally usually surrounded by Spruce-Fir Forest or Northern Hardwood Forest communities, potentially by High Elevation Red Oak Forest or other higher elevation forests. In the Balsam Mountains, many examples also occur in high elevation successional vegetation, where spruce was destroyed by past logging and slash fires.

Variation: High Elevation Boggy Seeps are highly variable among examples, but no patterns of variation have been clarified.

Dynamics: Dynamics of High Elevation Boggy Seeps are likely similar to other seeps. Productivity is limited by the short growing season and low temperatures at high elevation, as well as by wetness. Wetness is enhanced by the high rainfall, frequent fog, and low evapotranspiration at high elevation. The boggy character of these communities may be related to reduced organic matter decomposition in the cool climate. Groundwater provides some nutrients, but low nutrient content in the groundwater may be partly responsible for their boggy character.

High Elevation Boggy Seeps are susceptible to rooting by feral pigs, but probably are less attractive to them than Rich Montane Seeps because of the greater graminoid and moss dominance in the vegetation.

Comments: These communities are intermediate conceptually between Southern Appalachian Bogs and Montane Rich Seeps. They tend to occur at higher elevations than Rich Montane Seeps, but with substantial overlap. The difference likely depends on the nature of the groundwater. However, the character of High Elevation Boggy Seeps also depends on high elevation. Similar topographic settings and seeps at lower elevation do not have a similarly bog-like character.

This community was recognized in Wichmann (2009) as *Betula* spp./*Carex ruthii* - *Avenella flexuosa / Sphagnum* spp. Newell (1997) recognized a *Carex gynandra* wetland and a *Carex ruthii* wetland, based primarily on the same plots.

Rare species:
Vascular plants – *Bromus ciliatus, Carex cristatella, Carex oligosperma, Gentiana latidens, Glyceria nubigena, Huperzia appalachiana, Ilex collina, Ilex longipes, Lilium grayi, Lonicera canadensis, Lycopodiella inundata, Muhlenbergia glomerata, Phegopteris connectilis, Platanthera herbiola, Rhododendron vaseyi, Rhynchospora alba, Solidago uliginosa* var. *uliginosa, Stenanthium leimanthoides*, *Triantha glutinosa, Vaccinium macrocarpon,* and *Veronica americana*.

Nonvascular plants – *Gymnoderma lineare.*

RICH MONTANE SEEP

Concept: Rich Montane Seeps are non-boggy seeps of the middle to lower elevations of the Mountains and possibly the foothills. They generally lack *Sphagnum* and have lush herb layers dominated by forbs, sharing many species with Rich Cove Forest. They may or may not have trees rooted within the seep but are generally small enough to be shaded by trees rooted in adjacent forests.

Distinguishing Features: Rich Montane Seeps are distinguished by saturated soil and an herb layer that includes a combination of the more water-tolerant Rich Cove Forest species along with some distinctive seep species. The characteristic extreme acid-tolerant wetland herbs of the bog communities are absent or scarce and limited to a few species. Both High Elevation Boggy Seep and Low Elevation Seep have flora that suggests more acidic conditions and have much less affinity with Rich Cove Forests.

Crosswalks: *Impatiens (capensis, pallida) – Monarda didyma – Rudbeckia laciniata var. digitata* Herbaceous Seep (CEGL004293). *Diphylleia cymosa – Saxifraga micranthidifolia – Laportea canadensis* Herbaceous Seep (CEGL004296).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern Appalachian Seepage Wetland Ecological System (CES202.317).
High Elevation Seep, Low Elevation Seep (3rd Approximation).

Sites: Rich Montane Seeps occur along small headwater streams or on upland slopes that are gentle to moderate. A few examples may occur at the base of cliffs and have substantial bedrock. They can occur over a very wide range of elevations, from 1000 feet to 5500 feet or higher. They are more likely to occur over or near mafic rocks such as amphibolite, but they may occur in any kind of geology.

Soils: Soils are usually wet loamy soils or gravel, but may include deep mucky areas, abundant boulders, or bedrock outcrops. Patches are too small to be distinguished in soil mapping.

Hydrology: Rich Montane Seeps are saturated permanently or nearly so by discharging groundwater. Often the ground water appears to be shallow and very local in origin. The water moves through the community and through the soil, sometimes in a shallow sheet, sometimes in rivulets with limited development of channels.

Vegetation: Rich Montane Seeps have a dense herb layer that may be very lush. Most are dominated by large forbs but a minority are dominated by sedges. Some combination of *Diphylleia cymosa, Laportea canadensis, Monarda didyma*, and somewhat less frequently, *Rudbeckia laciniata, Impatiens capensis, Impatiens pallida, Micranthes micranthidifolia*, or *Chrysosplenium americanum* dominate most patches. Other herbs that occur with at least fairly high frequency in CVS plot data and site descriptions include *Tiarella cordifolia, Arisaema triphyllum, Veratrum viride, Chelone glabra, Chelone lyonii, Eurybia chlorolepis, Ageratina roanensis, Viola cucullata, Packera aurea, Dryopteris intermedia, Galium triflorum, Thalictrum clavatum, Polystichum acrostichoides, Angelica triquinata, Athyrium asplenioides, Eutrochium purpureum, Huperzia lucidula, Trillium erectum, Solidago curtisii, Hydrophyllum canadense, Actaea podocarpa, Actaea* *racemosa, Cardamine diphylla, Osmorhiza claytonii,* and *Circaea alpina*. Other species shared with other seep communities, though less frequently in this community, include *Trautvetteria carolinensis, Houstonia serpyllifolia, Oxypolis rigidior, Osmundastrum cinnamomeum*, and *Osmunda spectabilis*. *Carex scabrata* is a common sedge. Other species of *Carex* may be present but are low in cover, low in constancy, and are more likely to be mesophytic upland species rather than wetland species. Less frequent plants that are nevertheless notable include *Aconitum reclinatum, Aconitum uncinatum, Lilium grayi, Platanthera psycodes*, and *Platanthera grandiflora*. Most seeps have few trees or shrubs rooted in the middle, but woody vegetation may be dispersed throughout with low cover. Most examples are small or narrow enough to have substantial shading from the adjacent forest. Trees tend to be mesophytic species of surrounding Rich Cove Forest or Northern Hardwood Forest, most constantly *Aesculus flava, Acer saccharum,* and *Betula alleghaniensis*, but often *Fraxinus americana, Quercus rubra, Tilia americana* var. *heterophylla, Acer spicatum, Halesia tetraptera*, and *Magnolia acuminata*. Shrubs are generally scarce, but *Hydrangea arborescens* or *Hamamelis virginiana* may be present.

Range and Abundance: Ranked G3 but apparently more common. Aggregate acreage nevertheless is low. Examples are scattered throughout the Mountain Region and, though not known, could occur in the foothills. This community is a Southern Appalachian endemic, ranging to Virginia, Georgia, South Carolina, and Tennessee.

Associations and Patterns: Rich Montane Seeps are small patch communities. Patches may be well under an acre, and the community may be well developed even when only a few meters wide. Many are narrow bands a few meters wide but running much farther along a drainage or down a slope. They usually are surrounded by Rich Cove Forest or Northern Hardwood Forest but may be surrounded by other upland forests.

Variation: Rich Montane Seeps are extremely variable. Early drafts of the 4th Approximation recognized subtypes corresponding to the two synonymized NVC associations, representing lower and higher elevation seeps. These proved impossible to apply as defined. The high variability suggests a need for subdivision into variants or, likely, subtypes, but the best way to do this is not yet apparent.

Dynamics: Dynamics of Rich Montane Seeps are similar to those of the Upland Seepage and Spray Cliffs theme as a whole. Their occurrence primarily in mesic forests makes them unlikely to burn frequently, and their lush forb vegetation is unlikely to carry fire well.

Where feral pigs are present, Rich Montane Seeps are particularly vulnerable to their damage. Rossell, et al. (2016) documented the effects of their rooting in Rich Montane Seep communities in the Great Smoky Mountains, which included loss of plant cover and severe loss of salamanders.

Comments: This community was recognized in Wichmann (2009) as *Betula* spp./*Viburnum cassinoides*/*Athyrium asplenioides*. She noted that it was extremely variable and would probably warrant further subdivision with more data but did not find a pattern matching the two NVC associations that have been lumped here.

The two NVC associations crosswalked to this community were intended to represent lower and higher elevation seeps. However, seep vegetation does not sort out by elevation as they describe. Most of the nominal species occur over a very wide elevational range. Any combination of potential dominants can occur together, rather than segregating into distinct subtypes. Attempts to recognize a distinction in early drafts of the 4th Approximation did not work, leading them to be lumped into a single, albeit heterogeneous, community awaiting further clarification.

Rich Montane Seeps may be particularly important habitat for salamanders. Rossell, et al. (2016), studying Rich Montane Seeps in the Great Smoky Mountains, found densities of up to 13 per square meter, with an average of 1.37 per square meter. Ten species were found, including one rare and two uncommon species.

Rare species:
Vascular plants – *Aconitum reclinatum, Bromus ciliatus, Cardamine clematitis, Cardamine rotundifolia, Chelone obliqua* var. *erwiniae, Conioselinum chinense, Epilobium ciliatum* ssp. *ciliatum*, *Euphorbia purpurea, Geum geniculatum, Helianthemum propinquum, Lilium grayi, Lilium philadelphicum* var. *philadelphicum, Liparis loeselii, Lonicera canadensis, Meehania cordata, Platanthera grandiflora, Platanthera peramoena, Rhododendron vaseyi, Streptopus amplexifolius* var. *amplexifolius*, and *Veronica americana.*

Nonvascular plants – *Gymnoderma lineare.*

Vertebrate animals – *Desmognathus wrightii*.

LOW ELEVATION SEEP (TYPIC SUBTYPE)

Concept: Low Elevation Seeps are seepage-fed wetlands that are intermediate in apparent fertility and that lack the distinctive species composition and other characteristics of Hillside Seepage Bog, Piedmont Boggy Streamhead, High Elevation Boggy Seep, Sandhill Seep, and of Southern Appalachian Bogs and Fens on the one hand and of Rich Montane Seep on the other. Low Elevation Seep sites include small hollows on slopes, slope breaks, toe slopes, or edges of floodplains. They can be quite small but have vegetation that contrasts sharply with adjacent communities. The Typic Subtype covers seeps that occur on upland slopes in the Piedmont and Coastal Plain, that lack distinctive Blue Ridge flora, and that lack the characteristics of the other subtypes.

Distinguishing Features: Low Elevation Seeps are distinguished by abundant wetland vegetation, without the characteristic composition and setting of other seepage wetlands or bogs. *Sphagnum* is not generally abundant but may be present in limited amounts. Many species may be shared with Southern Appalachian Bogs, Hillside Seepage Bogs, and Piedmont Boggy Streamheads, including *Viburnum nudum, Viburnum cassinoides, Impatiens capensis, Osmundastrum cinnamomeum, Osmunda spectabilis, Lorinseria* (*Woodwardia*) *areolata*, and *Carex* spp. However, other species indicative of less nutrient-poor conditions, such as *Saururus cernuus, Lycopus virginicus*, and *Lindera benzoin*, are also present.

The Typic Subtype may be distinguished from the Floodplain Subtype by occurring in uplands or at the heads of small streams, rather than on the edge of larger floodplains. It consequently lacks the admixture of floodplain and alluvial species found in the Floodplain Subtype, such as *Acer negundo, Fraxinus pennsylvanica*, and *Celtis laevigata*, as well as species of wetter conditions such as *Peltandra virginica, Sagittaria* spp., and *Cephalanthus occidentalis*.

Crosswalks: *Acer rubrum var. trilobum / Viburnum nudum var. nudum / Osmunda cinnamomea - Saururus cernuus – Impatiens capensis* Seep Forest (CEGL004426).
G044 Central Interior-Appalachian Seepage Swamp Group.
Piedmont Seepage Wetland Ecological System (CES202.298).
Rich Foot-slope Seeps (Seymour 2011).

Sites: The Typic Subtype occurs on upland slopes, usually lower to mid slopes, sometimes at the head of small drainages. Seymour (2011) described her equivalent group as occurring on foot-slopes, but many other known examples occur farther uphill. Some seeps may be caused by underlying rock fractures which conduct groundwater, others by an underlying layer of impermeable bedrock or clay. Some are associated with a distinct change in slope or with a small amphitheater-like basin, while some show no distinctive topographic expression.

Soils: Soils are saturated residual soils. Seymour (2011) described them as sandy, but it is unclear that this applies to all examples. Patches are too small to be distinguished in soil mapping.

Hydrology: Typic Subtype occurrences are saturated all or much of the year. A sheet of flowing water or small rivulets may uncommonly be present, but there is never significant surface flooding.

Vegetation: The Typic Subtype has moderate to dense herbaceous vegetation and may have sparse to moderate shrubs. Generally few or no trees are rooted in the community; most examples are fully shaded by trees rooted in the adjacent forest, but the canopy may be somewhat open. The most constant dominant herb is *Osmundastrum cinnamomeum*, which is almost always present. Other high constancy herbs reported by Seymour (2011) are *Saururus cernuus* and *Lorinseria areolata*, which had high average cover, and *Athyrium asplenioides, Arisaema triphyllum, Dichanthelium microcarpon (dichotomum* var. *ramulosum)*, and *Leersia virginica*, which had low average cover. Other herbs that were fairly frequent in Seymour (2011) include *Boehmeria cylindrica, Carex* spp. (*atlantica, crinita, debilis, laevivaginata*, and *lurida*), *Chasmanthium laxum, Cinna arundinacea, Dioscorea villosa, Glyceria striata, Impatiens capensis, Juncus effusus/pylaei, Lycopus virginicus, Mitchella repens, Polystichum acrostichoides, Solidago caesia, Solidago rugosa, Viola* spp., *Platanthera* sp., and the exotic *Microstegium vimineum*. Bryophytes in the genera *Sphagnum, Thuidium, Mnium*, and various liverworts were also frequent. *Sphagnum* is often present in clumps in the Typic Subtype but, in contrast to more boggy wetlands, has limited cover. Shrubs that are most frequently present in these seeps are *Vaccinium fuscatum, Vaccinium corymbosum/formosum, Viburnum nudum, Lindera benzoin*, *Euonymus americanus*, *Eubotrys racemosa, Arundinaria tecta, Aronia arbutifolia*, *Ilex verticillata*, and less frequently, *Alnus serrulata*. The most frequent dominant tree species rooted in the wetland is *Acer rubrum*. Other constant or frequent species include *Liriodendron tulipifera*, *Nyssa sylvatica, Carpinus caroliniana, Ilex opaca, Oxydendrum arboreum*, *Liquidambar styraciflua*, and *Magnolia virginiana*. Upland tree species, *Fagus grandifolia, Quercus alba*, and others, often have cover and may occasionally be rooted in the wetland. Some vines are frequent, and *Smilax rotundifolia* or *Muscadinia rotundifolia* may have fairly high cover. *Parthenocissus quinquefolia, Bignonia capreolata, Campsis radicans*, and the exotic *Lonicera japonica* are also fairly frequent in small amounts.

Range and Abundance: Ranked G3? but possibly less rare. Locations for this community can neither be predicted by topography nor detected by remote sensing; the small patches must be encountered in field surveys. New examples continue to be found even in fairly well-studied sites. Occurrences are scattered throughout the central and eastern Piedmont, with few or none in the foothills. A handful of examples is known in widely scattered locations in more hilly parts of the Coastal Plain. This community also is attributed to South Carolina and Georgia.

Associations and Patterns: Low Elevation Seep (Typic Subtype) is a small patch community, often occurring in patches just a few meters wide. Patches may be round or funnel-shaped or may be elongated in a downhill direction. They may be surrounded by any mesic or dry-mesic upland community and may occasionally border a floodplain community on one side. Those at the head of a drainage may give way to a Piedmont Headwater Stream Forest.

Variation: Examples vary in composition in ways that reflect wetness, as well as potentially biogeography. Examples may be well-developed even when very small, but some small examples are depauperate and appear to be less wet. Though differences are not well documented, two variants are recognized for further exploration, based on biogeography and geologic setting.

1. Piedmont Subtype includes the majority of examples, which are in the Piedmont.

2. Coastal Plain Subtype includes examples in the Coastal Plain, which are less well understood but are expected to have some floristic differences. It is unclear which variant examples in the fall zone are most likely to resemble.

Dynamics: Dynamics of the Typic Subtype are similar to those described for seeps in general. Water moving through the system provides some continual input of nutrients, though nutrient concentrations may be limited. Though plot data show them to be more fertile than the other Piedmont seepage wetlands, (with the exception of the Floodplain Subtype), they are acidic and not highly fertile.

The Typic Subtype occurs farther uphill than many seep communities, and it may be more prone to drying out in late summer or during drought. Because the surrounding upland communities may be either dry or mesic, exposure to fire in seeps under natural conditions varies. Though the seep vegetation and wet litter generally would not carry fire well, because patches are small, much of the community could be scorched if the surrounding vegetation is flammable. Coastal Plain examples tend to occur in places that are topographically sheltered from fire and are surrounded by hardwood forest rather than longleaf pine communities, and they are more often adjacent to floodplains, so their natural fire frequency may not be high.

Comments: The circumscription of subtypes of Low Elevation Seeps largely follows the comprehensive quantitative analysis by Seymour (2011). However, this subtype may be defined more broadly here. Seymour (2011) called her corresponding type Rich Foot-slope Seeps, and described it as occurring primarily on lower slopes near floodplains. However, a number of sites not represented in her study occur farther uphill but fit this group better than any other. The Rich Foot-slope Seeps are rich only in the context of other Piedmont seepage wetlands such as the Piedmont/Mountain Springhead Subtype and Hillside Seepage Bog, and they are less fertile than the Floodplain Subtype. The flora does not indicate rich soil conditions, and it is not at all comparable to Rich Montane Seep for richness. In addition, the Typic Subtype includes similar seeps in the Coastal Plain, which was outside Seymour's scope.

The NVC association synonymized with this subtype does not describe the range of vegetation well. In addition, it can be difficult to characterize the vegetation structure of these communities. They may be considered either forests, because they usually have a tree canopy covering them, or herbaceous vegetation, because few trees are rooted in the community. Though this association is characterized as a forest, other associations with similar vegetation structure are treated as herbaceous vegetation in the NVC.

Acer rubrum – Nyssa sylvatica – Magnolia virginiana / Viburnum nudum var. nudum / Osmunda cinnamomea Swamp Forest (CEGL006238) is a seepage swamp of states to the north, primarily in the Coastal Plain. It may be related.

Rare species:
Vascular plants – *Micranthes pensylvanica* and *Platanthera peramoena*.

Vertebrate animals – *Hemidactylium scutatum*.

LOW ELEVATION SEEP (MONTANE SUBTYPE)

Concept: Low Elevation Seeps are seepage-fed wetlands that are intermediate in apparent fertility and that lack the distinctive species composition and other characteristics of Hillside Seepage Bog, Piedmont Boggy Streamhead, High Elevation Boggy Seep, Sandhill Seep, and of Southern Appalachian Bogs and Fens on the one hand and of Rich Montane Seep on the other. They can be quite small, but their vegetation contrasts sharply with adjacent communities.

The Montane Subtype covers examples of the Mountains and upper Piedmont, which have a number of distinctive Blue Ridge species that are scarce or absent farther east. They occur on slopes, in small cove bottoms, and along headwater streams.

Distinguishing Features: Low Elevation Seeps are distinguished by saturated soil and by abundant wetland vegetation and flora that includes species that are intermediate in nutrient needs, while lacking those most characteristic of High Elevation Boggy Seep and the Mountain Bogs and Fens communities.

Many species may be shared with High Elevation Boggy Seep and with various Mountain Bogs and Fens communities, including *Viburnum nudum, Viburnum cassinoides, Impatiens capensis, Osmundastrum cinnamomeum, Osmunda spectabilis, Lorinseria areolata*, and some *Carex* spp. However, other species indicative of less nutrient-poor conditions, such as *Lycopus virginicus*, *Thalictrum clavatum,* and *Lindera benzoin*, are also present in Low Elevation Seep in large numbers. More narrowly distributed species of bogs, such as *Vaccinium macrocarpon, Sarracenia* spp., *Drosera rotundifolia*, and *Carex folliculata* are absent or very scarce in Low Elevation Seeps, and *Sphagnum* generally is not abundant.

Rich Montane Seeps share some species with the Montane Subtype but tend to be dominated by species rarely if ever found in it, such as *Laportea canadensis, Diphylleia cymosa,* and *Monarda didyma.* Other species characteristic of Rich Montane Seep communities, such as *Rudbeckia laciniata* may be present but have lower frequency and abundance. *Osmundastrum cinnamomeum* and *Osmunda spectabilis*, among the most important herbs in Low Elevation Seeps, are rarely present in Rich Montane Seeps.

The Montane Subtype is distinguished from the Typic Subtype by floristic differences, with the presence of species that are scarce or absent in Piedmont seeps, such as *Micranthes (Saxifraga) micranthidifolia, Houstonia serpyllifolia*, *Thalictrum clavatum*, and *Chelone glabra*. It is distinguished from the Floodplain Subtype by not occurring in a medium to large floodplain, lacking evidence of flooding, and by lacking the characteristic species of that subtype. It lacks most of the species of Coastal Plain affinities that characterize the Piedmont/Mountain Springhead Subtype. The Montane Subtype can have some bedrock present, as well as often having boulders or cobbles, but it lacks the continuous rock layer of the Bedrock Subtype.

Crosswalks: *Alnus serrulata - Lindera benzoin / Scutellaria lateriflora - Thelypteris noveboracensis* Seepage Shrubland (CEGL003909).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern Appalachian Seepage Wetland Ecological System (CES202.317).

Sites: The Montane Subtype may occur in several kinds of settings in mountainous terrain, including along intermittent or small perennial headwater streams, at the origin of such streams at the head of a valley, at the foot of slopes on the edges of cove bottoms, and occasionally on open mountain slopes.

Soils: Soils are saturated residual or colluvial soils, which may be deep or relatively shallow and rocky. Patches are too small to be distinguished in soil mapping.

Hydrology: Montane Subtype occurrences are saturated all or much of the year. A sheet of flowing water or small rivulets may often be present. Examples along drainages may rarely be affected by flash floods.

Vegetation: The Montane Subtype has moderate to dense herbaceous vegetation and may have sparse to fairly dense shrubs. Generally few or no trees are rooted in the community; those that are, are primarily *Liriodendron tulipifera* and *Acer rubrum*. Most examples are fully shaded by trees rooted in the adjacent forest, but the canopy may be somewhat open. The most constant herbs are *Osmundastrum cinnamomeum* and *Osmunda spectabilis*, which may dominate, and *Chelone glabra*. Other frequent herbs in site descriptions include *Thalictrum clavatum, Carex bromoides, Oxypolis rigidior, Impatiens capensis, Houstonia serpyllifolia, Lycopus virginicus, Lobelia amoena, Athyrium asplenioides, Platanthera clavellata*, *Micranthes micranthidifolia,* and *Lobelia cardinalis*. Fairly frequent also are *Carex intumescens, Eurybia divaricata, Solidago patula, Rudbeckia laciniata, Viola blanda, Viola cucullata, Juncus gymnocarpus*, and *Leersia virginica*. A great diversity of other *Carex* species occur occasionally, including *scabrata, debilis, styloflexa, leptalea, atlantica, gynandra*, and many others. The most constant shrubs, which may dominate, are *Lindera benzoin, Alnus serrulata*, *Ilex verticillata*, and *Viburnum nudum*. *Xanthorhiza simplicissima* is also often present if there is a rocky channel in the seep. A great variety of other wetland shrubs may be present at lower frequency, including *Leucothoe fontanesiana, Sambucus canadensis, Vaccinium fuscatum, Rhododendron maximum, Rhododendron arborescens, Clethra acuminata, Viburnum cassinoides*, *Swida* (*Cornus*) *amomum*, and many others.

Range and Abundance: Ranked G2? but possibly less rare. Locations for this community cannot be predicted by topography nor detected by remote sensing; the small patches must be encountered in field survey. Examples may have sometimes been overlooked in earlier site surveys. Occurrences are scattered throughout the Mountain Region, with a few in the foothills area of the Piedmont. The synonymized NVC association ranges southward to Georgia and possibly Alabama, and also occurs in Tennessee.

Associations and Patterns: Low Elevation Seep (Montane Subtype) is a small patch community. It sometimes occurs in patches that are just a few meters wide or may occur in narrow bands along small streams, though many patches are larger. It may occur in complexes that amount to several acres.

Variation: Examples of the Montane Subtype are extremely variable. Variation clearly results from different physical settings, particularly depth or rockiness of the soil and amount of water.

Other variation may relate to elevation or to biogeographic patterns. No variants have been recognized.

Dynamics: Dynamics of the Montane Subtype are similar to those described for seeps in general. Though plot data show them to be more fertile than various bogs, they are less fertile than the Floodplain Subtype and less fertile than Rich Montane Seep. This presumably is because of the chemistry of the water moving through them.

Fire is probably of limited importance in the Montane Subtype even under natural conditions. Fire is unlikely to carry well through the forb-dominated vegetation and moist litter, and most are surrounded by mesic communities where fire is likely of low intensity.

Comments: Defining the vegetation structure of this subtype, as in some others, is problematic. Patches tend to be small, and often are largely shaded by trees rooted in adjacent communities, in combination with only a few trees rooted in the seep. The association for this subtype is named as herbaceous vegetation, while those synonymized to other subtypes are named as forests, but the canopy cover and light levels are very similar.

The association linked to this subtype is problematic and the linkage may be inappropriate. An earlier description that seemed to link it to the boggy openings in Swamp Forest–Bog Complex was changed to one that appears more like the Montane Subtype. However, Wichmann (2011) characterized her Low Elevation Saturated Forest type, which was primarily related to Swamp Forest–Bog Complex, as including this association. This appears to correspond to *Glyceria striata – Carex gynandra – Chelone glabra – Symphyotrichum puniceum / Sphagnum* spp. Herbaceous Seep (CEGL008438). That association, described as a poorly developed bog, has a history of confusion and has been variously linked to Low Elevation Seep (Montane Subtype) and Swamp Forest—Bog Complex.

Rare species:

Vascular plants – *Carex cherokeensis, Carex projecta, Carex trichocarpa, Chelone obliqua* var. *erwiniae, Chelone obliqua* var. *obliqua, Collinsonia tuberosa, Danthonia epilis, Pedicularis lanceolata,* and *Platanthera peramoena*.

Nonvascular plants – *Aneura sharpii*.

Vertebrate animals – *Plethodon wehrlei*.

LOW ELEVATION SEEP (BEDROCK SUBTYPE)

Concept: Low Elevation Seeps are seepage-fed wetlands that are intermediate in apparent fertility and that lack the distinctive species composition and other characteristics of Hillside Seepage Bog, Piedmont Boggy Streamhead, High Elevation Boggy Seep, Sandhill Seep, and of Southern Appalachian Bogs and Fens on the one hand and of Rich Montane Seep on the other. They can be quite small, but their vegetation contrasts sharply with adjacent communities. The Bedrock Subtype consists of large seeps in shallow soil over unfractured bedrock, such as the edges of granitic domes or along bedrock stream beds.

Distinguishing Features: Low Elevation Seeps are distinguished by saturated soil and by abundant wetland vegetation and flora that includes species that are intermediate in nutrient needs, while lacking those most characteristic of High Elevation Boggy Seep and the Mountain Bogs and Fens communities.

The Bedrock Subtype is distinguished from other subtypes by occurring on shallow soil over bedrock and having a distinctive flora that includes some bog species. Small seepage patches are common in various rock outcrop communities and in Spray Cliffs, but this subtype is reserved for larger patches that are well-differentiated from the adjacent community and have a substantial wetland flora. Examples should be at least several meters wide and tens of meters long. Though treated as a subtype of Low Elevation Seep, the Bedrock Subtype can occur over a wide range of elevations, overlapping with High Elevation Granitic Dome, Northern Hardwood Forest, and other communities of fairly high elevations.

Low Elevation Acidic Glade (Biltmore Sedge Subtype) is similar to some examples of the Bedrock Subtype in occurring in bedrock seepage areas on granitic dome outcrops; the Bedrock Subtype is distinguished by longer-term wet conditions and by vegetation that is not dominated by *Carex biltmoreana*.

Crosswalks: *Oxypolis rigidior – Drosera rotundifolia – Platanthera clavellata – Rhexia mariana* var. *mariana* Herbaceous Seep (CEGL007043).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern Appalachian Seepage Wetland Ecological System (CES202.317).
Cataract Bog (various usages).

Sites: The Bedrock Subtype occurs on smooth, largely unfractured rock outcrops, usually at the edges of granitic domes or on exposed bedrock on edges of stream beds, occasionally on vertical cliff faces. Seepage emerges from soil on the edge of the rock outcrop. Examples range widely in elevation, with most in the 3000-4500 foot range but with one example at 5400 feet.

Soils: The substrate consists of shallow organic or sediment mats and areas of bare bedrock.

Hydrology: The Bedrock Subtype is wet perennially or through most of the growing season, though it may dry out during drier periods. Shallow groundwater or soil water moving through permeable soil is discharged at the edge of the rock outcrop. It flows in a sheet over the bare rock and saturates the shallow soil mats that may be present. A better developed stream with a bedrock bed may run through or adjacent to the community.

Vegetation: The Bedrock Subtype consists of moderate to dense herbaceous vegetation. *Sphagnum lescurii*, possibly other *Sphagnum* species, usually occur as scattered patches or as extensive mats. *Aulacomnium palustre, Philonotis fontana*, and a variety of other mosses and liverworts are usually abundant. Vascular plants are sparse to moderate in density and are extremely variable. The only species occurring in more than half of the known examples is *Oxypolis rigidior*. *Drosera rotundifolia, Thalictrum clavatum, Solidago patula, Rhexia mariana, Platanthera clavellata,* and *Calopogon tuberosus* occur in multiple examples. *Rhynchospora*, perhaps usually *capitellata*, occurs in several. Several species of *Carex* have been reported, including *folliculata, virescens*, and *styloflexa*. A wide variety of species occurs in one or two examples. Many are species shared with the Montane Subtype or with High Elevation Boggy Seep, such as *Impatiens capensis, Diphylleia cymosa, Viola primulifolia, Solidago patula, Eupatorium perfoliatum*, and *Lobelia cardinalis*. A number of additional species are more characteristic of the Coastal Plain, such as *Pogonia ophioglossoides, Xyris torta, Bartonia virginica*, and *Utricularia subulata*. Some are species shared with the adjacent rock outcrop community, such as *Carex biltmoreana, Micranthes petiolaris*, and *Packera millefolium*. No trees are present in these seeps. Shrubs may be present at low density. A variety of wetland shrubs may occur, along with shrubs of the adjacent communities, but only *Aronia arbutifolia* and *Alnus serrulata* are known in more than a single example.

Range and Abundance: Ranked G1 but perhaps G2. Fewer than ten examples are known in North Carolina. A few more may be found. They are sparsely scattered over the Mountain Region, with one example known in the foothills. They are somewhat more concentrated in the Cowee Mountains area where granitic domes are abundant. This community is also known in South Carolina.

Associations and Patterns: The Bedrock Subtype is a small patch community. Most examples are no more than one acre in size. Many are associated with Low Elevation Granitic Dome or High Elevation Granitic Dome communities. They usually are on the edge and are bordered by an upland forest community on one side. A few examples occur along streams, where they are bordered by mesic forest communities. Examples may potentially be associated with Montane Cliff communities as well.

Variation: The Bedrock Subtype is extremely variable, with most examples sharing only a few species with others. Examples appear to vary with gradation to other communities. Some are more bog-like, with extensive *Sphagnum* and with other plants characteristic of bogs. Some share a few species with Rich Montane Seeps. Some have large numbers of Coastal Plain species while some have few or none. The highest elevation example has species typical of higher elevations. While systematic differences might be expected between those on granitic domes and those on stream sides, no repeating pattern has been identified. A separate variant, if not a subtype or type, should be recognized for the most bog-like examples, known as cataract bogs, in South Carolina, but none of these are known in North Carolina.

Dynamics: Low Elevation Seep (Bedrock Subtype) communities are primary successional communities that may share more of their dynamics with rock outcrop communities than with other seeps. Despite abundant moisture and, presumably, at least some steady supply of nutrients, lack of soil limits the stature of their vegetation. While wet conditions might be expected to hasten weathering of the rock and promote soil development, the presence of plants not typical of the region suggests great antiquity of at least some examples. Examples on granitic domes presumably are renewed in the same way as the drier communities, by soil mats sloughing off and by occasional spalling of the rock surface along exfoliation joints. Examples along streams also usually occur on exfoliated granitic rock. They probably are subject to occasional disturbance by flooding, which could be a catastrophic disturbance. Flowing water could easily remove the shallowly rooted vegetation and thin soil mats. Drought presumably is also a natural disturbance in these communities, though it is unclear how severe it might be. Fire likely has little influence in them.

The Bedrock Subtype, like rock outcrop communities, is extremely sensitive to trampling. It may also be altered, potentially seriously degraded, by hydrological changes in the adjacent forest where seepage water originates.

Comments: The Bedrock Subtype was recognized relatively late in development of the 4th Approximation. Many of the known examples had already been described, being characterized as bogs, as part of the rock outcrop community, or as Low Elevation Seep. This subtype perhaps only marginally fits the general concept of Low Elevation Seep. Future consideration may lead to recognition as a new type. Because they are extremely hazardous to work in, almost no plot data exist for these communities. A few plots have been sampled in South Carolina but none in North Carolina.

The Bedrock Subtype incorporates the cataract bogs of South Carolina. Those communities are known for their bog-like character and for the presence of rare bog species such as *Sarracenia jonesii*. They also have a large pool of Coastal Plain species, some shared with North Carolina examples but many not. North Carolina's bedrock seeps appear to be of similar size but are less diverse and do not contain rare plants. However, North Carolina examples have fairly diverse flora that includes regionally rare species and species of Coastal Plain affinities.

Rare species:
Vascular plants – *Packera millefolium.*

Nonvascular plants – *Sphagnum subsecundum*.

LOW ELEVATION SEEP (PIEDMONT/MOUNTAIN SPRINGHEAD SUBTYPE)

Concept: Low Elevation Seeps are seepage-fed wetlands that lack the distinctive species composition and other characteristics of Hillside Seepage Bog, High Elevation Boggy Seep, Rich Montane Seep, or Sandhill Seep communities. The Piedmont/Mountain Springhead Subtype covers rare, more forested examples of very acidic seeps of the upper Piedmont and Mountains, with a component of Coastal Plain species such as *Nyssa biflora, Viburnum nudum*, and *Smilax laurifolia*. They generally occur at the headwaters of small streams in relatively subdued topography and are sometimes associated with amphitheater-like basins.

Distinguishing Features: The Piedmont/Mountain Springhead Subtype is distinguished from all other communities by the presence of multiple Coastal Plain plant species in a saturated wetland in the upper Piedmont or Mountains, while lacking the distinctive flora of Hillside Seepage Bog, Piedmont Boggy Streamhead, French Broad Valley Bog, Low Mountain Seepage Bog, and Southern Appalachian Bog, and not occurring in larger floodplains. It appears not to overlap the geographic range of the Typic Subtype or Piedmont Boggy Streamhead. More than most other communities in the Upland Seepages and Spray Cliffs theme, this subtype tends to have a substantial component of trees and shrubs rooted in the wetland.

Hillside Seepage Bogs that have been hydrologically altered or that have had inadequate fire sometimes develop denser woody vegetation resembling the Piedmont/Mountain Springhead Subtype but the ranges of the two appear to have no overlap. Wetlands that are known to once have had the more distinctive herbs typical of the Hillside Seepage Bog type, such as *Sarracenia flava, Sarracenia purpurea*, and *Helenium brevifolium*, should be treated as degraded Hillside Seepage Bogs rather than as this subtype.

Crosswalks: *Acer rubrum / Viburnum nudum – Aronia arbutifolia / Smilax laurifolia / Carex debilis var. pubera* Seep Forest (CEGL007041).
G044 Central Interior-Appalachian Seepage Swamp Group.
Southern Appalachian Seepage Wetland Ecological System (CES202.317).
Piedmont Seepage Wetland Ecological System (CES202.298).
Infertile Swampy Seeps (Seymour 2011).

Sites: The Piedmont/Mountain Springhead Subtype usually occurs at the head of a small stream in areas of gentle slope. Some are in broad amphitheater-like basins with seepage seeming to come from several sides. These may have been formed by sapping by the groundwater discharge.

Soils: Soils are soft and show evidence of wetland conditions. Though patches often are large enough to be mapped, their treatment varies substantially. Some are mapped as floodplain soils such as Wedhadkee (Typic Fluvaquent). Some in Polk Country are mapped as Dogue (Aquic Hapludult) and Roanoke (Typic Endoaquult), Coastal Plain soils of nonriverine wetlands. Others are treated as inclusions in upland soils.

Hydrology: Piedmont/Mountain Springheads are permanently saturated by seepage. They appear to be wetter than other subtypes of Low Elevation Seep or other wetlands in this theme. Multiple rivulets in the community and a well-developed stream exiting the wetland are common.

Vegetation: The Piedmont/Mountain Springhead Subtype usually has a well-developed, though sometimes short or open, canopy of trees rooted in the wetland. *Acer rubrum* and *Nyssa sylvatica* or *Nyssa biflora* usually dominate, though *Liriodendron tulipifera*, *Liquidambar styraciflua*, or other species may also be present. The understory consists primarily of the same species but may have *Magnolia virginiana*. The shrub layer is generally well developed and often relatively diverse. *Viburnum nudum* is most constant and often dominant. Other frequent shrubs in Seymour (2011) and in site descriptions include *Eubotrys racemosa, Aronia arbutifolia, Vaccinium corymbosum, Vaccinium fuscatum, Toxicodendron vernix, Alnus serrulata, Ilex verticillata, Itea virginica*, and *Xanthorhiza simplicissima*. Vines may be prominent and may represent a fairly diverse collection of species, including *Smilax rotundifolia, Smilax laurifolia, Smilax walteri, Toxicodendron radicans, Hydrangea* (*Decumaria*) *barbara*, and *Parthenocissus quinquefolia*. The herb layer may range from sparse to dense, or it may be patchy. *Osmundastrum cinnamomeum* and *Osmunda spectabilis* are the most frequent and most often dominant species in site descriptions. Also frequent are *Lorinseria areolata, Oxypolis rigidior, Amauropelta* (*Parathelypteris*) *noveboracensis*, and *Platanthera clavellata*. Less frequent species include *Arisaema triphyllum, Lycopus virginicus, Leersia virginica, Chelone* spp., and a diversity of other species that occur in single examples. Seymour (2011) and site reports note a diversity of *Carex* species, none with high frequency, including *alleghaniensis, leptalea, atlantica, howei, lurida, debilis*, and *folliculata*. *Sphagnum* spp. is present in limited amounts in fewer than half the examples.

Range and Abundance: Ranked G2. Fewer than ten examples are known in North Carolina. There is a small cluster in the Piedmont part of Polk County. Other examples are widely scattered in the western Piedmont with a few in the Mountains. This community is also known in South Carolina and could potentially occur in Georgia.

Associations and Patterns: The Piedmont/Mountain Springhead Subtype is a small patch community, but patches are larger than most other communities in this theme. Most examples are several acres. A Piedmont Headwater Stream Forest may occur along the outlet stream, and other floodplain communities may be nearby. Otherwise, examples are surrounded by mesic or dry-mesic upland communities.

Variation: Variation of this subtype has not been sorted out. A cluster of examples appears fairly similar to each other, while several other examples each appear unique. A particularly diverse example in South Carolina probably warrants a different variant, perhaps a different subtype.

Dynamics: Dynamics of this subtype are particularly uncertain. It is unclear how these sites came to have multiple species typical of the Coastal Plain. The same species occur in French Broad Valley Bogs and a few other mountain communities, but they are generally lacking in the surrounding landscape, and sometimes they are disjunct considerable distances from other populations.

Piedmont/Mountain Springheads are wetter than most seeps, apparently due to greater groundwater discharge, and Seymour (2011) characterized them as infertile even among the generally infertile seeps she studied. This presumably leads to slow plant growth and low productivity, as well as limiting the species present. Given the width of patches, sheltering topography, the wet substrate, and limited graminoid vegetation, fire likely seldom penetrated them even when the surrounding landscape burned.

There is some question whether occurrences may once have been more open. The dominant woody species include many that sometimes invade open wetland communities such as Southern Appalachian Bogs, and the herbs are largely the more shade-tolerant wetland species. Seymour (2011) found that plots from degraded, formerly open Hillside Seepage Bog occurrences clustered in analysis with the well-developed Piedmont/Mountain Springhead plots, presumably because of their high tree and shrub cover. However, Piedmont/Mountain Springheads occur in a different geographic range, and none are known to have previously been more open. Only one example, at Hanging Rock State Park, is associated with an open herbaceous wetland, and that occurs in a distinctly different microsite. The *Sarracenia* that drew early attention to Hillside Seepage Bogs have never been reported in most counties where Piedmont/Mountain Springhead examples occur.

Comments: The Piedmont/Mountain Springhead Subtype was not known at the time of the 3rd Approximation. When examples were discovered, they were first treated as anomalous Hillside Seepage Bog, Southern Appalachian Bog, or Low Elevation Seep communities. This subtype is distinctive in occurring in the upper Piedmont but having characteristically Coastal Plain species that are lacking in most eastern Piedmont seeps (but many of which are present in French Broad Valley Bogs). It corresponds to one of Seymour's (2011) five distinct types of Piedmont seeps. Though the geomorphic setting and the Coastal Plain flora suggest a close relationship with Piedmont Boggy Streamhead, its vegetation grouped most closely with the less acidic and more widespread seeps of lower slopes (the Typic Subtype), rather than with Hillside Seepage Bogs or Piedmont Boggy Streamheads. However, it was distinctly more acidic and nutrient poor. She did not have data from the mountain examples. Though she included some plots from Hillside Seepage Bogs in Iredell County that have lost their characteristic open bog flora, this resemblance appears to be superficial. They are not included in the concept of this subtype here.

Rare species:
Vascular plants – *Hexastylis naniflora* and *Hexastylis rhombiformis*. Though not known in this community in North Carolina, *Sagittaria fasciculata* occurs in an example in South Carolina.

LOW ELEVATION SEEP (FLOODPLAIN SUBTYPE)

Concept: Low Elevation Seeps are seepage-fed wetlands that lack the distinctive species composition and other characteristics of Hillside Seepage Bog, High Elevation Boggy Seep, Rich Montane Seep, Sandhill Seep, and other seepage wetland communities. The Floodplain Subtype represents seeps on medium to large floodplains, where upland seepage dominates hydrology but where flooding, alluvial deposition, and potentially blocking of drainage by alluvial landforms or beaver impoundment are also influences. It occurs in the Piedmont and Mountains.

Distinguishing Features: Low Elevation Seeps are distinguished by abundant wetland vegetation, without the characteristic composition and setting of other seepage wetlands or bogs.

The Floodplain Subtype generally is readily distinguished by the physical environment, which has at least occasional flooding as well as seepage. It generally is in a recognizable floodplain, with alluvial soil. It also contains plants characteristic of floodplains as well as seeps, and often contains plants of wetter conditions. Species frequent in the Floodplain Subtype and seldom in other seepage wetlands include *Cinna arundinacea*, *Persicaria sagittata*, *Carex tribuloides*, *Carex laevivaginata*, *Carex lurida*, *Impatiens capensis*, species of wetter areas such as *Peltandra virginica*, *Sagittaria* spp., and *Cephalanthus occidentalis*, and floodplain species such as *Acer negundo*, *Fraxinus pennsylvanica*, and *Betula nigra*. This subtype also tends to have nonnative species characteristic of floodplains and scarce in uplands, including *Microstegium vimineum*, *Murdannia keisak*, and *Persicaria longiseta* (*cespitosum*). Other species that are often dominant and that are most common in the Floodplain Subtype (compared to other subtypes) include *Boehmeria cylindrica*, *Glyceria striata*, *Saururus cernuus*, *Leersia oryzoides*, and *Lindera benzoin*. Species seldom found in the Floodplain Subtype include *Vaccinium fuscatum*, *Viburnum nudum*, *Ilex opaca*, *Osmundastrum cinnamomeum*, *Osmunda spectabilis, Platanthera* spp., *Arisaema triphyllum*, *Viola primulifolia*, and *Lorinseria areolata*.

Crosswalks: *Acer rubrum / Alnus serrulata – Lindera benzoin / Glyceria striata – Impatiens capensis* Seep (CEGL007031).
G184 Central & Southern Appalachian Seep & Seepage Bog Group.
Southern Piedmont Seepage Wetland (CES202.298) Ecological System.
Southern Appalachian Seepage Wetland Ecological System (CES202.317).
Floodplain Seep (Seymour 2011).

Sites: The Floodplain Subtype occurs on flat ground at the edges of medium to large bottomlands. It generally is right at the base of the upland slope, extending as far into the floodplain as the seepage keeps the soil saturated.

Soils: The Floodplain Subtype has silty or clayey alluvial soil that shows evidence of saturation. It is generally mapped as part of larger map units of alluvial soils such as Chewacla (Fluvaquentic Dystrudept), Wehadkee (Typic Fluvaquent), or Iotla (Fluvaquentic Dystrudept), but likely represents a more hydric soil inclusion. A few examples are included in upland soil map units.

Hydrology: Floodplain Subtype occurrences are saturated year-round. A thin sheet of flowing or standing water or small rivulets may uncommonly be present, or water may move solely through the soil. They are flooded at least occasionally by overflow from the river or stream.

Vegetation: The Floodplain Subtype generally has dense herbaceous vegetation with abundant graminoids. *Glyceria striata, Cinna arundinacea*, or the exotic *Microstegium vimineum* may dominate, and a number of *Carex* species may be abundant, including *lurida, atlantica, howei, laevivaginata, crinita, tribuloides*, and *radiata*. Other constant or high-frequency herbs include *Impatiens capensis, Lycopus virginicus, Boehmeria cylindrica, Sagittaria latifolia*, and *Persicaria sagittata*. *Sphagnum* sp. maybe present, but only in small amounts. *Mnium* spp. and other mosses and liverworts may also be present. Other herbs with moderate frequency include *Dichanthelium microcarpon* (*dichotomum* var. *ramulosum*), *Dioscorea villosa, Galium tinctorium, Hypericum mutilum, Juncus effusus/pylaei, Lycopus virginicus, Persicaria sagittifolia, Saururus cernuus, Solidago caesia, Symphyotrichum puniceum* var. *puniceum, Viola* spp., and the exotics *Murdannia keisak* and *Persicaria longiseta* (*cespitosum*). The shrub layer may be sparse or fairly dense. *Alnus serrulata* may dominate thickets, or it and *Lindera benzoin* may dominate more open stands. A few vines are usually present, though cover is generally low. These include *Toxicodendron radicans, Parthenocissus quinquefolia*, *Smilax rotundifolia*, and *Lonicera japonica.* Trees rooted in the community are variable, with *Acer rubrum, Fraxinus pennsylvanica,* and *Liquidambar styraciflua* most frequent and *Betula nigra* and other alluvial species also common.

Range and Abundance: Ranked G4. This community is scattered throughout the Piedmont and, more sparsely, in the Mountains. A few examples are known in the Coastal Plain. It is thus one of the most widely ranging communities in the state. The synonymized association is definitively attributed only to North Carolina and questionably to South Carolina but may be present in Georgia.

Associations and Patterns: The Floodplain Subtype is a small patch community. Occurrences tend to be larger than those of the Typic or Montane Subtype, because of flatter topography, generally wetter surrounding conditions, and perhaps because of greater amounts of groundwater, but most are still a few acres or less in size. They generally are surrounded by Piedmont Alluvial Forest or Piedmont Bottomland Forest but are often bordered by an upland community on one side.

Variation: Examples of the Floodplain Subtype vary with wetness. Seymour (2011) noted that this group of plots had the highest internal consistency of any of her Piedmont seepage wetland groups. The constraints of the environment allow communities recognizable as the same subtype to occur in all three regions of the state. Nevertheless, though not largely different in vegetation, variants are recognized based on expected biogeographic differences.

1. Mountain Variant occurs in the Mountain Region and possibly in the foothills area.

2. Piedmont Variant occurs in the central and eastern Piedmont, and potentially in the foothills area.

3. Coastal Plain Variant encompasses the few Coastal Plain examples. Examples are known on both brownwater and blackwater floodplain, which may suggest a further division of variants.

Dynamics: Dynamics of the Floodplain Subtype are a mix of those of other Low Elevation Seep subtypes and floodplain communities. Because saturation by seepage is perennially present, it is a stronger influence than flooding. However, this is the most fertile group of Piedmont seeps because of the fertility of the alluvium as well as nutrients brought in by flooding. Though probably rare, they may also be subject to changes in drainage caused by movement of sediment in outlet channels and to flooding by beaver ponds. Like floodplain communities, the Floodplain Subtype of Low Elevation Seep is particularly susceptible to invasion by exotic plants. *Microstegium vimineum, Murdannia keisak, Lonicera japonica*, and *Ligustrum sinense* may all be abundant and can come to dominate in disturbed examples.

Comments: This subtype fits quite well with the Floodplain Seeps type of Seymour (2011) within the Piedmont, but it is broadened to include similar communities in the Mountains and Coastal Plain. Seymour (2011) found it to be the most distinctive of her five types of Piedmont seeps, more distinct than the Hillside Seepage Bog or Piedmont Boggy Streamhead types. This suggests consideration should be given to treating it as a full type rather than a subtype in the future. It does, however, appear to have more overlap in composition in some examples than her general analysis suggests.

Several extensive, very wet, marsh-like communities that have been called "Piedmont Fens" are included here. They have had limited study and need further exploration to clarify their ecological character. They may represent an unrecognized subtype or may represent examples of the Floodplain Subtype that have been affected by beaver or human impoundments.

Liquidambar styraciflua - Quercus laurifolia / Magnolia virginiana / Carex lonchocarpa Wet Forest (CEGL004631) is a seepage association described from the South Carolina Coastal Plain and questionably attributed to North Carolina. Though it is described as occurring on low flats that seldom flood, the described vegetation suggests affinities with the Floodplain Subtype. The NVC description indicates uncertainty if it is a natural or an anthropogenic community. Similar vegetation is not known in North Carolina but, if found, it might be interpreted as a special case of the relatively broadly defined Floodplain Subtype.

Rare species:
Vascular plants – *Platanthera peramoena, Sida elliottii* var. *elliottii,* and *Silphium connatum*.

Vertebrate animals – *Glyptemys muhlenbergii* and *Hemidactylium scutatum*.

HILLSIDE SEEPAGE BOG

Concept: Hillside Seepage Bogs are sloping seepage wetlands of the Piedmont that have a distinctive acid-tolerant, bog-like flora that generally includes *Sarracenia flava* or *Sarracenia purpurea*, *Sphagnum*, and often herbaceous species of Coastal Plain affinities.

Distinguishing Features: Hillside Seepage Bogs share many woody species with other Piedmont upland seeps, including multiple species of Coastal Plain affinities, such as *Magnolia virginiana, Smilax laurifolia, Nyssa biflora,* and *Viburnum nudum*. They also share widespread species of saturated wetland, such as *Osmundastrum (Osmunda) cinnamomeum*, *Osmunda spectabilis*, and *Sphagnum* spp. They are distinguished by a collection of more acid-tolerant herbs, many of which also have Coastal Plain affinities. *Sarracenia flava* or *Sarracenia purpurea* are usually, though not always, present, or have been in the past. *Sphagnum* is generally more extensive than in other Piedmont seeps. When examples are burned, a variety of herbaceous species not found in other seeps are present, including *Symphyotrichum dumosum*, *Rhexia mariana, Danthonia sericea, Eupatorium leucolepis*, *Drosera brevifolia*, and *Helenium brevifolium*. Low Elevation Seep (Typic Subtype) communities may occur in similar uphill settings but contain fewer extremely acid-tolerant species. Species such as *Arisaema triphyllum ssp. triphyllum, Glyceria striata, Boehmeria cylindrica*, and *Saururus cernuus* are characteristic of Low Elevation Seeps but are not generally present in Hillside Seepage Bogs. Low Elevation Seep (Piedmont/Mountain Springhead) communities have a similar collection of Coastal Plain woody species but lack the natural herbaceous component. Piedmont Boggy Streamheads lack most of these specialized herbaceous species, and they contain a few more widespread floodplain species such as *Lindera benzoin* and *Xanthorhiza simplicissima*. Low Elevation Seep (Floodplain Subtype) communities have even more floodplain species and more species of richer soils.

Many Hillside Seepage Bogs have been overgrown by shrubs and trees, in response to lack of fire and to hydrologic alteration. These lack the distinctive herbaceous component and are very difficult to distinguish from other seeps without knowing that they once harbored these species. Their vegetation may be very similar to that of Low Elevation Seep (Piedmont/Mountain Springhead), but they should be treated as degraded Hillside Seepage Bogs. The ranges of these two communities are not known to overlap. Hillside Seepage Bogs are known only from the middle and lower Piedmont.

The Low Mountain Seepage Bog community type shares a similar topographic and hydrologic setting with Hillside Seepage Bogs, along with sharing some species, but its location in the western Mountains leads to a substantially different flora.

Crosswalks: *Acer rubrum var. trilobum / Morella caroliniensis - Gaylussacia frondosa / Andropogon glomeratus - (Sarracenia flava)* Seep Woodland (CEGL004781).
G044 Central Interior-Appalachian Seepage Swamp Group.
Piedmont Seepage Wetland Ecological System (CES202.298).
Headwater Boggy Seep (Seymour 2011).

Sites: Hillside Seepage Bogs occur on sloping uplands, generally on mid to lower slopes. They are not on floodplains of even small streams, though they may have rivulets and some may have a headwater stream issuing from them. Seymour (2011) described them as having the nearest stream being the smallest and steepest of any Piedmont seeps. Some Hillside Seepage Bogs are in distinct amphitheater-like indentations in the slope, suggesting effects of sapping. A few may have a distinct steepening of the slope, suggesting a different underlying layer. Some have no obvious difference from the adjacent slope.

Soils: Soils are saturated residual soils, which may or may not have a substantial organic component. Seymour (2011) found this to be the most acidic and infertile of her five groups of Piedmont seep communities, with soils high in clay. Some other examples are distinctly silty. Examples are generally too small to be distinguished in soil mapping and are included with adjacent upland soils.

Hydrology: Hillside Seepage Bogs are perennially saturated. They tend to be wetter than Low Elevation Seeps of most subtypes.

Vegetation: Hillside Seepage Bogs in natural condition have moderate to dense herbaceous vegetation and have sparse trees and sparse-to-moderate shrubs. *Sphagnum* spp. is usually present and often extensive. *Osmundastrum cinnamomeum* and *Osmunda spectabilis* are highly constant and often codominant. *Sarracenia flava* and *Sarracenia purpurea* are frequent in examples that have stayed open; they apparently were more constant in the recent past but have been lost from a number of sites. Other frequent herbs in both Seymour (2011) and in site descriptions include *Lorinseria areolata, Viola primulifolia, Chasmanthium laxum, Eleocharis tuberculosa, Scleria triglomerata*, *Andropogon* spp. (*glomeratus, virginicus*, and possibly others), and *Rhexia mariana*. *Carex* is fairly constant as a genus; species include c*rinita, intumescens, leptalea, folliculata, complanata, lurida*, and several others, no one of which has high frequency. *Rhynchospora capitellata* and *Rhynchospora glomerata* are frequent and may be abundant in patches. A large suite of less frequent species of open wetlands may be present, including *Pteridium pseudocaudatum (aquilinum), Mitchella repens, Sophronanthe (Gratiola) pilosa, Eupatorium rotundifolium, Eupatorium pilosum, Eupatorium leucolepis, Danthonia sericea, Erianthus* spp., *Calamagrostis coarctata (cinnoides*), *Sporobolus (Calamovilfa*) *brevipilis*, *Drosera brevifolia, Polygala lutea, Platanthera clavellata, Pogonia ophioglossoides, Calopogon tuberosus, Calopogon pulchellus, Xyris caroliniana, Juncus coriaceus, Scutellaria integrifolia, Scleria ciliata, Scutellaria integrifolia, Asclepias rubra, Danthonia spicata*, *Medeola virginiana*, *Drosera rotundifolia, Oxypolis rigidior,* and number of others. The shrubs that most often codominate are *Viburnum nudum, Alnus serrulata, Eubotrys racemosa, Aronia arbutifolia*, and *Vaccinium* spp. (*fuscatum, formosum,* possibly *corymbosum*), but *Gaylussacia frondosa* dominates patches in a few examples. Other shrubs include *Cyrilla racemiflora, Morella caroliniana, Clethra alnifolia, Lyonia ligustrina, Arundinaria tecta, Ilex laevigata*, and *Itea virginica*. *Smilax laurifolia* occurs with high frequency and sometimes forms large tangles. The tree canopy is most often *Acer rubrum*, at least some of which is *trilobum*, and *Liriodendron tulipifera*. *Nyssa sylvatica, Pinus taeda, Pinus echinata, Liquidambar styraciflua*, and other species sometimes are present. Upland species such as *Quercus alba* and *Quercus stellata* appear in plot data; they may be rooted in the edge of the wetland but may represent overhanging canopy. Understory trees include *Magnolia virginiana* and *Ilex opaca*, as well as canopy species.

Range and Abundance: Ranked G2 but potentially G1 because so many of the examples are in poor condition. This community is endemic to North Carolina. There are two distinct clusters of occurrences, one in northern Iredell County, the other in the Uwharrrie area of Montgomery and Randolph County. Only a couple of examples of questionable identification are in other Piedmont locations.

Associations and Patterns: Hillside Seepage Bogs are generally surrounded by upland forests. In the Uwharrie cluster, many of the examples are associated with Piedmont Longleaf Pine Forest, though some may be in Dry Oak–Hickory Forest. Many examples in the Iredell County cluster have lost their natural surroundings, but they appear to be associated with Dry-Mesic Oak–Hickory Forests or Mesic Mixed Hardwood Forest.

Variation: The two geographic clusters correspond to marked floristic differences; they are recognized as variants and could potentially be regarded as subtypes.

1. Uwharrie Variant occurs in eastern Piedmont. It has a large component of Coastal Plain herbs, with particular affinities to Sandhill Seep communities of the nearby Sandhills Region.

2. Iredell Variant occurs in the central Piedmont. It has fewer Coastal Plain species, though a number are still present in good examples. It may have some species more typical of mountain wetlands, such as *Oxypolis rigidior, Drosera rotundifolia,* and *Symphyotrichum puniceum*.

Dynamics: Hillside Seepage Bogs are tied to distinct, rare, specialized environments and, given their distinctive flora containing disjunct species, presumably have persisted in them for a very long time. However, they appear to be unstable communities under current environmental conditions. They are prone to increases in trees and shrubs, with the loss of the distinctive herbaceous component and reduction of the herb layer to the few most shade-tolerant species. This change has occurred over the last several decades, so that examples that were described as diverse herbaceous communities containing *Sarracenia* in the 1970s-1990s now are shaded and have few distinctive nonwoody species. Seymour (2011) found plots from several well-known sites had lost their distinctive character enough that they clustered with the woody-dominated Low Elevation Seep (Piedmont/Mountain Springhead Subtype) plots rather than with more intact Hillside Seepage Bogs.

Despite their wetness, Hillside Seepage Bogs appear to be highly dependent on fire and presumably burned under natural conditions. This is abundantly clear in the Uwharrie Variant, where most examples are associated with longleaf pine communities. The examples with the most diverse vegetation, strongest herb dominance, and strongest Coastal Plain affinities are those that have had prescribed burning in recent years. A few unburned examples that were clearcut retained herbaceous flora longer but ultimately became shaded by dense saplings and shrubs. Where subject to prescribed fires, fire usually spreads at least partway across the community patches. It is likely that feedback between vegetation and fire is important, with fire promoting more flammable graminoid-dominated vegetation.

The role of fire is less clear in the Iredell Variant. Prehistorically, they presumably burned at the same frequency as the Piedmont oak forest landscape that surrounded them, but evidence of fire was not noted in any of the twentieth century descriptions of diverse herbaceous vegetation. However, many are associated with pasture lands at present, and it is possible burning of pastures subjected them to fire through part of that century.

Hydrology is also clearly important to the persistence of Hillside Seepage Bogs. They appear to have more discharge than most Piedmont seeps, and wetness excludes most upland species and limits tree growth. The lower pH in them may reflect the source of groundwater. The deterioration of some of the Iredell County bogs is clearly related to increased drainage driven by entrenchment or headward erosion of small streams. The author witnessed new headward erosion at one site some 30 years ago, with a knickpoint on the nearby stream having just reached the bog but the vegetation in good condition. A visit 20 years later found the stream channel entrenched along the entire edge of the bog, the knickpoint far upstream, dense young trees over most of the bog area, and only a few patches of wetland vegetation remaining where water seeped in the channel bank. Several other examples now retain saturated soil only on the edge of an entrenched channel that likely was not present 50 years before. The cause of this ongoing erosion is unclear, given that it comes after more than a century of agricultural land use in the vicinity and is not associated with new urban development or land clearing. While hydrology is clearly important in the Uwharrie bogs, the recent deterioration of examples there is not associated with known hydrological changes.

Comments: Seymour (2011), in her study of Piedmont seep vegetation, recognized a Headwater Boggy Seep type that corresponded to Hillside Seepage Bogs. She said it was more broadly defined than the corresponding NVC association, but it appears more narrowly defined than the 4th Approximation concept because she had intact plots only in the Uwharrie Variant. The plots from Iredell Variant bogs were taken after they had become overgrown, and her analysis did not group the altered vegetation with the intact Uwharrie Variant plots. The description here is based on information from more intact vegetation.

Rare species:
Vascular plants – *Carex barrattii, Danthonia epilis, Fothergilla major, Helenium brevifolium,* and *Lindera subcoriacea.*

Invertebrate animals – *Exyra ridingsii*.

PIEDMONT BOGGY STREAMHEAD

Concept: Piedmont Boggy Streamheads are conceptually intermediate between other Piedmont seepages and Piedmont Headwater Stream Forest. Saturated soil caused by seepage creates wetland conditions, but brief flooding and movement of sediment also occurs. The vegetation is a mix of widely tolerant acidic seepage species and of species shared with Piedmont Headwater Stream Forests and uplands, often with some characteristic Coastal Plain species.

Distinguishing Features: Piedmont Boggy Streamheads are distinguished by the combination of extensive seepage-saturated soil with a headwater stream setting. A recognizable channel and usually evidence of flooding is present. They contain a suite of species, many of them more characteristic of the Coastal Plain, that distinguish them from most subtypes of Low Elevation Seep, including *Smilax laurifolia, Cyrilla racemiflora,* and *Magnolia virginiana*, as well as being more likely to have *Vaccinium fuscatum, Vaccinium formosum*, and *Osmunda spectabilis*. Though Piedmont Boggy Streamheads share many of these species with Hillside Seepage Bogs, they lack *Sarracenia flava*, *Sarracenia purpurea*, and most of the diverse collection of herbaceous species characteristic of that community. At the same time, they have some plants of richer and better drained communities that are generally absent in Hillside Seepage Bogs, such as *Lindera benzoin*, *Toxicodendron radicans, Fraxinus* spp., *Glyceria striata, Eutrochium fistulosum,* and *Lobelia cardinalis*.

Many of the species of Piedmont Boggy Streamheads are shared with the Piedmont/Mountain Springhead Subtype of Low Elevation Seep than with the other subtypes (e.g., *Vaccinium* spp., *Viburnum nudum, Ilex opaca, Alnus serrulata, Smilax laurifolia, Lorinseria areolata*). However, the geographic ranges of these communities do not overlap. Piedmont/Mountain Springheads tend to lack other characteristic species of Piedmont Boggy Streamheads, such as *Liquidambar styraciflua, Morella caroliniensis (Myrica heterophylla), Cyrilla racemiflora, Gaylussacia frondosa, Pinus taeda*, and *Chasmanthium laxum*, and are more likely to have other species such as *Toxicodendron vernix, Hydrangea* (*Decumaria*) *barbara*, and various species of *Carex*.

Some of the wetland species of Piedmont Boggy Streamheads, such as *Osmundastrum* and *Viburnum nudum*, may also occur in Piedmont Headwater Stream Forest, but there they have low frequency, have low diversity in any given occurrence, and are confined to small wet microsites.

Crosswalks: *Acer rubrum var. trilobum – Liriodendron tulipifera / Ilex opaca / Osmunda cinnamomea* Seep Forest (CEGL004551).
G044 Central Interior-Appalachian Seepage Swamp Group.
Piedmont Seepage Wetland Ecological System (CES202.298).
Streamhead Seep (Seymour 2011).

Sites: Piedmont Boggy Streamheads occur along headwater streams, generally intermittent or 1st to 2nd order streams with a moderate gradient. Many occur in relatively low relief areas underlain by argillite or other silty/clayey substrates, but some are in more rugged rocky areas of granite or hard volcanic rocks. A well-developed channel generally is present, which may be entrenched but not deeply in examples in good condition. There may be distinct areas where strong seepage emerges, sometimes in basins that appear to result from sapping, or seepage may be diffuse over much of the site.

Soils: Soils are probably mainly residual, with local pockets of alluvial material. Most do not appear to be mucky, except in small pockets. Most examples are too narrow to be distinguished in soil mapping and are included in upland soil units. The Secrest series (Aeric Epiaquult) is mapped for a few, and it may represent the identity of inclusions in other map units.

Hydrology: Piedmont Boggy Streamheads are saturated by seepage through much or all of the year. Wetness may be heterogeneous, in response to multiple discharge locations and varying dispersal of water. Areas nearest the channel may be drier due to the drainage effect of the channel, but they may be wetter, as indicated by *Sphagnum* clumps. Stream flooding is intermittent and of brief duration but may have enough current to move litter and to scour the ground in small areas.

Vegetation: Piedmont Boggy Streamheads generally have a substantial tree canopy, which may be as dense as a typical forest or may be somewhat open. They are dominated by a mix that most often includes *Acer rubrum*, sometimes var. *trilobum*, *Liriodendron tulipifera, Liquidambar styraciflua*, *Quercus alba*, and less often, *Nyssa sylvatica, Pinus taeda, Quercus rubra, Fraxinus pennsylvanica, Fraxinus profunda*, or other species. *Magnolia virginiana, Oxydendrum arboreum* and *Ilex opaca* are the most frequent understory species. Shrubs are usually moderate in density and fairly diverse. The most constant species in Seymour (2011) and in site descriptions are *Viburnum nudum, Vaccinium fuscatum, Vaccinium formosum, Eubotrys racemosa*, *Alnus serrulata*, and *Arundinaria tecta*. Also frequent are *Morella caroliniana, Aronia arbutifolia, Ilex verticillata, Itea virginica*, *Gaylussacia frondosa*, *Euonymus americanus*, and *Lindera benzoin*. *Toxicodendron vernix* and the rare *Lindera subcoriacea* have also been found. Vines are often abundant, especially *Smilax rotundifolia* and *Smilax laurifolia*, but also *Toxicodendron radicans, Smilax glauca, Muscadinia rotundifolia*, and occasionally *Smilax walteri*. The herb layer is usually moderate in density. *Osmundastrum cinnamomeum* and *Osmunda spectabilis* are the most constant species and often the most abundant. Other constant or frequent species include *Lorinseria areolata, Chasmanthium laxum, Mitchella repens, Arisaema triphyllum, Lycopus virginicus, Scutellaria integrifolia, Viola primulifolia, Carex debilis, Athyrium asplenioides, Eutrochium fistulosum, Medeola virginiana, Uvularia puberula, Dioscorea villosa, Dichanthelium microcarpon (dichotomum* var. *ramulosum)*, *Chelone glabra*, and *Solidago caesia*. Infrequent but notable species include *Glyceria striata, Orontium aquaticum, Dryopteris cristata, Triadenum* (*Hypericum*) *walteri, Platanthera clavellata, Solidago salicina (patula* var. *strictula), Lobelia cardinalis, Hypoxis hirsuta*, and *Oxypolis rigidior*. *Sphagnum* spp. is present in clumps but generally does not have extensive cover. Clumps may be scattered or may be concentrated on the channel banks or in pockets along the upland edge where seepage is stronger. Exotic plant species such as *Lonicera japonica* and *Microstegium vimineum* may occur in Piedmont Boggy Streamheads but are less frequent and less abundant than in floodplain communities.

Range and Abundance: Ranked G2G3. Fewer than 20 examples are known; they may tend to be overlooked or unreported in older site descriptions but appear to be rare. In North Carolina they are strongly concentrated in the Uwharrie region, with other examples widely scattered in the eastern Piedmont. The NVC association also occurs in Georgia and probably South Carolina.

Associations and Patterns: Piedmont Boggy Streamheads are small patch communities, occurring as narrow bands that generally have only limited length. However, they can occur in clusters that may amount to 10–50 acres, lining multiple drainages in sites where conditions are suitable. Patches give way to Piedmont Headwater Stream Forest or Piedmont Alluvial Forest downstream, where seepage ends or where the stream channel and floodplain become better developed. Otherwise, they are surrounded by upland communities, typically Dry-Mesic or Dry Oak–Hickory Forest or, particularly in the Uwharrie area, by Dry Piedmont Longleaf Pine Forest. Piedmont Boggy Streamheads may occur in the same sites as Hillside Seepage Bogs but usually are not directly connected.

Variation: Patterns of variation have not been identified.

Dynamics: The dynamics of Piedmont Boggy Streamheads are not well known. Given their occurrence in upland landscapes with flammable oak or longleaf pine vegetation, they would naturally be exposed to frequent fire. Prescribed fires appear to penetrate them sometimes but not always. When they burn, shrubs and small trees may be killed but readily resprout. The larger canopy trees are generally not harmed by fires, but chronic fire likely would reduce canopy density and reduce the amount of *Acer rubrum*. As in Hillside Seepage Bogs, it is possible there is a vegetation-fire feedback, with fire promoting more flammable vegetation.

As in other seeps, groundwater input presumably provides a nutrient subsidy to the community, but the water may often be very acidic and low in nutrients. Flooding also provides input of nutrients. Input of ash when the surrounding landscape burns, even if the streamhead does not burn, would also supply nutrients.

Comments: The Piedmont Boggy Streamhead was not recognized in the published 3rd Approximation; it was recognized and tracking begun shortly after that publication. Definition of the conceptual boundary with Hillside Seepage Bog has always been difficult because of the loss of herbaceous flora in many Hillside Seepage Bogs. Some examples may remain ambiguous. However, Seymour (2011) found them to be distinct.

Piedmont Boggy Streamheads also share some environmental characteristics and flora with Low Elevation Seep (Piedmont/Mountain Springhead Subtype), enough that it can be argued that the two should be treated as subtypes of the same community type. Nevertheless, analysis by Seymour (2011) found both to be distinct and not the most closely related.

Rare species:
Vascular plants – *Carex barrattii, Carex vestita, Fothergilla major, Lindera subcoriacea,* and *Magnolia macrophylla.*

Vertebrate animals – *Hemidactylium scutatum*.

COASTAL PLAIN SEEPAGE BANK

Concept: Coastal Plain Seepage Banks are rare communities of very steep, wet clay bluffs along Coastal Plain rivers. Though the lower parts may occasionally be flooded, they are kept constantly wet by seepage from more permeable sediment layers above. They are usually dominated by liverworts and mosses and have only sparse vascular plants.

Distinguishing Features: Coastal Plain Seepage Banks are distinguished from cliff communities by having a substrate composed primarily of dense clay which is permanently or semi-permanently wetted by seepage, and by having predominantly wetland plants. *Viola primulifolia* appears to be the most common vascular plant. Coastal Plain Cliff communities and cliffs in other regions may have local saturated seepage zones, but these are limited in extent and tend to support denser vegetation. Edges of this community may have sandy soil which is also saturated and supports wetland shrubs. Sandhill Seeps may have steep clay faces covered with seepage, but do not occur along rivers and have dense vascular vegetation.

Crosswalks: *Pallavicinia lyellii – Sphagnum* sp. Cliff Vegetation (CEGL004779).
G842 Southeast Coastal Plain Cliff & Rock Vegetation Group.
Piedmont Seepage Wetland Ecological System (CES202.298).
Little River Seepage Bank (early 4th Approximation drafts).

Sites: Coastal Plain Seepage Banks occur along rivers or large creeks in the Coastal Plain where dense clay beds are exposed in steep outcrops created by undercutting by the flowing water. The substrate generally is one of the Cretaceous age units that underlie the Coastal Plain, such as the Cape Fear Formation. Most examples are in the eastern Sandhills region, where apparent geologic uplift has led the Cape Fear River and its major west-side tributaries to carve deep valleys. However, they may occur anywhere else in the Coastal Plain where rivers flow against uplands and where the underlying substrate includes a thick clay bed at the right elevation.

Soils: Coastal Plain Seepage Banks do not have developed soil. The surface is dense clay and is nearly vertical.

Hydrology: Coastal Plain Seepage Banks are perennially wet. Shallow groundwater moving through permeable sediment is blocked by the impermeable clay and discharged in the bluff. It flows in a thin sheet across the face of the clay layer.

Vegetation: Vascular vegetation is sparse over most of the extent of Coastal Plain Seepage Banks. Some portions may have high cover of liverworts, while others have extensive bare wet clay. The taxa of the liverworts are not well known, though the *Pallavicinia lyellii* used in the NVC name likely is important. Mosses, *Sphagnum, Polytrichum*, and others, may be abundant. The most frequent and usually most abundant vascular plants are *Erigeron vernus, Viola primulifolia*, and *Lorinseria areolata*. Other species that are fairly frequent include *Drosera capillaris*, *Mikania scandens, Lygodium palmatum, Hydrocotyle verticillata, Hydrocotyle tribotrys (verticillata* var. *triradiata), Rhynchospora* spp. (*gracillima, gracilescens*), and *Boehmeria cylindrica*. In Sandhills examples, *Drosera rotundifolia*, disjunct from the Mountain Region, is also frequent. A variety of other herbs of Sandhill Seeps, savannas, or other wetlands may be present, including *Triadenum* (*Hypericum*) *walteri, Hypericum virginicum, Carex debilis, Dichanthelium ensifolium*, *Sarracenia purpurea, Xyris baldwiniana, Platanthera clavellata*, and *Aletris aurea*. Shrubs are scarce or absent on the main clay face but are usually present, sometimes dense, on the edge. Frequent species include *Xanthorhiza simplicissima, Cyrilla racemiflora, Eubotrys racemosus, Symplocos tinctoria, Kalmia latifolia, Alnus serrulata*, and *Vaccinium elliottii*. Trees generally do not root in the seep but often shade it from the edge. Several seeps have *Chamaecyparis thyoides* on the edge, along with *Pinus taeda, Acer rubrum, Quercus nigra*, and other species.

Range and Abundance: Ranked G3 but probably rarer. In North Carolina, only a handful of locations are known, though some are extensive complexes. Almost all examples are in the eastern Sandhills Region, along entrenched tributaries of the Cape Fear River. However, one example farther out in the Coastal Plain is known and more may be found. The total number of occurrences is likely to remain fewer than ten. The synonymized association is considered potentially wide-ranging but is apparently poorly known. Besides North Carolina, it is attributed definitively only to Mississippi and Texas, though it could occur in any of the states between. In none is it reported to be common. It may be wondered whether communities over such a wide range are really similar enough to be the same association.

Associations and Patterns: Coastal Plain Seepage Bank is a small patch community. Area is difficult to define because the sites are usually so steep that they may have almost no area in map projection. Individual patches may range up to 200 meters long and are less than 10 meters high. Multiple patches often occur along a river, occasionally adding up to areas of a few acres of surface area. They are usually bordered by a riverbank below, though they potentially could have floodplain at the base. Some are associated with Cape Fear Valley Mixed Bluff Forest, a community confined to the deeply entrenched valleys of Cape Fear River tributaries. Most probably were naturally bordered by dry longleaf pine communities above, but some may have occurred with mesic hardwood forests on adjacent bluffs.

Variation: Variation is not well known. The examples in the Sandhills appear fairly similar, with the one in the northern Coastal Plain somewhat different.

Dynamics: Coastal Plain Seepage Banks may be flooded in their lower portions. It is unclear what effect this has on the community. Portions that get flooded too frequently appear to lack bryophytes and to stay largely bare, but for portions that flood rarely, scouring or battering by floating material may be a periodic natural disturbance that strips the plants from local areas.

The long-term dynamics of Coastal Plain Seepage Banks are not well known. They seem to be primary successional communities. The lack of denser vegetation presumably is due to difficulty rooting in the dense clay, perhaps combined with the steepness, rather than wetness itself. Over time, erosion of the clay banks might reduce the steepness, allowing loose material to accumulate and form soil. The community might succeed to something like a Low Elevation Seep or Cape Fear Valley Mixed Bluff Forest. However, undercutting by the river probably causes periodic collapse of the faces, creating new bare clay surfaces and driving a kind of cyclic succession. It is unclear how often this happens, or how often it is needed to maintain these communities indefinitely. Collapse could also contribute to succession; if fallen material is not removed by stream erosion, it will pile up at the base and eventually bury the steep face.

Comments: This community type was not known in 1990 and had no close equivalent in the 3rd Approximation. It was first described by Bruce Sorrie and Brian van Eerden in Natural Heritage survey work on Fort Liberty, with additional examples found in county natural area inventories in the Sandhills counties. These communities are virtually impossible to sample with standard plot sampling techniques, and no CVS plot data exist.

Rare species: No rare species are known to be specifically associated with this community.

PIEDMONT AND MOUNTAIN UPLAND POOLS AND DEPRESSIONS THEME

Concept: Piedmont and Mountain Upland Pools and Depressions are isolated wetlands of small basins in upland settings. They are filled by rainwater and local runoff from a limited area, and they hold standing water part but generally not all of the year. They may be forests or open woodland or shrub/herb vegetation. Most are in the central and eastern Piedmont, but one rare subtype is in the Blue Ridge.

Distinguishing Features: Piedmont and Mountain Upland Pools and Depressions are distinguished from all other communities by their occurrence in upland settings in the Piedmont or Mountains, outside of floodplains and generally not associated with streams, with wetness resulting from naturally ponded water rather than seepage or overbank flooding. When not flooded, they may be distinguished by dominance of wetland vegetation, generally in strong contrast to that of the surrounding uplands.

Within the theme, Upland Pool communities are distinguished by being wet enough to not support a closed tree canopy, while Upland Depression Swamp Forests have a full forest canopy when not disturbed.

Sites: Piedmont and Mountain Upland Pools and Depressions communities occur in both gently sloped basins in unusually flat upland topography associated with mafic or clay-rich rocks and in steeper ridgetop depressions in more rugged terrain. Infiltration of water may be prevented by either a dense clay hardpan or apparently by bedrock. They are most often associated with mafic rocks such as gabbro and diabase, but they may occur on felsic rocks, clay-rich sedimentary or meta-sedimentary rocks, or, rarely, on flat-lying quartzite beds.

Soils: These communities have soils where internal drainage is restricted, either by bedrock or by a dense clay hardpan. Many, but not all, have shrink-swell clays such as montmorillonite, which prevent infiltration. Iredell soil (Vertic Hapludalf) is the most frequent soil mapped, but Misenheimer (Aquic Dystrudept) occurs in several examples and other soils are possible. Though examples on mafic rocks may be higher in pH and base cation levels than those on felsic rock, all are more acidic than drier soils on mafic rocks.

Hydrology: Piedmont and Mountain Upland Pools and Depressions are seasonally flooded by standing water that may range from a few inches to several feet deep. Water comes from rainfall and from a small local watershed. An impermeable substrate, either a clay hardpan or possibly bedrock, prevents infiltration. Water loss is primarily through evaporation and transpiration. Some basins have a visible overflow channel while others do not, but all must have a place where water overflows the basin in wetter periods. Standing water typically lasts into the growing season but is gone by summer in most examples. In some years standing water may be absent, may persist through more of the season, or may return later in the season after heavy rains. Because of the impermeable substrate and limited rooting depth, conditions for plants may be dry when water has evaporated and soil has dried.

Vegetation: Vegetation in Piedmont and Mountain Upland Pools and Depressions may be either a forest with a full tree canopy, or somewhat more open vegetation that includes trees confined to the edges and shrubs or herb dominating in the middle. In most examples, *Quercus phellos* is the dominant or most abundant tree. Some communities have codominant or dominant *Quercus lyrata*, or more rarely, *Quercus michauxii, Quercus bicolor*, or in the mountains, *Nyssa sylvatica*. In the more open Upland Pools, shrubs are abundant at least on the edges. *Cephalanthus occidentalis, Vaccinium fuscatum, Vaccinium formosum, Eubotrys racemosus*, and in the mountains*, Leucothoe fontanesiana* may dominate. In many examples, tangles of vines, especially *Smilax rotundifolia* or *Smilax walteri,* are extensive. The herb layer consists of species tolerant of prolonged flooding or able to respond to drawdown. *Carex joorii* dominates in many examples, both forested and open. In more open Upland Pools, *Scirpus cyperinus, Dulichium arundinaceum*, or other species may dominate. *Sphagnum* spp. and *Climacium americanum* are often present. Examples are often notable for containing species more typical of the Coastal Plain than of the Piedmont or Blue Ridge.

Dynamics: As in most seasonally flooded wetlands, there is substantial variation in water presence and depth, both with seasons and among years with different rainfall. When flooded, these depressions support an ephemeral fauna of invertebrates, which presumably consume the leaf litter. All of the communities in this theme may be important breeding sites for frogs and salamanders, both common and rare species, attracting them from a large surrounding area. This makes them important to the fauna and ecosystem dynamics of the landscape, despite their small size. It also makes their fauna dependent on the presence and condition of upland habitat in the landscape. Seymour (2011) noted that the pronounced seasonal variation in vegetation of many other depressional wetland, such as North Carolina's Coastal Plain depressions, is muted in Upland Depression Swamp Forests. The predominant plants are long-lived perennials that persist through seasons and years, though a few species may temporarily appear or greatly expand in dry years.

The basins that support Piedmont and Mountain Upland Pools and Depressions communities appear to be stable long-term features, but their origin is unclear. LeGrand (1952) noted that no mechanism of surface erosion seems capable of creating them and suggested that they originate by solution of the underlying rock. He noted that mafic rocks have much more soluble mineral matter than felsic. This mechanism would need further explanation for why the depressions occur in small areas on the mafic rocks. A feedback process that amplifies minor differences in ability to hold water might be sufficient explanation, or underlying fractures that promote ground water movement might be a cause. Reed et al. (1963) offered a similar explanation for the pools in quartzite on the rim of Linville Gorge, calculating that, given the range of silica content found in the water, the volume of the pools could have been removed in tens of thousands, if not thousands, of years. Though the basins appear to be long-lasting, given the high rainfall of the region, it would seem likely that basins would overflow enough to lead to eventual erosion of channels that would permanently drain them. However, the flatness of the landscape where many occur may slow this process.

KEY TO PIEDMONT AND MOUNTAIN UPLAND POOLS AND DEPRESSIONS

1. Community with a well-developed forest canopy when not recently disturbed, with trees rooted throughout the community; *Quercus phellos, Quercus lyrata*, or rarely, *Quercus michauxii* or *Quercus bicolor* dominant; in the eastern or central Piedmont…..…………………………………… ……………………………………………………………… **Upland Depression Swamp Forest**

1. Community without a well-developed forest canopy, with trees largely confined to the shallower edges; trees various; in either Piedmont or Mountains.
   2. Community in the Mountain Region ....**Upland Pool (Mountain Subtype)**
   2. Community in the Piedmont Region.
      3. Community with strong zonation, with deep water in the center; edge zone dominated by *Nyssa biflora*; substantial Coastal Plain flora, such as *Smilax walteri*, present; known only in Uwharrie National Forest..**Upland Pool (Pleasant Grove Subtype)**
      3. Community with moderate or weak zonation; water shallower in the center, though deep enough to limit tree establishment; *Nyssa biflora* absent; other Coastal Plain flora present or not.
         4. Community with substantial Coastal Plain flora, including abundant *Smilax walteri, Dulichium arundinaceum*, *Rhynchospora* spp., and *Eleocharis* spp.; known only in Uwharrie National Forest ....**Upland Pool (Roberdo Subtype)**
         4. Community without substantial Coastal Plain flora, though a few species may be present; *Smilax walteri* absent, though *Smilax rotundifolia* or other species may be abundant; *Quercus phellos* generally dominant on the edge; anywhere in the eastern or central Piedmont ………………………………………………… **Upland Pool (Typic Piedmont Subtype)**

UPLAND DEPRESSION SWAMP FOREST

Concept: Upland Depression Swamp Forests are forested isolated wetlands in shallow depressions or perched on upland ridges and flats with impeded soil drainage. Water stands for part of the year, but wetness is not great enough to prevent a closed tree canopy from developing. They occur on unusually flat areas with hardpan soils derived from mafic rocks or slates, or in small topographic basins on ridgetops on volcanic rock. The forests are usually dominated by *Quercus phellos*, sometimes codominant with or replaced by *Quercus lyrata, Quercus bicolor, Quercus michauxii*, or *Liquidambar styraciflua*. Successional examples may be dominated by *Acer rubrum* or *Liquidambar styraciflua*.

Distinguishing Features: Upland Depression Swamp Forests are distinguished from Upland Pools by having a closed canopy all the way across the basin when not recently disturbed, and therefore lacking shade-intolerant shrubs and herbs. Upland Pools may have trees on the edge but lack them in the center and have a less diverse flora because of the long hydroperiod.

Upland Depression Swamp Forests are distinguished from floodplain forests of various kinds by their isolated upland location and lack of channel flow or overbank flooding. This is indicated by the lack of most characteristic floodplain trees, the usual predominance of *Quercus phellos*, and the usual presence of *Sphagnum lescurii* and *Climacium americanum*. While some Upland Depression Swamp Forests have an outlet channel, the outlet is usually too small to form a floodplain. However, a few ambiguous and transitional examples occur, where Upland Depression Swamp Forests give way gradually to Piedmont Headwater Stream Forest (Hardpan Subtype) communities. Both of these communities may be dominated by *Quercus phellos* and share other flora, but the Piedmont Headwater Stream Forest has additional species of alluvial conditions and should show a channel or substantial evidence of flow.

Upland Depression Swamp Forests may closely resemble Mixed Moisture Hardpan Forests. They are distinguished by a strong predominance of wetland oaks, with virtually no individuals of upland oaks such as *Quercus stellata* or *Quercus alba* present. When water is not present, Upland Depression Swamp Forest basins may or may not look notably different from the surrounding uplands but they are recognizable by the canopy of wetland oaks.

Crosswalks: *Quercus phellos / Carex (albolutescens, intumescens, joorii) / Climacium americanum* Wet Forest (CEGL007403).
G654 South-Central Flatwoods & Pond Forest Group.
Piedmont Upland Depression Swamp Ecological System (CES202.336).

Sites: Upland Depression Swamp Forests occur in both unusually flat upland topography associated with mafic or clay-rich rocks and in ridgetop depressions in more rugged terrain such as the Uwharrie Mountains. On ridge tops, basins usually have visibly sloping sides, but on upland flats the basins may be so subtle as to be invisible without water present.

Soils: Upland Depression Swamp Forests usually have soils with limited internal drainage and often with shrink-swell clays such as montmorillonite. The predominant soil series mapped is Iredell (Vertic Hapludalf), but the swamps likely represent inclusions of a wetter soil. Some examples are mapped as other soils of mafic rocks such as Orange (Albaquic Hapludalf); a few are associated with clay-rich soils of sedimentary or metasedimentary rocks, particularly Misenheimer (Aquic Dystrudept) or Leaksville (Typic Albaqualf). Examples on ridge tops tend to not be distinguished from the surrounding uplands, but they presumably represent inclusions. Soil chemistry of examples varies with substrate. All examples are highly acidic, but those on mafic rock have higher pH and higher abundance of base cations. Wetter examples are more acidic and lower in nutrients than drier examples on all substrates.

Hydrology: Upland Depression Swamp Forests are seasonally flooded by water that may range from a few inches to two or three feet deep. Water comes from rainfall and from a small local watershed. An impermeable substrate, either a clay hardpan or bedrock, prevents infiltration. Water loss is primarily through evaporation and transpiration. Some basins have a visible overflow channel while others do not, but all must have a place where water overflows the basin in wetter periods. Standing water typically extends into the growing season but is gone by summer, but in some years standing water may be absent, may persist through more of the season, or may return after heavy rains. Because of the impermeable substrate and limited rooting depth, conditions for plants may be dry when water has evaporated and soil has dried.

Vegetation: Upland Depression Swamp Forests have a full forest canopy but limited understory, with trees rooted throughout the basin unless recently disturbed. The vegetation has been well described in a comprehensive plot study by Seymour (2011) and in numerous site reports. *Quercus phellos* is constantly present and most often strongly dominant, though it may be codominant or occasionally have only minor abundance. *Quercus lyrata* is codominant or dominant in some wetter examples, and *Quercus bicolor* or *Quercus michauxii* are prominent in a very few examples. *Liquidambar styraciflua* is highly constant in the canopy or understory but dominates only in disturbed examples. Other trees often occurring in small numbers include *Acer rubrum, Fraxinus americana*, and *Nyssa sylvatica*. Upland species such as *Quercus stellata, Quercus alba, Ulmus alata, Juniperus virginiana, Pinus* spp., or others may be present in small numbers, especially in drier examples or on the edges. Shrubs may be sparse, fairly dense throughout, or concentrated in a zone around the edge. *Vaccinium fuscatum* and *Vaccinium formosum* are most often dominant, *Ilex verticillata* may be frequent, and *Cephalanthus occidentalis* may be present in wetter examples. Vines tend to be abundant, often dominating the shrub layer in patches around the edge. *Smilax rotundifolia* is almost universally present, and *Muscadinia rotundifolia, Smilax bona-nox*, *Thyrsanthella difformis*, *Toxicodendron radicans*, *Campsis radicans*, and *Parthenocissus quinquefolia* are frequent and sometimes very abundant. Herbs are usually patchy; they may range from locally dense to sparse or nearly absent. They are often zoned, with a dense ring around the edge where vines are not abundant. *Carex* species are most often dominant. *Carex joorii* dominates in the wetter examples, while *Carex albolutescens, lupulina, complanata, louisianica, typhina, flaccosperma, glaucodea, pigra*, and others may be present and sometimes abundant in other examples. Other herbs that may be abundant include *Scirpus cyperinus, Chasmanthium laxum,* and *Leersia virginica*. *Climacium americanum* and *Sphagnum lescurii* are frequent but usually with limited abundance. *Danthonia spicata, Coleataenia anceps, Scutellaria integrifolia, Asplenium platyneuron*, and *Cinna arundinacea* may be fairly frequent. Seymour (2011) also noted moderate frequency of weedy species such as *Erechtites hieracifolia* and *Andropogon* spp., perhaps in canopy gaps but perhaps reflecting opportunistic establishment in dry years.

Range and Abundance: Ranked G2G3 but more appropriately G3. Nearly 80 examples are scattered across the eastern and central Piedmont, with a concentration in the extensive mafic rocks around Charlotte, some around Butner and Durham, and a cluster of ridgetop examples in the Uwharrie area. This community also occurs in South Carolina and Georgia, and the association is attributed to Maryland, Virginia, and Alabama.

Associations and Patterns: Upland Depression Swamp Forests are generally small patch communities. Most examples are only one or a handful of acres in size. However, a few large examples exceed 20 acres. They may be associated with other forests of hardpan or shrink-swell soils, such as Xeric Hardpan Forest, Mixed Moisture Hardpan Forest, or Piedmont Headwater Stream Forest (Hardpan Subtype), rarely with Upland Pool, but many examples are surrounded by Dry Basic Oak–Hickory Forest or Dry Oak–Hickory Forest.

Variation: Seymour (2011) identified four different groups of Upland Depression Swamp communities, divided first by wetness and then by rock substrate. Some of these may be further subdivided by markedly different canopy dominants. The following may be recognized as variants:

1. Wet Mafic Variant occurs in the wettest sites over mafic rocks. *Quercus lyrata* is frequent in this variant and is often codominant. Shrubs tend to be scarce, though vines may dominate the shrub layer.

2. Wet Felsic Variant occurs in the wettest sites over other kinds of rocks, including felsic igneous and metamorphic rocks and acidic sedimentary rocks. It less often has *Quercus lyrata* codominating. *Acer rubrum* and *Nyssa biflora* are fairly constant understory species. A shrub layer dominated by *Vaccinium* spp. often is dense throughout. *Sphagnum* is more likely to be present.

3. Dry Mafic Variant occurs in drier, less deeply flooded sites over mafic rocks. It is dominated by *Quercus phellos* but may have abundant *Ulmus alata* and *Fraxinus americana*, and there may be small numbers of other upland trees common in basic oak forests, such as *Juniperus virginiana*. There may be saplings of *Celtis* sp. and *Gleditsia triacanthos*. Vines are still prominent, including more *Smilax bona-nox* and *Campsis radicans*. Herbs are more diverse and include species such as *Scutellaria integra* and *Asplenium platyneuron*, as well as widespread species such as *Danthonia spicata*.

4. Swamp Chestnut Oak Variant is a very rare variant of drier mafic rock sites where *Quercus michauxii* is codominant or dominant. It shares many other species with the Dry Mafic Variant.

5. Swamp White Oak is a very rare variant of calcium-rich sedimentary rocks where *Quercus bicolor* is dominant.

6. Dry Felsic Variant occurs in drier, less deeply flooded sites over felsic or other acidic rocks. It is strongly dominated by *Quercus phellos*, but often has some *Acer rubrum, Liquidambar styraciflua*, *Ulmus alata*, or occasional upland species such as *Pinus* spp. Shrubs tend to be few, but vines, including *Smilax glauca* and *Muscadinia rotundifolia*, as well as *Smilax rotundifolia*, are abundant.

While Seymour (2011) named four of these variants as associations, they are treated as variants here because they seem less distinct than most subtypes. Further study may find more distinctions. Because her analysis was based on plots, it is also unclear if they represent distinct kinds of basins or, to some degree, zones within basins. It is interesting that her analysis did not distinguish *Quercus lyrata*-dominated examples from wetter *Quercus phellos*-dominated examples, though *Quercus lyrata* is distinctly associated with wetter sites in other communities. She noted that flora was highly variable among occurrences of these isolated small patch communities, and suggested that, as in some other small patch wetlands, founder effects or other random fluctuations may be important.

Dynamics: Dynamics of Upland Depression Swamp Forests are similar to those described for the Piedmont and Mountain Upland Pools and Depressions in general, including seasonal and year-to-year variation in water levels, the ephemeral invertebrate and amphibian communities, and the questions of origin and longevity of the basins.

Tree dynamics of Upland Depression Swamp Forests are similar to those of most North Carolina forests, with trees regenerating primarily in small gaps. This community is more susceptible to windthrow than upland forests, because of the shallow rooting of the trees, likely increasing the size of gaps somewhat. Given the small size of many patches, it is possible for much of the canopy in a patch to be lost at one time.

Upland Depression Swamp Forests are not very susceptible to fire. They may burn when dry, but movement and consumption of leaf litter may leave discontinuous fuel, and the matting of litter after flooding reduces its flammability.

Comments: Upland Depression Swamp Forest is well characterized by the work of Seymour (2011). It was recognized in several earlier descriptive studies, including Wells (1974) and Ohman (1980).

Liquidambar styraciflua - Acer rubrum / Carex spp. - *Sphagnum* spp. Forest (CEGL007388) is an association of depressional wetlands attributed to several states and regions, including North Carolina and the Piedmont. It was initially assigned to one North Carolina Piedmont location that investigation proved to be a successional Upland Depression Swamp Forest that had been clearcut. However, in other states it appears to be intended to represent rare natural communities such as a distinctive swamp in Cades Cove in the Great Smoky Mountains. This mix of stable natural vegetation and ruderal vegetation in an association is problematic. *Liquidambar*-dominated vegetation in Piedmont upland depressions is better regarded as altered examples of *Quercus phellos / Carex (albolutescens, intumescens, joorii) / Climacium americanum* Forest, and the other association is not otherwise recognized in North Carolina.

Rare species:
Vascular plants – *Carex bushii, Ilex longipes* and *Swida racemosa.*

Nonvascular plants – *Dichelyma capillaceum*.

Vertebrate animals – *Ambystoma talpoideum* and *Hemidactylium scutatum*.

UPLAND POOL (TYPIC PIEDMONT SUBTYPE)

Concept: Upland Pools are rare, isolated wetlands in upland settings, with water deep enough to prevent the formation of a forest canopy across the basin. Water stands well into the growing season, though it often dries by the end of summer. Examples may occur on unusually flat areas with hardpan soils derived from mafic rocks or slates, or in small topographic basins on ridgetops on various kinds of rock. The Typic Piedmont Subtype covers most of the still-rare Piedmont examples, which lack the distinctive Coastal Plain flora and other distinctive features of the Pleasant Grove and Roberdo subtypes.

Distinguishing Features: Upland Pools are distinguished from Upland Depression Swamp Forests by the lack of a full tree canopy. Some trees may be present, scattered in the pool or forming an edge zone within the wetland. The pool may also be partly shaded by trees from adjacent forests but should have sufficient light to allow shade-intolerant plants to survive even in the absence of recent disturbance.

The Typic Piedmont Subtype is distinguished from the Pleasant Grove and Roberdo subtypes by the absence of the characteristic Coastal Plain species that distinguish them — *Nyssa biflora, Cyrilla racemiflora*, and *Smilax walteri*. It is distinguished from the Mountain Subtype by the absence of the characteristic Blue Ridge components of the flora, as well as occurrence in the eastern or central Piedmont.

Crosswalks: *Cephalanthus occidentalis - (Eubotrys racemosa) / Carex joorii* Shrub Swamp (CEGL004075).
G654 South-Central Flatwoods & Pond Forest Group.
Piedmont Upland Depression Swamp Ecological System (CES202.336).
Carex joorii Pools (Seymour 2011).

Sites: Upland Pools occur in deeper depressions than Upland Depression Swamp Forests. Water may stand for much, sometimes all, of the growing season in the center. Examples occur in both ridgetop saddles and on upland flats, and they may be associated with either mafic or felsic rock.

Soils: Upland Pools have soils with limited internal drainage, created either by a hardpan of shrink-swell clay or by bedrock. They are small enough that they generally are not distinguished in soil mapping; they represent inclusions of wetland soil in upland map units. Seymour (2011) found soils to be highly acidic and low in nutrients regardless of the geologic substrate.

Hydrology: Upland Pools are seasonally to semipermanently flooded, holding water through much of the growing season in many years. Water comes from rainfall and from a small local watershed. An impermeable substrate, either a clay hardpan or potentially bedrock, prevents infiltration. Water loss is primarily through evaporation. Some basins have a visible overflow channel while others do not, but all must have a place where water overflows the basin in periods of extreme wetness. The center is wet enough that it may not dry completely in wetter years.

Vegetation: Upland Pool (Typic Piedmont Subtype) communities have partial tree cover, coming primarily from *Quercus phellos* and *Liquidambar styraciflua* rooted on the shallower edges. Some

Acer rubrum may also be present. A few trees may be present in the interior, often on stumps or higher microsites. Shrubs are also primarily confined to edges. *Cephalanthus occidentalis* is usually present in either the edges or the interior and is an indicator of the wetness of the community. *Vaccinium fuscatum* and sometimes *Eubotrys racemosus* may be abundant on the edges, as may *Smilax rotundifolia*. The herb layer is usually dominated by *Carex joorii*, which may have substantial cover. A little *Sphagnum* and *Climacium americanum* may be present. There are few or no other herbs in the interior, but *Carex gigantea* and *Isoetes melanopoda* have been found in plots and *Cyperus pseudovegetus* was noted in one pond when water was low.

Range and Abundance: Ranked G1. This community is known only in North Carolina, though the NVC association is questionably attributed to South Carolina. It could potentially occur in other nearby Piedmont states but presumably would be extremely rare everywhere.

Associations and Patterns: Upland Pools are small patch communities, usually less than one acre in size. They are surrounded by upland communities of various kinds, including Xeric Hardpan Forest, Dry Basic Oak–Hickory Forest, and Piedmont Monadnock Forest.

Variation: Variation is limited because of the small size and limited species pool in this community. No variation is recognizable related to the substrate or topographic setting.

Dynamics: Dynamics of Upland Pools are similar to those described for the Piedmont and Mountain Upland Pools and Depressions theme in general, including seasonal and year-to-year variation in water levels, the ephemeral invertebrate and amphibian communities, and the questions of origin and longevity of the basins.

Upland Pools are not susceptible to fire and likely would not burn when the surrounding forests burned, though their edges might be affected to some degree.

Comments: Seymour (2011) noted that, while *Carex joorii* usually strongly dominated the herb layer, the absence of other species was more characteristic than the presence of *Carex joorii*. This was the most species-poor of the communities she analyzed. She found it to be the most distinct group among the groups of Upland Depression Swamp plots; however, plots representing the Pleasant Grove Subtype and Roberdo Subtype were removed from analysis as outliers.

Rare species:
Vertebrate animals – *Ambystoma talpoideum* and *Hemidactylium scutatum.*

UPLAND POOL (PLEASANT GROVE SUBTYPE)

Concept: Upland Pools are rare, isolated wetlands in upland settings, with water deep enough to prevent the formation of a forest canopy across the basin. Water stands well into the growing season. The Pleasant Grove Subtype is a distinctive example with strong concentric zonation, a *Nyssa biflora*-dominated edge zone, and a number of plants of Coastal Plain affinities. This subtype is currently known only from Pleasant Grove Bog in Uwharrie National Forest, but discovery of additional examples in the eastern Piedmont is conceivable.

Distinguishing Features: Upland Pools are distinguished from Upland Depression Swamp Forests by the lack of a full tree canopy. The Pleasant Grove Subtype is distinguished by the presence of substantial concentric zonation, with *Nyssa biflora* dominating the edge, and by overall vegetation of deciduous wetland species more typical of the Coastal Plain. Though many species are shared with the Coastal Plain, the abundance of *Cephalanthus occidentalis* distinguishes it from Small Depression Pond and Small Depression Drawdown Meadow communities.

Crosswalks: *Nyssa biflora / Cephalanthus occidentalis - Eubotrys racemosa* Swamp Forest (CEGL004550).
G654 South-Central Flatwoods & Pond Forest Group.
Piedmont Upland Depression Swamp Ecological System (CES202.336).

Sites: The Pleasant Grove Subtype occurs in a fairly deep basin in a ridgetop saddle in rolling terrain on felsic metavolcanic rock.

Soils: The soil in the one known example is mapped as Biscoe-Secrest (Aeric Epiaquult), but clearly represents a wetter inclusion.

Hydrology: The pool appears to be flooded in the center during most years, with the edges drying progressively through the growing season. Water comes from rainfall and from a small local watershed. An impermeable substrate presumably prevents infiltration. Water loss is primarily through evaporation.

Vegetation: The Pleasant Grove Subtype has vegetation that is strongly zoned. The center remains flooded most of the time and generally appears as open water. Where it draws down, *Scirpus cyperinus* or *Juncus repens* may dominate, and scattered *Cephalanthus occidentalis* are present. A denser vine tangle zone is dominated by *Smilax walteri*. The edge is dominated by *Nyssa biflora*, with a substantial shrub layer of *Eubotrys racemosus* and *Cephalanthus occidentalis*. *Acer rubrum* is also abundant and some *Liquidambar styraciflua* is present. Other shrubs present include *Viburnum nudum, Vaccinium fuscatum, Alnus serrulata*, *Ilex verticillata*, and *Itea virginica*. There is a little *Smilax laurifolia* and *Toxicodendron radicans*. The CVS plot also includes some *Carex crinita*, but no other herbs have been noted.

Range and Abundance: Ranked G1. This community is endemic to North Carolina and is known from a single example in Uwharrie National Forest.

Associations and Patterns: The Pleasant Grove Subtype is a small patch community. The known example is around 0.5 acre. It is associated with Dry Piedmont Longleaf Pine Forest, with Wet Piedmont Longleaf Pine Forest and Piedmont Boggy Streamhead nearby.

Variation: Only a single example is known.

Dynamics: Dynamics of the Pleasant Grove Subtype are presumed to be similar to those described for the Piedmont and Mountain Upland Pools and Depressions theme in general, including seasonal and year-to-year variation in water levels, the ephemeral invertebrate and amphibian communities, and the questions of origin and longevity of the basin. Fire in the frequently burned surrounding longleaf pine communities may affect the edges of the community but would not spread within it.

Comments: Seymour (2011) found this community to be a statistical outlier in her analysis of Piedmont depressions, because there was only a single plot. This community is unique in its combination of Piedmont and Coastal Plain characteristics. Though it shares some species with the Roberdo Subtype, its overall composition is different because of the relatively steep-sided basin and strong zonation. The setting is different from other Upland Pools but the depression appears to be of natural origin.

Rare species:
Vertebrate animals – *Ambystoma talpoideum*.

UPLAND POOL (ROBERDO SUBTYPE)

Concept: Upland Pools are rare, isolated wetlands in upland settings, with water deep enough to prevent the formation of a forest canopy across the basin. Water stands well into the growing season. The Roberdo Subtype covers the distinctive example with a more "pocosin-like" character, with a substantial component of evergreen Coastal Plain shrubs and greenbriers.

Distinguishing Features: Upland Pools are distinguished from Upland Depression Swamp Forests by the lack of a full tree canopy. The Roberdo Subtype is distinguished by having weak zonation, with extensive areas of shrub and vine cover as well as open herbaceous areas. The Pleasant Grove Subtype, in contrast, has deeper water, strong zonation, and an edge dominated by *Nyssa biflora*. Both are distinguished from the Typic Piedmont Subtype by the component of Coastal Plain species.

Crosswalks: *Eubotrys racemosa - Vaccinium fuscatum - Smilax walteri* Wet Shrubland (CEGL004533).
G654 South-Central Flatwoods & Pond Forest Group.
Piedmont Upland Depression Swamp Ecological System (CES202.336).

Sites: The Roberdo Subtype occurs in a shallow, gently sloped basin in a ridgetop saddle in rolling terrain on felsic metavolcanic rock.

Soils: The soil in the one known example is mapped as Biscoe-Secrest (Aeric Epiaquult) but clearly represents a wetter inclusion.

Hydrology: The Roberdo Subtype pool is flooded well into the growing season and holds standing water in the center throughout some years. Water comes from rainfall and from a small local watershed. An impermeable substrate presumably prevents infiltration. Water loss is primarily through evaporation.

Vegetation: The Roberdo Subtype shows weak zonation, with a more open, wetter center and a broad, densely vegetated edge. Some drawdown areas are dominated by *Dulichium arundinaceum* or *Scirpus cyperinus*. Other herbs in the open center include *Utricularia gibba, Eleocharis* sp., *Carex crinita, Carex glaucescens, Rhynchospora* sp., and *Scleria* sp. *Sphagnum* is present in patches. In the broad shallower area, *Smilax walteri* dominates in extensive shrub layer tangles. The dominant shrubs are *Eubotrys racemosus*, *Vaccinium formosum,* and *Vaccinium fuscatum*, with some *Viburnum nudum* and *Cephalanthus occidentalis*. Scattered *Acer rubrum* and small *Liquidambar styraciflua* are present. In the outer edge, large *Pinus taeda* and a few *Pinus palustris* occur. In the past, there may have been more *Pinus palustris*.

Range and Abundance: Ranked G1? but rightly unquestioned G1. This community is regarded as endemic to North Carolina and is known from only a single example in Uwharrie National Forest. That example is threatened with degradation by highway widening.

Associations and Patterns: The Roberdo Subtype is a small patch community. The known example is about one acre. It is surrounded by Dry Piedmont Longleaf Pine Forest and is associated with Piedmont Boggy Streamhead.

Variation: Only a single example is known.

Dynamics: Dynamics of the Roberdo Subtype are presumed to be similar to those described for the Piedmont and Mountain Upland Pools and Depressions theme in general, including seasonal and year-to-year variation in water levels, the ephemeral invertebrate and amphibian communities, and the questions of origin and longevity of the basin. Because of the gentle slope and the broad edge zone where water draws down, fire may be able to spread into much of this community and be a significant influence.

Comments: Seymour (2011) found this community to be a statistical outlier in her analysis of Piedmont depressions. There was only a single plot, though a second CVS plot has since been added in the same site. This community is unique in its combination of Piedmont and Coastal Plain characteristics. Though it shares some species with the Pleasant Grove Subtype, its overall composition is different because of the gentle slope, weak zonation, and perhaps greater influence of fire. The setting is different from other Upland Pools, but the depression appears to be of natural origin.

Rare species:
Vertebrate animals – *Ambystoma talpoideum*.

UPLAND POOL (MOUNTAIN SUBTYPE)

Concept: Upland Pools are rare, isolated wetlands in upland settings, with water deep enough to prevent the formation of a forest canopy across the basin. Water stands well into the growing season. The Mountain Subtype covers the few examples in the Blue Ridge region.

Distinguishing Features: Upland Pools are distinguished from Upland Depression Swamp Forests by the lack of a full tree canopy. The Mountain Subtype has some plants more typical of lowlands, such as *Dulichium arundinaceum*, but lacks *Cephalanthus occidentalis* and does not have as well-developed a Coastal Plain flora as Piedmont examples have.

Crosswalks: *Scirpus cyperinus - Dulichium arundinaceum / Sphagnum* spp. Marsh (CEGL004134).
G654 South-Central Flatwoods & Pond Forest Group
Piedmont Upland Depression Swamp Ecological System (CES202.336).

Sites: The Mountain Subtype occurs in natural depressions on flat ridgetop areas. The two known good examples occur on flat-lying quartzite.

Soils: The soil within the basins of the known examples consists of accumulated muck and fragments of quartzite.

Hydrology: The Mountain Subtype is flooded well into the growing season but probably usually lacks standing water by the end of summer.

Vegetation: The Mountain Subtype includes an open center without trees but with substantial herbaceous vegetation. Dominant herbs in patches include *Scirpus cyperinus, Dulichium arundinaceum, Persicaria hydropiperoides, Osmunda spectabilis*, and *Sphagnum lescurii*. Other herbs include *Bartonia verna, Juncus effusus,* and *Juncus canadensis*. A substantial woody edge zone is present. In one example it is dominated by *Liquidambar styraciflua, Acer rubrum,* and *Nyssa sylvatica*; in the other *Quercus montana* and *Quercus coccinea* are the most abundant. *Leucothoe fontanesiana, Kalmia latifolia*, and *Galax urceolata* are found in the edge zones.

Range and Abundance: Ranked G1Q but truly G1. In North Carolina, well-developed examples are known only on the rim of Linville Gorge, but a nearby site called Pond Mountain needs investigation. Another site called Pond Mountain, in Ashe County, has ridgetop depressions that may have been natural ponds but are now heavily altered.

The synonymized association is attributed to Georgia and potentially to Tennessee.

Associations and Patterns: The Mountain Subtype is a small patch community, well less than one acre in the known examples. It is surrounded by upland communities such as Pine–Oak/Heath and Chestnut Oak Forest.

Variation: If additional examples exist, they may be substantially different.

Dynamics: Dynamics of Upland Pools are similar to those described for the Piedmont and Mountain Upland Pools and Depressions theme in general, including seasonal and year-to-year variation in water levels, the ephemeral invertebrate and amphibian communities, and the questions of origin and longevity of the basins. Reed et al. (1963) suggested these pools were created by solution of the quartzite, calculating that, given the range of silica content found in the water the volume of the pools could have been removed in tens of thousands, if not thousands, of years.

Comments: This community was recognized by Newell (1997) and Newell and Peet (1998) in their study of Linville Gorge vegetation. The Mountain Subtype is unlike any other community in the Mountain Region and is notable for the lowland species present at relatively high elevation in it.

The placement of the synonymized association in the Juncus effusus - Andropogon glomeratus var. pumilus - Saccharum giganteum Ruderal Marsh Alliance and the Southeastern Ruderal Marsh, Wet Meadow & Shrubland Group in NVC is completely erroneous. This is a natural drawdown community and is described as such in the NVC.

Rare species:
Vertebrate animals – *Ambystoma talpoideum*.

COASTAL PLAIN NONALLUVIAL WETLAND FOREST THEME

Concept: Coastal Plain Nonalluvial Wetland Forests are communities of flat, poorly drained interfluvial areas that naturally have infrequent fire and do not have the characteristic vegetation of Wet Pine Savannas or Peatland Pocosins. They are forests dominated by *Taxodium, Nyssa, Liquidambar, Chamaecyparis*, wetland species of *Quercus*, *Pinus taeda,* or *Liriodendron*; have little or no *Pinus serotina*; and completely lack *Pinus palustris*. They may occur on either mineral or organic soils. They are kept wet by rainfall, sheet flow, and seasonal high water tables; are not in closed basins; and never have flooding from rivers, streams, or estuaries.

Distinguishing Features: Coastal Plain Nonalluvial Wetland Forests are distinguished by natural dominance of wetland deciduous hardwoods, *Taxodium,* or *Chamaecyparis* in areas remote from estuaries, streams, and rivers, and not in closed basins.

Within the theme, Nonriverine Swamp Forests are distinguished by dominance by *Nyssa biflora* and *Taxodium distichum*, sometimes codominant with *Pinus taeda*, *Liquidambar styraciflua¸ Liriodendron tulipifera*, or other species. Nonriverine Wet Hardwood Forests are distinguished by the presence of wetland *Quercus* species, usually *Quercus laurifolia, michauxii*, or *pagoda*. Peatland Atlantic White Cedar Forest is dominated by *Chamaecyparis thyoides*. The unique Wet Marl Forest is distinguished by a diverse mix of calciphilic wetland species in all strata, from *Carya myristiciformis* in the canopy to *Swida (Cornus) asperifolia* in the shrub layer and *Carex basiantha* in the herb layer.

Sites: Coastal Plain Nonalluvial Wetland Forests generally occur on flat, poorly drained upland areas that are not associated with streams, generally in the outer Coastal Plain. These are geologically young surfaces in the areas between stream systems, where stream drainages have not yet developed and topographic relief is practically nonexistent. They may make up the center of such areas, or they may occupy the periphery of large domed peatlands. These surfaces may be fine-textured relict sea bottom or lagoon bottom sediments between ancient shorelines. Nonriverine Swamp Forests may be bounded by scarps. Coastal Plain Nonalluvial Wetland Forests also occur more locally in peat-filled drowned river valleys along estuaries. There they are on slightly elevated areas of peat, surrounded by tidally influenced swamps but above significant tidal influence.

Soils: Soils of Coastal Plain Nonalluvial Wetland Forests may be deep or shallow organic soils or wet fine-textured mineral soils. The wetter Nonriverine Swamp Forests are often on Histosols such as Dorovan, Pungo, Belhaven, Scuppernong, or Ponzer, or on wet, organic-rich Ultisols such as Hyde, Roper, or Portsmouth. The less wet Nonriverine Wet Hardwood Forests may be mapped as these Ultisols or others such as Pantego, Roanoke, or Portsmouth, or may occur on wet Alfisols such as Argent, Brookman, or Hydeland. The very rare Wet Marl Forest occurs on Meggett, a Typic Albaqualf.

Hydrology: Coastal Plain Nonalluvial Wetland Forest sites are kept wet by rainfall and sheetflow. The water is not confined in a closed basin but drainage is limited by lack of relief and distance to stream channels. The wetter sites have some surface water during wet seasons, while the driest may be saturated near the surface but rarely flooded. The hydrology is not as extremely ombrotrophic as in Peatland Pocosins, but the water is oligotrophic because flow is limited and is from other oligotrophic areas.

Vegetation: Coastal Plain Nonalluvial Wetland Forest communities all have well-developed forest canopies where not recently disturbed. The canopy is dominated by varying combinations of *Taxodium, Nyssa, Liquidambar, Chamaecyparis*, *Pinus taeda, Acer rubrum*, wetland species of *Quercus*, and occasionally *Liriodendron*. While the canopy composition often resembles that of various Coastal Plain Floodplain communities and even some mesic upland forests, the lower strata tend to share species with Peatland Pocosins and other more oligotrophic wetlands. *Persea palustris* and *Magnolia virginiana* are often the most abundant understory, though *Carpinus caroliniana* or *Ilex opaca* may also be abundant. *Ilex glabra, Lyonia lucida, Cyrilla racemiflora, Leucothoe axillaris, Clethra alnifolia,* or *Smilax laurifolia* may be dense, but *Vaccinium fuscatum, Vaccinium formosum, Eubotrys racemosus*, and *Itea virginica* may also occur. *Anchistea virginica, Lorinseria areolata*, and *Sphagnum* spp. are usually the dominant herbs, though *Saururus cernuus* and various other wetland species may be present.

Dynamics: Most Coastal Plain Nonalluvial Wetland Forests have stand dynamics typical of most forest communities in North Carolina. Their natural state is as predominantly old-growth forests, with a wide variety of tree ages in a stand, and with tree regeneration occurring over periods of years in small to medium size canopy gaps. Their location near the coast, combined with the shallow rooting of some dominant trees in wet sites, makes them more susceptible to wind throw than many hardwood forests. One member of this theme, Peatland Atlantic White Cedar Forest, has a distinctly different form of population dynamics. In it, natural regeneration is by catastrophic disturbance and stands are naturally even aged.

Coastal Plain Nonalluvial Wetland Forests vary in the influence of fire, but they have limited flammability at most times and have less frequent natural fire than Peatland Pocosins. Peatland Atlantic White Cedar Forests depend on fire to promote regeneration of the canopy, but their dominant tree species has very little tolerance of fire. Natural fires must be infrequent enough that canopies can mature between them. Other communities probably are affected by fire even less frequently and don't tend to be catastrophically disturbed by it.

It is unclear to what extent boundaries between this theme and more flammable themes such as Peatland Pocosins are determined by fire history and to what extent fire history is driven by the flammability of the vegetation. There is a belief that Nonriverine Swamp Forest, Bay Forest, Peatland Atlantic White Cedar Forest, Pond Pine Woodland, and Peatland Canebrake differ primarily in their fire regime rather than their physical sites, and that they might naturally form a shifting mosaic upon the landscape. In this view, communities could readily turn into each other in response to fire history. It is well documented that Peatland Atlantic White Cedar Forests were once much more extensive, and lack of fire as well as logging appears to have contributed to many coming to resemble Nonriverine Swamp Forests. Frost (2000) believed that many Nonalluvial Wetland Forest areas once burned much more frequently and would have supported Peatland Canebrake. However, the long-lived dominant species in most communities and the limited ability of species such as *Arundinaria tecta* to move into new sites suggests patches of different communities could not have shifted very readily. Natural variation in chronic fire regime, caused by landscape configuration and fire compartment size, may have led to community patterns that were stable in the long term, or that perhaps expanded and contracted at their boundaries in response to the influence of climatic cycles on fire frequency rather than shifting randomly.

Coastal Plain Nonalluvial Wetland Forests are among the communities most threatened by accelerating rise in sea level. While a few are as much as 50 feet above sea level, many examples are only a couple feet in elevation, immediately inland of tidal communities or even surrounded by them. Many of their characteristic species are extremely sensitive to salt, even at oligohaline levels. As estuarine waters penetrate farther inland, zones of Coastal Plain Nonalluvial Wetland Forests turn into Freshwater Tidal Wetlands over the space of a few years. In most places, the community is Nonriverine Swamp Forest, and this transition occurs with the canopy of *Nyssa* and *Taxodium* remaining as a relict stand while the lower strata die out and are replaced by *Morella cerifera* and the various herbs of Tidal Swamp.

Comments: The name for this theme and names for many of the individual communities are somewhat unsatisfactory, but no better ones have been found. Names such as Nonriverine Wet Hardwood Forest and Nonriverine Swamp Forest are based on what the ecological setting is not, rather than what it is. Because of their shared canopy species, these communities have often in the past been called “bottomland hardwoods” or simply “swamp”, so there is a need to make the distinction clear. There seem to be no specific folk name for these communities nor for the extensive wet flats with sheet flow hydrology that support them. The present community names are also unsatisfactory because they appear broader than the concepts they denote. Other Coastal Plain wetlands are also not alluvial or riverine, including Peatland Pocosins, Wet Pine Savannas, and Coastal Plain Depression Communities. Nevertheless, Coastal Plain Nonalluvial Wetland Forests are a distinctive group of communities and ecosystems, with their own hydrology and nutrient dynamics and with combinations of plants that are different from all other communities. North Carolina, especially the northeastern Coastal Plain, is the center for them. They are much less extensive in nearby states.

KEY TO COASTAL PLAIN NONALLUVIAL WETLAND FORESTS

1. Forest dominated by *Chamaecyparis thyoides*, at least weakly (more than 50% of the canopy cover or basal area, unless recently disturbed). ....**Peatland Atlantic White Cedar Forest**

1. Forest not dominated by *Chamaecyparis thyoides*, though the species may be present.

 2. Very rare forest community occurring on shallow limestone substrate with calcareous soil. Forest containing calciphilic species, including *Carya myristiciformis, Swida (Cornus) asperifolia*, and *Tilia americana* var. *caroliniana*, along with other species of richer soils not found in other communities of this theme, such as *Carya cordiformis, Acer negundo,* and *Cercis canadensis*. Presently known only at Rocky Point Marl Forest.. ....**Wet Marl Forest**

 2. Forest not containing the above species, not influenced by shallow limestone.

  3. Forest dominated or codominated by *Quercus* species, or forest dominated by *Liquidambar styraciflua* and containing *Quercus* species.

   4. Forest dominated by *Quercus laurifolia* and *Nyssa biflora*. Less water-tolerant *Quercus* species absent or present only as a minor component in drier microsites. .... **Nonriverine Wet Hardwood Forest (Oak–Gum Slough Subtype)**

   4. Forest dominated by *Quercus michauxii, Quercus pagoda,* or other oaks of less wet sites, along with *Quercus laurifolia* and *Liquidambar styraciflua*. *Nyssa biflora* absent or scarce. . ...**Nonriverine Wet Hardwood Forest (Oak Flat Subtype)**

  3. Forest not containing *Quercus* species beyond single individuals in uncharacteristic microsites.

   5. Forest containing *Liquidambar styraciflua* or *Liriodendron tulipifera*, in combination with *Nyssa biflora* or other species of wetter sites. *Liquidambar or Liriodendron* may be dominant, codominant, or present in smaller numbers.

    6. Forest containing *Liriodendron tulipifera* as a significant component, or forest containing appreciable *Asimina triloba*. *Liquidambar* may be present or absent, and the forest generally dominated by *Nyssa biflora* and contain at least some *Taxodium distichum* ……….. ....**Nonriverine Swamp Forest (Poplar–Pawpaw Subtype)**

    6. Forest not containing *Liriodendron* or *Asimina*; dominated by combinations of *Nyssa biflora, Liquidambar styraciflua*, and other wetland species. ....**Nonriverine Swamp Forest (Sweetgum Subtype)**

   5. Forest not containing *Liquidambar* or *Liriodendron*.

    7. Forest containing *Pinus taeda, Pinus serotina,* or *Chamaecyparis thyoides*, though *Nyssa biflora* and *Acer rubrum* are usually dominant and there is usually a minority of *Taxodium distichum*. ....**Nonriverine Swamp Forest (Mixed Subtype)**

    7. Forest consisting largely of *Nyssa biflora, Nyssa aquatica*, *Acer* rubrum, and *Taxodium distichum*, without *Pinus* or *Chamaecyparis*. .... **Nonriverine Swamp Forest (Cypress–Gum Subtype)**

NONRIVERINE WET HARDWOOD FOREST (OAK FLAT SUBTYPE)

Concept: Nonriverine Wet Hardwood Forests are wetland forests of nonalluvial mineral soil flats not underlain by limestone, dominated by wetland oaks along with other hardwoods. The Oak Flat Subtype covers the less wet examples, containing *Quercus michauxii, Quercus pagoda*, *Liquidambar styraciflua*, and often *Quercus laurifolia*, but lacking *Nyssa biflora* and other species of wetter communities.

Distinguishing Features: Nonriverine Wet Hardwood Forests are distinguished by the dominance or substantial presence of bottomland oaks (*Quercus laurifolia, Quercus michauxii, Quercus pagoda*) in sites remote from rivers and not subject to overland flooding. The canopy composition may resemble Brownwater Bottomland Hardwoods but the dominance of the shrub layer by *Leucothoe axillaris* or *Clethra alnifolia* distinguishes the community. Nonriverine Wet Hardwood Forests are distinguished from the wetter Nonriverine Swamp Forests by the presence of *Quercus*. *Liquidambar* is also usually present in Nonriverine Wet Hardwood Forest but is absent from most Nonriverine Swamp Forest (except the Sweetgum Subtype). *Taxodium* is absent from Nonriverine Wet Hardwood Forests. Disturbed examples of either may become strongly dominated by *Pinus taeda*, *Acer rubrum*, or *Liquidambar styraciflua*, and may be distinguishable only by the water tolerance of their lower strata or by remnant oak saplings or seedlings.

The Oak Flat Subtype is distinguished from the Oak–Gum Slough Subtype by a canopy containing *Quercus michauxii, Quercus pagoda*, or a mixture of oaks rather than being dominated by *Quercus laurifolia* and *Nyssa biflora*. The Oak Flat Subtype is the least wet of Coastal Plain Nonalluvial Wetland Forests. Where it grades into Mesic Mixed Hardwood Forest, which may share *Quercus michauxii* or other oaks, it may be distinguished by the absence of *Fagus grandifolia* and *Quercus alba*.

Crosswalks: *Quercus michauxii - Quercus pagoda / Clethra alnifolia - Leucothoe axillaris* Wet Flatwoods Forest (CEGL007449).
G130 Hardwood - Loblolly Pine Nonriverine Wet Flatwoods Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Nonriverine Wet Hardwood Forests occur on flat, poorly drained upland areas that are not associated with streams. They tend to be midway between stream systems, beyond the headwaters of local tributaries.

Soils: Nonriverine Wet Hardwood Forests have loamy or clay-rich soils with well-developed horizons. They may be mapped as a wide variety of Ultisols and Alfisols. Most common map units are Roanoke (Typic Ochraquult) and Cape Fear (Typic Umbraquult). Other units include Argent (Typic Endoaqualf), Brookman (Typic Umbraqualf), Pantego (Umbric Paleaquult), Portsmouth (Typic Umbraqualf), Tomotley (Typic Ochraqult), and Leaf (Typic Albaqualf). The soil often has a hummock and hollow structure, with several inches or more of local relief.

Hydrology: As with other nonalluvial wetlands, Nonriverine Wet Hardwood Forests are wetted by rainfall, seasonal high water table, and by sheet flow from adjacent flats. The water table may be perched, but this is not well known. Surface water a few inches deep may be present in wet seasons, and water may persist into the growing season in local lower areas. The Oak Flat Subtype is the least wet of Coastal Plain Nonalluvial Wetland Forests.

Vegetation: Rheinhardt and Rheinhardt (2000) and Morris (2004) present quantitative data on the woody vegetation in most examples of the Oak Flat Subtype known at the time. The canopy at present is generally dominated by varying combinations of *Liquidambar styraciflua* and *Acer rubrum* along with *Quercus michauxii, Quercus laurifolia,* or *Quercus pagoda*. *Acer rubrum* may be abundant, even dominant, in more disturbed canopies, while oaks were presumably more abundant before logging in the last century. Occasional examples observed since that study have had other species abundant, including *Quercus shumardii, Carya ovata, Quercus nigra, Quercus phellos, Fraxinus pennsylvanica,* and *Ulmus americana*. Trees of wetter sites, such as *Nyssa biflora* or *Taxodium distichum* are absent or confined to wetter microsites. The understory is usually well-developed and has one or two species strongly dominant. These are most frequently *Persea palustris, Ilex opaca, Carpinus caroliniana*, or *Acer rubrum*. *Magnolia virginiana* and the various canopy species are also typical in the understory. The shrub layer may be open or dense. No species has high constancy, but *Vaccinium formosum, Vaccinium fuscatum, Ilex glabra*, *Leucothoe axillaris*, *Clethra alnifolia*, or *Asimina triloba* may dominate. Other less dominant shrubs found in quantitative studies and site reports include *Symplocos tinctoria, Arundinaria tecta, Ilex coriacea, Gaylussacia frondosa,* and *Sabal minor*. Vines are usually present and may be diverse and abundant. Species noted in site reports include *Muscadinia rotundifolia, Toxicodendron radicans, Smilax rotundifolia, Smilax walteri, Smilax laurifolia, Campsis radicans, Berchemia scandens, Gelsemium sempervirens*, and several others. The herb layer is similarly variable. In site reports, the most constant species is *Lorinseria areolata*. Also frequent are *Carex* spp., *Osmundastrum cinnamomeum, Osmunda spectabilis, Anchistea virginica, Athyrium asplenioides*, *Mitchella repens*, and *Chasmanthium laxum*. Other species include *Arisaema triphyllum, Amauropelta* (*Parathelypteris*) *noveboracensis, Hexastylis arifolia, Tipularia discolor*, and, locally in wetter patches, *Saururus cernuus*. *Climacium americanum* is fairly frequent, but *Sphagnum* spp. is only occasional. Exotic plants, especially *Lonicera japonica* and *Microstegium vimineum*, are sometimes present but tend to be extensive only in drier microsites.

Range and Abundance: Ranked G2. The Oak Flat Subtype is found almost exclusively in the outer part of the Embayed Region, in the northern part of North Carolina's Coastal Plain. The greater relief of the Coastal Plain farther south does not seem suitable for it. A few examples occur in adjacent Virginia but this community is nearly endemic to North Carolina.

The Oak Flat Subtype is one of the most threatened communities in North Carolina in terms of the proportion that has been lost and the ease with which it can be lost. If Pinchot and Ashe's (1897) concept of oak flats was similar, their estimate of some 640,000 acres implies loss of catastrophic proportions, given that less than 6,000 acres now remain. This community occurs on soils that are more fertile than most Coastal Plain soils and which are easily drained. Most of its acreage was likely converted to farmland early in colonial history. Additional area now is in pine plantation. Within the author's career, a larger portion of the remnants found by the Natural Heritage Program has later been lost than for any other community.

Associations and Patterns: The Oak Flat Subtype naturally occurred as a large patch community but now may function more like a small patch community. Most remaining examples are tens of acres. Occurrences of several thousand acres were present as recently as the 1980s, but only one such example remains. The Oak Flat Subtype often is associated with patches of the Oak–Gum Slough Subtype, which occur in lower areas that may be incipient stream drainages. The Oak Flat Subtype may grade to Mesic Mixed Hardwood Forest (Coastal Plain Subtype) Upland Flat Variant. The two may occur as patches adjacent to each other, or they may occasionally be interspersed in a mosaic. The Oak Flat Subtype may also be associated with Nonriverine Swamp Forest. However, most examples of it are now isolated amid heavily altered vegetation.

Variation: Rheinhardt and Rheinhardt (2000) and Morris (2004) noted that examples did not seem to vary with soil texture. There is substantial variation in associated vegetation, though the small number of remaining examples makes it difficult to find patterns. Two variants are tentatively recognized for trial, based on floristic variation that suggests different soil fertility. A broad range of soil fertility is also suggested by the occurrences of several Alfisol soil map units as well as Ultisols.

1. Oligotrophic Variant represents apparently less fertile examples, where species such as *Persea palustris, Magnolia virginiana, Leucothoe axillaris, Clethra alnifolia, Ilex glabra, Ilex coriacea,* and *Anchistea virginica* tend to occur and the species of the Eutrophic Variant are absent or scarcer.

2. Eutrophic Variant represents apparently more fertile examples, where *Carpinus caroliniana, Quercus shumardii, Carya ovata, Asimina triloba, Chasmanthium laxum,* and *Onoclea sensibilis* are present and the species listed for the Oligotrophic Variant are absent or scarce.

Dynamics: Dynamics of the Oak Flat Subtype are similar to the theme in general. Hurricanes in the last several decades have caused substantial windthrow in older forests, resulting in many small to medium size canopy gaps but not wholesale stand destruction. While the oak litter would potentially burn in dry years, fire is unlikely to be intense or to have much influence in these communities. Upland oak forests are now generally believed to depend on fire for oak regeneration. However, this is less clear for the wetland oaks. Oak saplings and understory size trees are more often present in the understory of Nonriverine Wet Hardwood Forests than of other oak communities.

The Oak Flat Subtype is one of the most threatened communities in North Carolina partly because of its response to use. Even in examples that are not deliberately converted to other vegetation, repeated logging has increased the portion of *Liquidambar* and *Acer*, so that few of even the best remaining examples are actually dominated by oaks. While all examples were logged in the past, remnants that are clearcut at present regenerate as successional vegetation with virtually no oaks and lose their distinctive character.

Comments: Nonriverine Wet Hardwood Forests apparently were recognized by Pinchot and Ashe (1897), under the name of oak flats. They were generally not otherwise a focus for early ecological work. Rheinhardt and Rheinhardt (2000), Andrews (2003), and Morris (2004) represent a period of greater interest more recently.

Quercus pagoda - Quercus michauxii - Quercus alba / Arundinaria gigantea ssp. *tecta - Sabal minor / Chasmanthium laxum* Wet Flatwoods Forest (CEGL007849) may be an analogous community of South Carolina and Georgia. It is unclear how distinct it is from this community, but there appears to be a significant geographic gap between the two. If the inclusion of *Quercus alba* in the name is truly representative, it may be a drier community, perhaps more akin to the Upland Flat Variant of Mesic Mixed Hardwood Forest.

Rare species:
Vascular plants – *Trillium pusillum sensu lato*.

Vertebrate animals – *Sistrurus miliarius miliarius*.

NONRIVERINE WET HARDWOOD FOREST (OAK–GUM SLOUGH SUBTYPE)

Concept: Nonriverine Wet Hardwood Forests are wetland forests of nonalluvial mineral soil flats not underlain by limestone, dominated by wetland oaks along with other hardwoods. The Oak–Gum Slough Subtype covers the wetter examples, usually in swales or incipient drainage systems, dominated by *Quercus laurifolia*, often with abundant *Nyssa biflora*. This subtype is transitional to Nonriverine Swamp Forest or Coastal Plain Small Stream Swamp.

Distinguishing Features: Nonriverine Wet Hardwood Forests are distinguished by the dominance or substantial presence of bottomland oaks in sites remote from rivers and not subject to overland flooding. The Oak-Gum Slough Subtype is distinguished by the dominance of *Quercus laurifolia* and *Nyssa biflora*, usually with only minor amounts of *Quercus michauxii* or *Quercus pagoda*. It is distinguished from Coastal Plain Small Stream Swamp, which could potentially be dominated by the same trees, by not occurring in a well-developed floodplain nor along a creek channel and not being subject to overbank flooding. It may, however, go through a gradual transition to a floodplain community as one moves away from the center of the wet flat.

Crosswalks: *Quercus laurifolia - Nyssa biflora / Clethra alnifolia - Leucothoe axillaris* Wet Forest (CEGL007447).
G130 Hardwood - Loblolly Pine Nonriverine Wet Flatwoods Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Nonriverine Wet Hardwood Forests occur on flat, poorly drained upland areas that are not associated with streams. They tend to be midway between stream systems, beyond the headwaters of local tributaries. The Oak–Gum Slough Subtype often occurs in elongate, slightly lower areas where more water collects than in the adjacent nonriverine wetlands. These may or may not drain from one end or feed into a gradually more developed stream channel and floodplain that carries water away from the nonriverine flat.

Soils: Nonriverine Wet Hardwood Forests have loamy or clay-rich soils with well-developed horizons. The Oak–Gum Slough Subtype generally is not distinguished from the Oak Flat Subtype in soil mapping. They may be mapped as a wide variety of Ultisols and Alfisols. Most common map units are Roanoke (Typic Ochraquult) and Cape Fear (Typic Umbraquult). Other units include Argent (Typic Endoaqualf), Brookman (Typic Umbraqualf), Pantego (Umbric Paleaquult), Portsmouth (Typic Umbraqualf), Tomotley (Typic Ochraqult), and Leaf (Typic Albaqualf). The soil often has a hummock and hollow structure, with several inches or more of local relief.

Hydrology: As with other nonalluvial wetlands, Nonriverine Wet Hardwood Forests are wetted by rainfall, seasonal high water table, and by sheet flow from adjacent flats. Surface water several inches deep may be present in wet seasons, and water may persist into the growing season in much of the community. The Oak–Gum Slough Subtype is wetter than the Oak Flat Subtype, often collecting water from it but is less wet than Nonriverine Swamp Forests.

Vegetation: The Oak–Gum Slough Subtype is a forest dominated by *Quercus laurifolia* and *Nyssa biflora*. *Acer rubrum* may be abundant. Other trees, present in smaller numbers, may include

Liquidambar styraciflua, Quercus nigra, Quercus phellos, Quercus michauxii, and occasionally *Fraxinus pennsylvanica, Populus heterophylla*, or *Taxodium distichum*. The understory often consists of *Acer rubrum* or *Carpinus caroliniana*; it may include *Magnolia virginiana* or other species. The shrub layer generally is low in density. Species in known examples include *Vaccinium formosum, Arundinaria tecta*, and *Cyrilla racemiflora*. *Smilax rotundifolia* or other vines may be present. Herbs are sparse to moderate, with no species having very high constancy. Species noted in site reports include *Saururus cernuus, Carex* spp., *Lorinseria areolata, Osmunda spectabilis, Persicaria* sp., *Limnobium spongia*, and *Sphagnum* sp.

Range and Abundance: Ranked G2G3. The Oak–Gum Slough is often not recognizable in earlier site reports, where it may be overlooked or lumped with the Oak Flat Subtype. Fewer examples are documented in North Carolina, but additional ones are likely to be discovered. Their greater wetness may have led some to be left where adjacent communities were destroyed. Most are in the Embayed Region in the northern Coastal Plain. The synonymized NVC association is defined as more wide-ranging than that of the Oak Flat Subtype, extending from Virginia to Georgia.

Associations and Patterns: The Oak–Gum Slough Subtype appears to be a small patch community, though this is not certain. Most of the few examples are tens of acres or less. They tend to occur with the Oak Flat Subtype but tend to be much less extensive.

Variation: Little is known of the variation in this subtype. This subtype appears to be narrowly defined, with little variation, but this may be because few examples have been described.

Dynamics: Little is specifically known about the dynamics of this subtype. It presumably is similar to the Oak Flat Subtype, but it may receive slightly more nutrient input from local collection of water. Because of the greater wetness, *Liquidambar* is less likely to take over after logging, though *Acer rubrum* may still dominate successional stands.

Comments: *Quercus phellos - Nyssa biflora / Panicum hemitomon - Carex* spp. - *Woodwardia virginica* Swamp Forest (CEGL004104) is an association defined in South Carolina which appears possibly related to the Oak–Gum Slough community. However, it may be more like a pond and be more akin to our Coastal Plain Depression Swamp.

Rare species:
Vertebrate animals – *Sistrurus miliarius miliarius*.

WET MARL FOREST

Concept: Wet Marl Forest is a perched wetland forest of nonalluvial flats influenced by limestone near the surface. It is dominated by calciphilic and rich-site wetland hardwood forest species, particularly *Carya myristiciformis*. The only example known to remain is at Rocky Point Marl Forest.

Distinguishing Features: Wet Marl Forests may be distinguished from Nonriverine Wet Hardwood Forests by the limestone-derived, calcareous soils and the strong presence of calciphilic plant species such as *Carya myristiciformis, Tilia americana var. caroliniana*, and *Swida* (*Cornus*) *asperifolia*, along with an abundance of other species of rich sites such as *Carya cordiformis, Quercus shumardii, Acer floridanum, Acer negundo, Cercis canadensis*, and *Sabal minor*. The Wet Marl Forest community is distinguished from Coastal Plain Marl Outcrop and Basic Mesic Forest by its occurrence on poorly drained flats and by the abundance of wetland species.

Crosswalks: *Carya cordiformis - Quercus pagoda - Carya myristiciformis / Sabal minor - Cornus asperifolia* Wet Flatwoods Forest (CEGL007316).
G130 Hardwood - Loblolly Pine Nonriverine Wet Flatwoods Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Wet Marl Forest occurs on poorly drained upland flats remote from streams. Limestone (locally called "marl") is near the surface. Small limestone outcrops or float may be present, but the site is not very rocky and shallowness of the soil is not an important influence.

Soils: The only known example of Wet Marl Forest is mapped as Meggett soil (Typic Albaqualf). The soil is relatively high in pH, base saturation, and calcium levels compared to most Coastal Plain soils.

Hydrology: Wet Marl Forest appears to be a perched wetland, wetted by rainfall and sheet flow and kept wet by limited infiltration and limited runoff in the flat topography. The soil surface has distinct hummock and hollow topography, with fine-scale variation in the depth and duration of standing water.

Vegetation: Wet Marl Forest is a diverse forest with a mix of species including many requiring higher pH, higher base saturation soil conditions. Abundant in the canopy and constant in CVS plots are *Carya myristiciformis, Liquidambar styraciflua, Quercus michauxii, Quercus laurifolia, Quercus shumardii, Carya ovata, Fraxinus americana*, and *Liriodendron tulipifera*. Moderately frequent additional species include *Fraxinus pennsylvanica, Carya cordiformis, Ulmus americana*, *Ulmus rubra,* and *Quercus pagoda*. The understory is dominated by *Carpinus caroliniana, Asimina triloba, Acer floridanum*, and *Acer rubrum*. Additional constant or frequent species include *Ilex opaca, Acer negundo, Benthamidia* (*Cornus*) *florida, Persea palustris*, *Tilia americana* var. *caroliniana, Morus rubra*, *Magnolia virginiana*, and *Crataegus macrosperma*. The shrub layer is moderate to dense. Over much of the community, *Sabal minor* is dominant. *Swida (Cornus) asperifolia* is also highly constant and often codominant. Other constant to frequent shrubs are *Aesculus pavia, Viburnum prunifolium, Euonymus americanus, Sambucus canadensis*, *Callicarpa americana*, and the exotic *Ligustrum sinense*. Woody vines are extremely diverse. Highly constant species in plots are *Berchemia scandens, Muscadinia rotundifolia, Toxicodendron radicans, Parthenocissus quinquefolia, Smilax bona-nox, Smilax rotundifolia, Campsis radicans, Nekemias arborea, Vitis cinerea* var. *baileyana, Hydrangea (Decumaria) barbara*, *Lonicera sempervirens*, and the exotic *Lonicera japonica*. Herbs are similarly diverse where *Sabal* is not too dense. *Carex basiantha* is constant and sometimes dominant. *Podophyllum peltatum, Arisaema triphyllum, Dichanthelium commutatum, Endodeca serpentaria, Sanicula canadensis, Mitchella repens, Solidago caesia, Polystichum acrostichoides, Sanicula odorata, Carex corrugata, Mikania scandens*, and *Saururus cernuus* are also highly constant in plots. Other frequent species include *Athyrium asplenioides, Boehmeria cylindrica, Cryptotaenia canadensis, Galium uniflorum, Glyceria striata, Juncus coriaceus, Solidago rugosa, Onoclea sensibilis, Ruellia strepens, Viola sororia, Asplenium platyneuron, Carex gholsonii, Chasmanthium laxum, Dichanthelium boscii, Festuca subverticillata, Galium circaezans, Geum canadense, Geum virginianum, Hexastylis arifolia, Hydrocotyle umbellata, Oplismenus setarius, Packera glabella, Persicaria setacea, Persicaria virginiana, Poa autumnalis, Sabatia calycina*, and *Passiflora lutea*.

Range and Abundance: Ranked G1. This community is only definitively known from a single site, with another site destroyed nearby. There is some possibility that similar communities exist in South Carolina or Georgia, where limestone occurs near the surface in wet flats; however, the calcareous communities known in those states are not considered to be the same community.

Associations and Patterns: Wet Marl Forest is a small patch community, though it once occurred as a large patch community. The natural surroundings of the one known example have been lost. It may have graded to a non-calcareous Nonriverine Swamp Forest or to better drained upland forests.

Variation: The single example known is highly diverse and heterogeneous on a fine scale, suggesting a broad range of wetness, but the several CVS plots sampled in it have a large number of highly constant species. The range of apparent wetness probably results from the microtopography, but it is possible plants are displaying different moisture tolerances because of the calcareous conditions.

Dynamics: Dynamics of this community are poorly known. They probably are similar to Nonriverine Wet Hardwood Forest, occurring as old-growth forest with tree regeneration occurring in small to medium size gaps. Fire likely naturally was of limited importance.

Rare species:
Vascular plants – *Carex basiantha, Carex cherokeensis, Carya myristiciformis, Lythrum lanceolatum, Oplismenus setarius, Ponthieva racemosa, Ruellia strepens, Scirpus lineatus,* and *Swida asperifolia*.

Vertebrate animals – *Crotalus adamanteus* and *Neotoma floridana floridana*.

Invertebrate animals – *Catocala myristica* and *Melanoplus nossi*.

NONRIVERINE SWAMP FOREST (CYPRESS–GUM SUBTYPE)

Concept: Nonriverine Swamp Forests are the wettest Coastal Plain Nonalluvial Wetland Forests. They are saturated to shallowly flooded wetlands not associated with rivers or basins, with canopies dominated or codominated by combinations of *Nyssa, Taxodium,* and *Acer rubrum*. The Cypress–Gum Subtype covers the wettest examples, with canopies of *Taxodium distichum, Nyssa biflora*, *Nyssa aquatica,* and *Fraxinus* spp. and few or no trees other than *Acer rubrum* present. Ground water input as well as poor drainage may be responsible for the wetness of this subtype, and minerals in ground water may give it some of its distinctive character. This subtype is more like riverine swamps in flora and vegetation structure than are the other subtypes.

Distinguishing Features: Nonriverine Swamp Forests are distinguished from Cypress–Gum Swamps and Tidal Swamps by occurring on wet flats away from the influence of rivers. They are distinguished from Coastal Plain Depression Swamps by not occurring in distinct closed basins. A few may be in very shallow basins, generally too subtle to be obvious.

The Cypress–Gum Subtype is distinguished from other Nonriverine Swamp Forests by strong dominance by *Taxodium distichum* or *Nyssa* spp. In known examples this is associated with composition more similar to river swamps and a smaller component of pocosin shrubs than in other subtypes.

Crosswalks: *Taxodium distichum - Nyssa biflora / Berchemia scandens - Toxicodendron radicans / Woodwardia areolata* Swamp Forest (CEGL004429).
G038 Coastal Plain Wet Flats & Basin Swamp Group. Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Nonriverine Swamp Forests occur on flat, poorly drained upland areas that are not associated with streams. They occur on geologically young surfaces in the areas where stream drainages have not yet developed and topographic relief is practically nonexistent. Some of the Cypress–Gum Subtype occur near scarps that represent ancient shorelines, with the swamp on what would have been the floor of the ocean or sound.

Soils: Most examples of the Cypress–Gum Subtype occur on organic soils such as Pungo or Dare (Typic Haplosaprist) or Ponzer, Belhaven, or Croatan (Terric Haplosaprist). A few are mapped as wet mineral soils such as Pantego (Umbric Paleaquult), Tomotley (Typic Ochraquult), or Leaf (Typic Albaquult). As in many other nonriverine wetlands, the soil surface often has a hummock and hollow structure, with several inches or more of local relief.

Hydrology: Nonriverine Swamp Forests are seasonally flooded, with shallow standing water over much or all of the area well into the growing season. They are wet primarily because of poor drainage in the flat terrain with no streams. Water comes primarily from rainfall or sheetflow, but some examples occur near scarps and may receive some groundwater from adjacent sandy uplands.

Vegetation: The Cypress–Gum Subtype is usually dominated by *Nyssa biflora*, sometimes with codominant *Acer rubrum* var. *trilobum* and with varying amounts of *Taxodium distichum*. It is likely that *Acer* is increased and *Taxodium* decreased in proportion to the impact of past logging.

A few examples have *Nyssa aquatica* present, rarely abundant. Other tree species may be present in small numbers, including *Populus heterophylla, Fraxinus profunda, Quercus laurifolia, Ulmus americana*, and *Liquidambar styraciflua*. The understory may be dominated by *Ilex opaca, Persea palustris*, or *Acer rubrum* in different places. *Magnolia virginiana* is also frequent. The shrub layer is generally open. No species has high constancy, but species with moderate frequency in site reports and the limited CVS plots include *Clethra alnifolia, Vaccinium fuscatum, Vaccinium formosum, Itea virginica, Eubotrys racemosus, Lyonia lucida, Cyrilla racemiflora*, and *Arundinaria tecta*. Less frequent species may include *Morella caroliniana, Viburnum nudum, Viburnum dentatum, Ilex laevigata*, and *Symplocos tinctoria*. Woody vines are usually abundant and diverse. *Muscadinia rotundifolia, Smilax rotundifolia*, and *Toxicodendron radicans* are the most frequent, but *Smilax laurifolia, Parthenocissus quinquefolia, Hydrangea (Decumaria) barbara, Bignonia capreolata, Berchemia scandens*, *Campsis radicans*, and *Gelsemium sempervirens* also occur. The herb layer may be sparse or fairly dense. The only herbs with fairly high frequency are *Lorinseria areolata* and *Carex* collectively. Other herbs that occur in some examples include *Anchistea virginica, Saururus cernuus, Dulichium arundinaceum, Osmunda spectabilis, Mitchella repens, Osmundastrum cinnamomeum, Persicaria* sp., *Thelypteris palustris, Impatiens capensis, Athyrium asplenioides, Hypericum walteri, Iris virginica, Dryopteris celsa*, and *Sphagnum* sp.

Range and Abundance: Ranked G2G3 but probably G2. In North Carolina, fewer than ten examples are known, all in the outer parts of the Coastal Plain. Most are in the Embayed Region in the northern part of the state. This community is also known from adjacent Virginia but is nearly endemic to North Carolina.

Associations and Patterns: The Cypress–Gum Subtype is a large patch community. It may grade to Nonriverine Wet Hardwood Forest, Peatland Atlantic White Cedar Forest, Pond Pine Woodland, or rarely to Tidal Swamp. It may be bordered by upland communities where a scarp occurs adjacent to it or where upland ridges protrude from the peat.

Variation: Known examples of the Cypress–Gum Subtype are quite variable, but the patterns remain to be sorted out. There is a gradient of apparent nutrient richness and species composition, from those more like river swamps to more pocosin-like examples. This is reflected by the presence of *Nyssa aquatica, Fraxinus profunda, Itea virginica*, and *Viburnum* spp. in some, *Gordonia lasianthus, Lyonia lucida, Anchistea virginica*, and *Sphagnum* sp. in some. The variation in the amount of *Taxodium* and *Acer* in the canopy probably reflects influence of past logging, but the natural range of variation in these species is not well known.

Dynamics: Dynamics of the Cypress–Gum Subtype are similar to those of most Coastal Plain Nonalluvial Wetland Forests in general. However, the resistance of *Taxodium* and *Nyssa* to windthrow presumably lead to fewer and smaller gaps and longer-lived trees. As in other swamps, *Taxodium* may have failed to regenerate well after logging and may be reduced in the long term in many if not all examples.

The environmental factors that lead to the formation of the Cypress–Gum Subtype rather than other subtypes are not well known. They seem to be more fertile than the Mixed Subtype and presumably are more wet than the Poplar–Pawpaw Subtype or Sweetgum Subtype. Some examples occur where groundwater input is possible, and this may increase fertility, but not all appear to have this influence.

There is some question of the relationship of Nonriverine Swamp Forest, both the Cypress–Gum Subtype and the Mixed Subtype, with other communities of peatlands. Heavily logged examples come to be dominated by *Nyssa biflora* and *Acer rubrum*, while logged Peatland Atlantic White Cedar Forests generally become dominated by the same species. The earlier vegetation in these areas can be difficult to tell. It is sometimes suggested that the past occurrences of these communities was related to fire frequency. Frost (2000) believed that Nonriverine Swamp Forests occurred naturally where fire was very infrequent, and that many areas that now appear to be this community were once frequently burned Peatland Canebrakes or Peatland Atlantic White Cedar Forests. This may be true in some areas, though the longevity of trees and the limited spread of *Taxodium* makes this seem unlikely in the most mature examples. It seems more possible in younger examples of more successional composition.

Comments: The Cypress–Gum Subtype has had limited study. The Great Dismal Swamp attracted some study around the time of the establishment of the National Wildlife Refuge (e.g., Kirk 1979; Carter and Gammon 1976). The Virginia Natural Heritage Program has collected a number of plots in the Great Dismal Swamp near the state line, but only a couple of CVS plots in North Carolina appear to represent this community.

Rare species:
Vertebrate animals – *Sistrurus miliarius miliarius*.

NONRIVERINE SWAMP FOREST (MIXED SUBTYPE)

Concept: Nonriverine Swamp Forests are the wettest Coastal Plain Nonalluvial Wetland Forests. They are saturated to shallowly flooded wetlands not associated with rivers or basins, with canopies dominated or codominated by combinations of *Nyssa, Taxodium,* and *Acer rubrum*. The Mixed Subtype covers examples on moderate-to-deep organic soils, dominated by a mixture of hardwoods and conifers that includes *Pinus taeda, Chamaecyparis thyoides*, or *Pinus serotina*, as well as the typical dominants.

Distinguishing Features: Nonriverine Swamp Forests are distinguished from Cypress-Gum Swamps and Tidal Swamps by occurring on wet flats away from the influence of rivers. They are distinguished from Coastal Plain Depression Swamps by not occurring in distinct closed basins. A few may be in very shallow basins, generally too subtle to be obvious.

The Mixed Subtype is distinguished from other subtypes by having *Pinus taeda* or *Chamaecyparis thyoides* as substantial components, in addition to *Nyssa, Taxodium*, and *Acer*. This subtype often resembles Pond Pine Woodland and Peatland Atlantic White Cedar Forest in the lower strata, differing mainly in the canopy. Peatland Atlantic White Cedar Forests that have been logged and have not regenerated well may be indistinguishable from similarly logged examples of the Mixed Subtype.

Crosswalks: *Pinus taeda - Chamaecyparis thyoides - Nyssa biflora / Lyonia lucida - Clethra alnifolia* Swamp Forest (CEGL007558).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Nonriverine Swamp Forests occur on flat, poorly drained upland areas that are not associated with streams. The Mixed Subtype occurs primarily on extensive flat peatlands or on small, elevated patches in peat-filled drowned river valleys. The elevated patches are generally oval in shape and stand above the tidal influence that surrounds them. They may be domed peatlands in miniature. A few examples are in Carolina bays or other inland peat-filled swales. Most examples are only a few feet above sea level.

Soils: The Mixed Subtype occurs primarily on organic soils, most often mapped as Dorovan or Pungo (Typic Haplosaprist) but sometimes as Ponzer, Belhaven, or Scuppernong (Terric Haplosaprists). A minority are mapped as mucky or wet mineral soils such as Roper (Histic Humaquept), Hyde (Typic Umbraquult), or several others. Several authors have suggested that the peat supporting Nonriverine Swamp Forests has a higher mineral content and may have received occasional input from nearby estuarine waters in the past.

Hydrology: As with other Nonriverine Swamp Forests, the Mixed Subtype is nearly permanently saturated and may be shallowly flooded seasonally by rainfall and local sheet flow. Sites are wet primarily because of poor drainage in the flat terrain with no streams. Most lie near sea level but they are beyond the influence of tidal waters, if only by a few inches of elevation and a few feet of distance.

Vegetation: The Mixed Subtype is universally dominated or codominated by *Nyssa biflora* and *Acer rubrum* with a significant minority or codominance of *Pinus taeda, Chamaecyparis thyoides, Taxodium distichum*, or, less often, *Pinus serotina*. *Magnolia virginiana* sometimes is in the canopy. The understory usually is dominated by *Persea palustris* or *Acer rubrum*, and it may include *Magnolia virginiana* or various of the canopy species. The shrub layer is fairly dense. In site reports, *Lyonia lucida* is the most constant and most often dominant species, closely followed by *Ilex glabra*. Moderately frequent species include *Vaccinium formosum, Ilex coriacea, Clethra alnifolia*, and *Morella caroliniensis*. Other shrub species sometimes include *Viburnum nudum, Leucothoe axillaris, Cyrilla racemiflora, Arundinaria tecta*, and *Morella cerifera*, with several other species occurring occasionally. *Smilax laurifolia* occurs with high constancy, and *Smilax walteri, Gelsemium sempervirens*, and *Toxicodendron radicans* are occasional. Herbs generally have limited cover. *Lorinseria areolata*, *Anchistea virginica*, *Saururus cernuus*, and *Sphagnum* spp. are the only species with even moderate constancy.

Range and Abundance: Ranked G2G3 but probably G3. This is the most extensive and numerous subtype in North Carolina, with more than 35 examples, a couple over 15,000 acres. However, much of this acreage is very close to sea level. And some it being lost with rising water levels. The Mixed Subtype occurs in adjacent Virginia but is nearly endemic to North Carolina.

Associations and Patterns: The Mixed Subtype may be thought of as a large patch community or as a matrix community that forms a common part of a couple of very specific kinds of landscapes in the outer Coastal Plain. It often grades to Tidal Swamp in drowned river valleys and on the edges of large peatlands near estuaries. In large peatlands and in the few Carolina bays where it occurs, it is often associated with Peatland Atlantic White Cedar Forest, Pond Pine Woodland, or Bay Forest. It may also be associated with Nonriverine Wet Hardwood Forest on the edges of peatlands.

Variation: Examples are quite variable in the relative proportions of canopy species. Much of the visible variation may be caused by different effects of logging history, as *Chamaecyparis, Taxodium*, and *Pinus taeda* are all highly valued species that have unpredictable ability to regenerate after logging.

Dynamics: Dynamics of the Mixed Subtype are not well known but may be intermediate between those of the Cypress–Gum Subtype and of Peatland Atlantic White Cedar Forest. The forests likely existed naturally as uneven-aged stands with tree regeneration primarily in small to medium size gaps. However, large gaps created by hurricanes may have been important. Occasional fires may have been important, both for creating gaps and for reducing the cover of the understory. The canopies of the Mixed Subtype contain a mix of species that normally demonstrate very different stand dynamics, with short-lived, catastrophically regenerated *Chamaecyparis thyoides* on one extreme and long-lived, rarely regenerated *Taxodium distichum* on the other. The very shade-tolerant *Acer rubrum* and shade-intolerant *Pinus taeda* represent a major contract along a different axis. The present species mix probably is partly a result of logging history and of fire exclusion. *Taxodium* and *Chamaecyparis* often fail to regenerate after logging, and they likely were more abundant in past stands. *Acer rubrum* and *Nyssa biflora* often increase with logging and fire exclusion and likely were less abundant in the past.

An alternative view advanced by Cecil Frost and others for some occurrences is that they were once Peatland Atlantic White Cedar Forests and that the current composition is a result of succession in the absence of the fire needed to regenerate the cedar, something that might happen with or without logging. This may be reasonable for examples where *Chamaecyparis* appears older than the other trees in the forest, or in relatively young examples that are predominantly *Acer* and *Nyssa*. It seems less likely where other canopy trees are the same age as the *Chamaecyparis*, and especially where older *Taxodium* is present.

The Mixed Subtype, by virtue of having most of its occurrences and acreage near sea level, is the Coastal Plain Nonalluvial Wetland Forest community most threatened by rising sea level. The dynamic of gradual conversion to Tidal Swamp, described for the theme, most often plays out in it, leaving perhaps thousands of acres in transition. In many places, around the shorelines of drowned rivers and other estuaries, this process is one that has been occurring for many centuries and may be regarded as natural. However, the process is accelerated and exacerbated in an avoidable way by the existence of sea level ditches, which bring oligohaline tidal waters well inland of where they would penetrate overland.

Much of this subtype occurs on deep organic soils that appear similar to those of pocosins. What causes the difference in community is not entirely clear. Intermittent mineral input by wind tides and differences in fire regime have both been suggested. This subtype often occurs with embedded patches of Peatland Atlantic White Cedar Forest, sometimes also Bay Forest and Pond Pine Woodland. It is possible that these communities exist as a long-term shifting mosaic with current condition determined by fire history. However, the longevity of the trees and the limited conditions suitable for seedling establishment of some of the species suggest that any shifting is infrequent or slow.

Comments: Heavily logged examples may regenerate as the successional *Acer rubrum* var. *trilobum - (Nyssa biflora) / Clethra alnifolia - (Persea palustris)* Ruderal Wet Forest (CEGL007445) or as a secondary bay forest (*Magnolia virginiana - Persea palustris / Lyonia lucida* Swamp Forest (CEGL007049)).

Study of the Mixed Subtype has been surprisingly limited, given its extent and its importance on conservation lands. CVS plots are either scarce or are not appropriately classified. Published literature is near nonexistent. However, numerous descriptions exist in Natural Heritage Program site reports and other unpublished material.

Rare species:
Vascular Plants – *Peltandra sagittifolia.*

Nonvascular plants – *Sticta deyana*.

Vertebrate animals – *Dryobates borealis, Haliaeetus leucocephalus, Setophaga virens waynei,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Hypagyrtis brendae* and *Iridopsis cypressaria.*

NONRIVERINE SWAMP FOREST (POPLAR–PAWPAW SUBTYPE)

Concept: Nonriverine Swamp Forests are the wettest Coastal Plain Nonalluvial Wetland Forests. They are saturated to shallowly flooded wetlands not associated with rivers or basins, with canopies dominated or codominated by combinations of *Nyssa, Taxodium,* and *Acer rubrum*. The Poplar–Pawpaw Subtype covers examples on shallow organic or mucky mineral soil, with vegetation that contains substantial amounts of *Liriodendron tulipifera* in the canopy and/or *Asimina triloba* in the understory. These species are generally not dominant, but their presence indicates a somewhat richer and less wet site.

Distinguishing Features: Nonriverine Swamp Forests are distinguished from Cypress-Gum Swamps and Tidal Swamps by occurring on wet flats away from the influence of rivers. They are distinguished from Coastal Plain Depression Swamps by not occurring in distinct closed basins. The Poplar–Pawpaw Subtype is distinguished from all other subtypes by having *Liriodendron tulipifera* and *Asimina triloba* as significant components of their strata.

Crosswalks: *Nyssa biflora - Acer rubrum var. trilobum - Liriodendron tulipifera / Magnolia virginiana / Clethra alnifolia Swamp* Forest (CEGL004428). G038 Coastal Plain Hardwood Basin Swamp Group. Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: The Poplar–Pawpaw Subtype occurs on large poorly drained upland flats, with or without organic deposits.

Soils: No consistent pattern can be found in the soils of the Poplar–Pawpaw Subtype. The four known examples are mapped with six different soil series, with Belhaven (Terric Haplosaprist) the only one found in more than one example. Other mapped soils include true organic soils (Dorovan – Typic Haplosaprist), organic-rich mineral soils (Pettigrew – Histic Humaquept, Murville – Typic Haplaquod), and less organic-rich mineral soils (Portsmouth and Cape Fear – Typic Umbraquults). Soils are usually strongly hummocky.

Hydrology: As with other Nonriverine Swamp Forests, the Mixed Subtype is nearly permanently saturated and may be shallowly flooded seasonally by rainfall and local sheet flow. Sites are wet primarily because of poor drainage in the flat terrain with no streams.

Vegetation: The Poplar–Pawpaw Subtype is dominated by a mix of trees with *Liriodendron tulipifera, Nyssa biflora,* and *Acer rubrum* constantly present. *Liquidambar styraciflua, Magnolia virginiana, Chamaecyparis thyoides, Taxodium distichum*, and other species occur in small numbers with low constancy. The understory is dominated by a varying mixture of *Asimina triloba, Persea palustris*, and sometimes *Ilex opaca*. The shrub layer is moderate to dense. *Clethra alnifolia* is more often dominant, but *Arundinaria tecta* may dominate. Other shrub species include *Eubotrys racemosus, Itea virginica*, and *Rhododendron* spp. Vines are sometimes prominent, including *Parthenocissus quinquefolia, Muscadinia rotundifolia, Toxicodendron radicans, Gelsemium sempervirens, Bignonia capreolata, Hydrangea (Decumaria) barbara, Berchemia scandens,* and several species of *Smilax*. Herbs are generally sparse, with no species having high constancy. *Lorinseria areolata, Boehmeria cylindrica, Osmunda spectabilis, Dryopteris* *carthusiana, Dryopteris ludoviciana*, and *Asplenium platyneuron* are among the species noted in one or two sites. *Pleopeltis michauxiana* (*Polypodium polypodioides*) is prominent as an epiphyte in one site.

Range and Abundance: Ranked G2 but probably G1. The association is known definitively only in North Carolina but is questionably attributed to Virginia. It is extremely rare in North Carolina, with only four examples known.

Associations and Patterns: The Poplar–Pawpaw Subtype is a large patch community, occurring in areas over 1000 acres. Most of the few examples are partly or fully isolated amid altered vegetation, making it difficult to tell their natural associations. They are sometimes associated with other subtypes of Nonriverine Swamp Forest, including the Sweetgum Subtype and Cypress–Gum Subtype, and may once have been associated with Nonriverine Wet Hardwoods.

Variation: Little is known about the natural variation within this subtype.

Dynamics: Little is known about the natural dynamics of this subtype. The abundance of *Liriodendron tulipifera*, a species that is shade-intolerant and less resistant to uprooting than *Nyssa* or *Taxodium*, may suggest a greater role for wind disturbance than in the other subtypes. Fire is unlikely to be an important influence. Most examples are at slightly higher elevation than some of the other subtypes, so rising sea level is unlikely to be a short-term concern.

Comments: The Poplar–Pawpaw Subtype is the least well studied and most poorly understood of the Nonriverine Swamp Forests. Only a single CVS plot appears to represent it, and there are only a few thorough site descriptions.

A question has been raised as to whether the distinctive vegetation of this subtype is of natural origin or if it may be an artifact of artificial drainage and logging history. Arguments for this view include that known sites are bordered or surrounded by large ditches or drained agricultural land, that the community contains species typically associated with different moisture levels, and that older trees often appear to be standing on "stilt roots," suggesting organic substrate has subsided or oxidized beneath them. However, examples of other Nonriverine Swamp Forests with similar altered hydrology and logging history remain recognizable as other subtypes or develop successional vegetation that does not resemble the Poplar–Pawpaw Subtype. While *Liriodendron tulipifera* is generally associated with mesic sites and *Nyssa biflora* with very wet sites, *Liriodendron* can tolerate saturated soil; the two sometimes occur together in other communities, including Sandhill Streamhead Swamp and Coastal Plain Small Stream Swamp. The "stilt root" phenomenon can result not only from subsidence of organic substrate beneath established trees, but also by establishment of tree seedlings on fallen logs which subsequently decay. The author has observed that sites with older trees on "stilt roots" also contain older trees rooted at the current ground surface level. Thus, while much remains unknown about the Poplar–Pawpaw Subtype, it appears appropriate to accept it as a natural community, probably developed on richer soils than those typical of the other subtypes.

Rare species:
Vertebrate animals – *Setophaga virens waynei* and *Sistrurus miliarius miliarius*.

NONRIVERINE SWAMP FOREST (SWEETGUM SUBTYPE)

Concept: Nonriverine Swamp Forests are nonalluvial wetlands of poorly drained flats, dominated or codominated by combinations of *Nyssa, Taxodium,* and *Acer rubrum*. The Sweetgum Subtype encompasses examples on mineral soil, with *Liquidambar styraciflua* codominant or in significant amounts, and lacking the distinctive characteristics of the Poplar–Pawpaw Subtype.

Distinguishing Features: Nonriverine Swamp Forests are distinguished from Cypress–Gum Swamps and Tidal Swamps by occurring on wet flats away from the influence of rivers. They are distinguished from Coastal Plain Depression Swamps by not occurring in distinct closed basins.

The Sweetgum Subtype is distinguished from other subtypes by the presence of *Liquidambar styraciflua* in either the canopy or understory, reflecting lower organic content in the soil. *Liquidambar* serves as an indicator; it may not dominate but is generally abundant. Nonriverine Wet Hardwood Forests may also contain abundant *Liquidambar*, but also contain oaks in more than minor numbers and have little or no *Nyssa biflora*.

Crosswalks: *Nyssa biflora - Liquidambar styraciflua - Acer rubrum var. trilobum / Clethra alnifolia* Swamp Forest (CEGL004679).
G038 Coastal Plain Hardwood Basin Swamp Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: The Sweetgum Subtype occurs on poorly drained flats, remote from streams. It is associated with mineral rather than organic substrates, at least locally. Some examples that occur adjacent to other subtypes may represent higher areas of a surface that has been partially buried in peat.

Soils: The Sweetgum Subtype is believed to be associated with fine-textured mineral soils, in contrast to the organic or organic-rich soils of the other common subtypes of Nonriverine Swamp Forest. Series such as Cape Fear and Hyde (Typic Umbraquults) and Leaf (Typic Albaquult) are characteristic. However, this character is not always apparent in soil mapping. A number of examples are mapped as Belhaven (Terric Haplosaprist) or Dorovan (Typic Haplosaprist). The community may be on inclusions within these map units.

Hydrology: As with other Nonriverine Swamp Forests, the Sweetgum Subtype is nearly permanently saturated and may be shallowly flooded seasonally by rainfall and local sheet flow. Sites are wet primarily because of poor drainage in the flat terrain with no streams.

Vegetation: The Sweetgum Subtype is generally dominated by *Nyssa biflora*, *Acer rubrum,* and *Liquidambar styraciflua*, with all species occurring with near 100% constancy in both CVS plots and site descriptions. *Taxodium distichum, Pinus taeda*, or *Pinus serotina* may occur in small numbers and with low to moderate frequency. Occasional *Quercus laurifolia* and *Quercus nigra* may occur in examples that are transitional to Nonriverine Wet Hardwood Forest. The understory is usually dominated by *Persea palustris*, along with *Acer rubrum*. Also fairly frequent are *Ilex opaca* and *Magnolia virginiana*. The shrub layer generally is dense, with *Clethra alnifolia, Lyonia lucida, Ilex glabra*, or *Arundinaria tecta* dominant. Other shrubs that occur with at least moderate frequency include *Vaccinium formosum, Vaccinium fuscatum,* and *Eubotrys racemosus. Cyrilla racemiflora, Viburnum nudum, Morella caroliniensis, Aronia arbutifolia*, and *Symplocos tinctoria* may occasionally be present. Several species of vines are frequent, including *Parthenocissus quinquefolia, Toxicodendron radicans, Smilax laurifolia, Smilax rotundifolia, Smilax walteri, Smilax glauca, Berchemia scandens, Gelsemium sempervirens,* and *Hydrangea (Decumaria) barbara*. Herbs are low in density, and no species occur with high frequency. *Lorinseria areolata* is the most frequent species in both plot data and site descriptions. Other species include *Anchistea virginica, Onoclea sensibilis, Saururus cernuus, Osmundastrum cinnamomeum, Osmunda spectabilis, Triadenum* (*Hypericum*) *walteri*, *Lobelia inflata*, and several species of *Carex*.

Range and Abundance: Ranked G2? This subtype occurs primarily in the northeastern Coastal Plain in the state, but a few examples are farther inland. The association appears to be endemic to North Carolina, though it might be found in adjacent Virginia. It is quite rare; fewer than 15 occurrences are known in North Carolina, though some are large. It is unclear how extensive it was before widespread land clearing. The mineral soil substrate may have made it more amenable to cultivation than most other subtypes, though it is still quite wet.

Associations and Patterns: The Sweetgum Subtype is a large patch community, with patches up to 1000 acres or more but apparently not a regular part of any typical landscape mosaic. Patches are often associated with other subtypes of Nonriverine Swamp Forest, especially the Mixed Subtype. It might also have been naturally associated with Nonriverine Wet Hardwood Forest.

Variation: Examples vary in canopy composition, but no pattern of variation has been recognized.

Dynamics: Dynamics for the Sweetgum Subtype are probably similar to those for the Coastal Plain Nonalluvial Wetland Forests theme as a whole.

Comments: The *Liquidambar* is probably increased in all examples as a result of past logging but presumably was present previously. It serves as an indicator of mineral soil. The 3rd Approximation previously recognized a Sweetgum variant of Nonriverine Wet Hardwood Forest. This has been dropped, but some examples have been reinterpreted as this wetter community.

Pinus taeda - Acer rubrum - Liquidambar styraciflua / Arundinaria gigantea ssp. *tecta* Forest (CEGL004649) is apparently a successional community that may be an altered version of this but may also be an altered version of other community types.

Rare species:
Vascular plants – *Lindera subcoriacea.*

Nonvascular plants – *Sticta deyana,*

Vertebrate animals – *Setophaga* (*Dendroica*) *virens waynei* and *Sistrurus miliarius miliarius*.

PEATLAND ATLANTIC WHITE CEDAR FOREST

Concept: Peatland Atlantic White Cedar Forests are wetland forests dominated by *Chamaecyparis thyoides* that occur on organic soils on poorly drained upland flats, in Carolina bays, or in other settings not flooded by rivers and not associated with seepage. Tree and shrub species of Nonriverine Swamp Forests, many also shared with pocosins, may be present and are sometimes abundant.

Distinguishing Features: Peatland Atlantic White Cedar Forests are distinguished from Streamhead Atlantic White Cedar Forests by occurrence on flats or in shallow depressions fed by sheet flow and rainwater, in contrast to seepage-fed drainages in sandhill terrain. There is normally a difference in associated plants, with *Liriodendron tulipifera* in particular usually present only in streamheads. *Chamaecyparis* is present in a few other communities, such as Blackwater Bottomland Hardwoods (Evergreen Subtype), but does not dominate.

Crosswalks: *Chamaecyparis thyoides / Persea palustris / Lyonia lucida - Ilex coriacea* Swamp Forest (CEGL006146). G038 Coastal Plain Hardwood Basin Swamp Group.
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Peatland Atlantic White Cedar Forests occur in several settings. The most extensive are on large peatlands on poorly drained upland flats in the outer Coastal Plain, distant from streams. A number of smaller stands are on elevated patches in peat-filled drowned river valleys. The elevated patches are generally oval in shape and stand above the tidal influence that surrounds them. They may be domed peatlands in miniature. Some small stands also occur in Carolina bays in the Bladen Lakes area. A few small stands occur on Coastal Plain river terraces in areas that appear to no longer flood.

Soils: Peatland Atlantic White Cedar Forests occur on a variety of shallow or deep organic soil and mucky mineral soils. Most peatland examples are mapped as Pungo (Typic Haplosaprist), some as Croatan (Terric Haplosaprist), Belhaven (Terric Haplosaprist), Roper (Histic Humaquept), Torhunta (Typic Humaquept), or Hyde (Typic Umbraquult). Those in drowned river valleys are usually mapped as Dorovan (Typic Haplosaprist). Carolina bay occurrences are usually mapped as Pamlico (Terric Haplosaprist), Lynn Haven (Typic Alaquod), or Torhunta. River terrace examples may be mapped as Murville (Umbric Endoaquod), Rutlege (Typic Humaquept), Johnston (Cumulic Humaquept), or other series. Regardless of mapped series, soils in Peatland Atlantic White Cedar Forests often are very distinctive, consisting of multiple layers of fallen logs draped with leaf litter and duff, with much void space beneath them. Because the cedar wood is very decay-resistant, this structure can persist beneath mature stands.

Hydrology: Peatland Atlantic White Cedar Forests are nearly permanently saturated and may be shallowly flooded seasonally by rainfall and local sheet flow. Sites are wet primarily because of poor drainage in the flat terrain with no streams. Most lie near sea level but they are beyond the influence of tidal waters, if only by a few inches of elevation and a few feet of distance.

Vegetation: Peatland Atlantic White Cedar Forests in natural condition have at least marginal dominance of the canopy by *Chamaecyparis thyoides*. Many stands, apparently more in the past, are nearly pure, with few other trees present. Some remnant stands, including some affected by blowdown or that regenerated poorly after past logging, may have a lower proportion and lower cover, and some stands may be naturally more mixed. *Acer rubrum* and *Nyssa biflora* are canopy associates with high constancy, which sometimes are codominant. *Pinus taeda, Pinus serotina*, and *Gordonia lasianthus* have fairly high frequency in CVS plot data and may also be abundant. The understory is usually dominated by *Persea palustris*, while *Magnolia virginiana* and *Acer rubrum* occur with high constancy. *Nyssa biflora* is frequent and *Ilex opaca* is occasional. The shrub layer is usually dense. *Lyonia lucida, Clethra alnifolia*, and *Ilex coriacea* have high constancy and sometimes dominate. *Ilex glabra* and *Cyrilla racemiflora* also are frequent and sometimes dominate. Other shrubs may include *Vaccinium formosum, Itea virginica, Eubotrys racemosus, Leucothoe axillaris*, *Morella cerifera*, and *Ilex laevigata*. Though not well represented in plots, *Vaccinium fuscatum, Morella caroliniensis*, and *Viburnum nudum* also occur occasionally in site descriptions. Among vines, *Smilax laurifolia* is present with high constancy and sometimes high abundance. Other vines fairly frequent in plot data include *Toxicodendron radicans, Parthenocissus quinquefolia, Gelsemium sempervirens*, and *Muscadinia rotundifolia*. Herbs are minor in this community. *Sphagnum* spp. is frequent and sometimes abundant, while *Anchistea virginica, Lorinseria areolata, Osmundastrum cinnamomeum*, and *Osmunda spectabilis* are also frequent. Other species occasionally present include *Dryopteris celsa*, *Peltandra virginica,* and *Peltandra sagittifolia*. Unpublished transect data in white cedar forests by Lee Otte around 1982 show similar composition and structure.

Range and Abundance: Ranked G2. The high global imperilment is partly due to high threat as well as to rarity. Approximately 40 occurrences are known in North Carolina. Many are much smaller than they were even several decades ago, and vast areas were lost in the 1800s and early 1900s. Atlantic white cedar lumber is valuable, and the forests are sought for logging. Because of their distinct dynamics and dependence on fire for natural regeneration, most logged areas do not regenerate in the species. Where steps are taken to regenerate the species, they involve intensive site preparation or broadcast herbicide use, leaving little natural character to the resulting vegetation. Natural occurrences also may fail to regenerate naturally after blowdowns or may gradually succeed to hardwood dominance.

The association is attributed to Virginia and Maryland, and questionably to South Carolina, but North Carolina appears to have the bulk of it, both at present and in the past.

Associations and Patterns: Peatland Atlantic White Cedar Forests are large patch communities, with patches of tens to hundreds of acres and a few clusters of thousands of acres. While occurrences in drowned river valleys, in Carolina bays, and on river terraces are naturally bounded and would have always been large patch communities, historical records suggest those in large peatlands were once matrix communities covering thousands of acres.

The different variants defined below have different natural associations. Because of this, Peatland Atlantic White Cedar Forests may be naturally associated with a wide variety of different natural communities, including Nonriverine Swamp Forest, Pond Pine Woodland, Bay Forest, Tidal Swamp, Blackwater Bottomland Hardwoods, Wet Pine Flatwoods, or other upland communities.

Variation: Two patterns of variation may be tentatively recognized among Peatland Atlantic White Cedar Forests, and both can be used as a basis for defining variants. Though not well studied, the different environmental settings seem likely to have different dynamics and potentially differences in fauna and flora. In addition, as suggested in earlier drafts of the 4th Approximation, at least among examples in large peatlands, variation may be recognized among associated tree and shrub species.

1. Peatland Swamp Variant occurs on large peatlands. Associated species are primarily those of Nonriverine Swamp Forest: *Nyssa biflora, Acer rubrum, Taxodium distichum*, and *Pinus taeda*. This variant once covered much larger areas of the landscape in places such as the Dare County mainland and the Great Dismal Swamp.

2. Peatland Pocosin Variant occurs on large peatlands but has associated species more typical of Pond Pine Woodland, primarily *Pinus serotina* and *Gordonia lasianthus*. It is unclear how extensive it was in the large peatlands. It may have occurred primarily in the transition to more extensive pocosins.

3. Tidal River Variant occurs on small, elevated patches in peat-filled drowned river valleys. It is normally surrounded by Tidal Swamp and presumably had little exposure to fire. It is unclear how the dynamics of catastrophic fire for stand regeneration could have occurred naturally there.

4. Carolina Bay Variant occurs in Carolina bays and other similar shallow depressions, farther inland. It may interact with a mosaic of peatland communities similarly to the Peatland Variant but exists in closer association with frequently burned uplands.

5. River Terrace Variant occurs on high terraces of rivers such as the Lumber River, Juniper Creek, and Northeast Cape Fear. Soils are less organic, patches are surrounded by upland or floodplain communities, and though they are believed not to have significant flooding, they may flood in the most extreme events.

Dynamics: Peatland Atlantic White Cedar Forests are believed to have tree dynamics unique among North Carolina forests. The high value of white cedar lumber, widespread logging, and variable regeneration led to early elucidation of these characteristics in forestry studies and publications such as Korstian (1924), Korstian and Brush (1931), Buell and Cain (1943), and Wells (1942). Later ecologists have elaborated on some aspects but report a similar picture (Kologiski 1977; Christensen 1981; Christensen 1988; Frost 1989; Moore and Carter 1987; Laderman 1989). *Chamaecyparis thyoides* is recognized as an extreme example of an early successional species, requiring high light levels and limited competition to establish, having prolific seed output capable of remaining viable in the soil, and readily regenerating in dense, often monospecific, even-aged stands after severe disturbance under the right conditions. The species is relatively short-lived, and stands are particularly susceptible to severe disturbance; the emphasis has been on catastrophic fire, but recent observations show that they are also very sensitive to wind throw in hurricanes. The right conditions for regeneration include removal of the dense shrubs that usually occur in these communities, as well as competing understory trees. Thus, stands regenerate best with a fire that kills the canopy, removes competing trees and shrubs, but with limited consumption of the surface organic matter where the seed bank resides. Unlike many early successional trees, *Chamaecyparis* seeds do not seem to disperse widely, so regeneration is dependent on the seed bank. Deeper burning during drought, which consumes the seed bank and can lower the organic ground surface, favors regeneration by *Pinus serotina*. Logging without control of the shrubs often leads to failure of regeneration and capture of sites by associated hardwoods, or may alternatively lead to shrubby vegetation without appreciable tree regeneration. Burning that is too frequent might lead to dominance of pocosin shrubs or *Arundinaria tecta*. Absence of any fire before senescence of the *Chamaecyparis* would lead to dominance by understory hardwoods, whether *Acer rubrum* and *Nyssa biflora* or *Gordonia lasianthus*, *Magnolia virginiana*, and *Persea palustris*. Likewise, a fire that kills a stand of *Pinus serotina*, *Nyssa biflora*, *Acer rubrum*, or other trees and reduces shrub cover may lead to establishment of a new stand of *Chamaecyparis* in places where some seed bank or seed source remains.

Because there are multiple possible outcomes following natural disturbances as well as logging of Peatland Atlantic White Cedar Forest, there is widespread belief that several communities could naturally have existed as a shifting mosaic in large peatlands. Pond Pine Woodland, Nonriverine Swamp Forest, Bay Forest, perhaps Peatland Canebrake, along with Peatland Atlantic White Cedar Forest might develop in a given patch, and any might follow another, depending on the occurrence or absence of particular kinds of fires. However, given the longevity and resilience of the dominant species and the limited dispersal of *Chamaecyparis*, *Arundinaria*, and perhaps *Taxodium*, it is unclear how readily communities could have shifted. Certainly, there is little evidence for new communities appearing in different places at present, beyond the replacement of white cedar by successional hardwoods. It may be more plausible that each community existed in areas where the chronic disturbance regime was best suited for it and that shifts were limited to expansion and contraction along the edges, perhaps in response to climatic cycles.

Despite the apparently exacting conditions required for establishment of *Chamaecyparis* stands, historical records and tallies of lumber harvested indicate that they were numerous and extensive in some large peatlands such as the Dare County peninsula and the Great Dismal Swamp. Current conditions, including exclusion of controllable wildfires, continued occurrence of uncontrollable wildfires during droughts, and limited prescribed burning in peatlands, along with continued widespread logging, have led to drastic declines in the abundance and extent of Peatland Atlantic White Cedar Forest.

Many aspects of this picture can be readily observed in remaining occurrences and in recently logged areas. However, some of these patterns may not be universal. Fire-scarred individuals may occasionally be seen, suggesting intolerance of fire is not absolute. Competing hardwoods sprout readily after most fires and are unlikely to be removed by a single one. The deep piles of logs in the soil of many forests may result from windthrow rather than from fire; in any case, they indicate that *Chamaecyparis* can at times regenerate in conditions other than bare ground. The existence of *Chamaecyparis* in mixed forest communities, including Nonriverine Swamp Forest (Mixed Subtype) and Blackwater Bottomland Hardwoods (Evergreen Subtype), indicates that there is an alternative strategy with which this species can also succeed. They can include trees of the same apparent age as other canopy trees, and young individuals can be seen in canopy gaps. Some settings where Peatland Atlantic White Cedar Forest occurs, especially those in peat-filled river valleys surrounded by Tidal Swamp, in places unlikely to attract human ignition, appear very unlikely to burn and probably established their dense even-aged stands by some other process. Additional study is needed to clarify how these mechanisms work.

Nevertheless, it remains clear that the largest acreage of Peatland Atlantic White Cedar Forest likely depended on fire, that it has declined greatly in the absence of fire, and that the amount has declined greatly with each round of logging.

Comments: While the equivalent NVC association ranges northward to Maryland, other *Chamaecyparis* communities that share some characteristics occur farther north, with extensive communities once present in New Jersey and some in New England. The species also occurs southward to Florida, but southern occurrences appear more similar to North Carolina's Streamhead Atlantic White Cedar Forest community.

Peatland Atlantic White Cedar Forest is an exception to the general limited study of communities in the Coastal Plain Nonalluvial Wetland Forests theme. The literature cited here is a sampling of that produced in recent years. Additional studies in North Carolina have focused especially on methods for regenerating *Chamaecyparis* after harvest, on the physiology of the species, and other topics. A series of published proceedings of symposia on management, ecology, and restoration of the species attest to the attest to the breadth of recent interest.

While Peatland Atlantic White Cedar Forest, and *Chamaecyparis thyoides* in general, is known to have declined drastically in historical time, there is evidence for changes in its distribution farther in the past. Multiple authors and literature reviewed by Laderman (1989) describe finding of abundant cedar logs buried in peat in areas that are now pocosins or other communities, indicating that these areas once supported forests of this species. Depths and ages of these logs are generally not given, and these observations have led to some belief that the historic loss is even larger than known. However, these buried logs likely are sub-fossil material, at least thousands of years old. Logs of *Taxodium* also are often found buried beneath pocosins, and the abundance of these two species in peat may reflect their decay resistance rather than overwhelming abundance. It is likely that the conversion of these former forests to pocosin was a result of paludification or to effects of ongoing rising water tables related to rising sea level in more distant prehistoric times.

The Peatland Atlantic White Cedar Forest community was formerly placed in the Peatland Pocosins theme. It was moved to Coastal Plain Nonalluvial Wetland Forests theme early in development of the 4th Approximation. It shares affinities with both themes and may be associated with both. However, its greatest affinities and most common association now appears to be with Nonriverine Swamp Forest (Mixed Subtype).

In addition to the rare species listed below, there is an additional suite of several possibly rare Lepidoptera specialized on *Chamaecyparis* on the NHP Watch List.

Rare species:
Vascular plants – *Lindera subcoriacea.*
Vertebrate animals – *Setophaga* (*Dendroica*) *virens waynei* and *Sistrurus miliarius miliarius*.
Invertebrate animals – *Callophrys hesseli,* and *Hypagyrtis brendae*.

PEATLAND POCOSINS THEME

Concept: Peatland Pocosins are saturated wetlands of Coastal Plain flats, swales, and Carolina bays, with organic matter accumulation (Histosols or histic surface layers), and with distinctive vegetation characterized by *Pinus serotina* and a suite of shrub species. Most but not all of the pocosin shrub suite is evergreen and is in the Ericaceae. Vegetation structure ranges from woodlands or nearly closed forests to dense shrublands to treeless herb-dwarf shrub vegetation, with each structure sharing most of these species.

Distinguishing Features: Peatland Pocosins are distinguished by the above combination of characters. The suite of characteristic pocosin species consists of *Lyonia lucida, Ilex glabra, Ilex coriacea, Zenobia pulverulenta, Cyrilla racemiflora,* and *Chamaedaphne calyculata*, along with the vine *Smilax laurifolia*, and the trees *Pinus serotina, Gordonia lasianthus, Magnolia virginiana*, and *Persea palustris*. A couple of communities are dominated by *Arundinaria tecta*. Some combination of this suite dominates, most species are usually present, and few additional woody species are present. A few other communities share dominance by these species but occur in different environmental settings and have additional species characteristic. The most closely related theme, Streamhead Pocosins, shares much of the flora but occurs in seepage-fed drainages in sandhill terrain rather than on flats or in large basins. *Liriodendron tulipifera* and *Toxicodendron vernix* are additional characteristic species in that theme. Several Coastal Plain Small Depression communities share many species but occur in small depressions with an influence of surface water flooding and have some additional species such as *Nyssa biflora, Taxodium ascendens*, and several deciduous shrubs. Coastal Plain Nonalluvial Wetland Forests share some of the species but are dominated by different trees and usually have additional shrub and herb species. Wet Pine Savanna communities may be invaded by pocosin shrubs with the long absence of fire, and in the most extreme cases may be difficult to distinguish, but savannas will have mineral soils and generally will have a least a few remnants of savanna species.

Within the theme, communities are distinguished by variation in typical vegetation structure, which reflects a gradient of wetness and peat depth. Variations in vegetational composition also distinguishes some types and subtypes. Pocosin Opening and Low Pocosin communities occur on the deepest peats, have shrub layers a meter or less tall, and have only sparse, stunted trees. High Pocosins occur on shallower peats, have shrub layers up to 2 meters tall, and can support somewhat larger and denser trees. Pond Pine Woodlands occur on even shallower organic deposits and have well-developed tree canopies of *Pinus serotina* and *Gordonia lasianthus*, while Bay Forests have well-developed canopies of *Gordonia, Magnolia virginiana*, and *Persea palustris* without appreciable pine. Peatland Canebrake is distinguished by a largely treeless bed of *Arundinaria tecta* in a peatland setting.

Sites: Peatland Pocosins occur on broad interstream flats in the outer Coastal Plain, in large Carolina bays, and in swales in relict dune fields with low relief – poorly drained settings where organic matter has accumulated. The most extensive pocosins are domed peatlands believed to be produced by paludification.

Soils: Examples occur on Histosols that range to peats several meters deep. On the less extreme end of the range are soils with organic-rich umbric horizons, such Murville (Umbric Endoaquod).

In the shallower organic deposits, plant roots are able to reach the mineral horizons beneath, while in the deeper they are not. All soils are extremely acidic, poor in nutrients, and apparently have nutrients immobilized in organic matter due to inhibited decomposition. Hungerford and Ryan (1988) studied soil structure and found hummocks to be an important part of soil structure and a large pool of soil carbon.

Hydrology: Sites are saturated but do not have standing water other than very locally. They receive minimal or no flowing water input from mineral soil areas. The centers of domed peatlands receive water only from rainfall; edges of domed peatlands also receive water by sheet flow from the peat at the center. The lower layers of organic matter have low hydraulic conductivity (Daniels et al. 1977), limiting downward movement of water even as water moves freely through less compact upper layers. Water tables may thus be perched, and water is also retained by the high water-holding-capacity of peat. Examples in swales may also be affected by a seasonal high water table. Water in natural sites exits through sheet flow.

Vegetation: Vegetation is characterized by a dense shrub layer consisting of *Lyonia lucida, Ilex glabra, Ilex coriacea, Zenobia pulverulenta, Cyrilla racemiflora, Chamaedaphne calyculata*, *Persea palustris, Magnolia virginiana,* and *Gordonia lasianthus,* rarely *Arundinaria tecta* or *Vaccinium macrocarpon*, along with the vine *Smilax laurifolia*. It is typically nearly impenetrable. The shrub layer may be up to 2-3 meters tall or may be a meter or less tall in deeper peats. Tree canopy structure can vary widely with peat depth; the canopy usually is dominated by *Pinus serotina*, alone or with *Gordonia lasianthus*, but may be dominated by *Gordonia* with *Magnolia virginiana* and *Persea palustris*. *Acer rubrum* var. *trilobum* may invade in the long absence of fire, but no other trees are commonly present. Characteristic herbaceous species are *Anchistea virginica*, *Carex striata*, *Andropogon glomeratus, Sarracenia flava, Sarracenia purpurea*, and *Sphagnum* spp. These species may be abundant in Pocosin Opening communities, but otherwise all herbs are sparse. *Andropogon* spp. may be abundant immediately after fire or mechanical disturbance.

Dynamics: Pocosins are naturally influenced by occasional catastrophic fires. Fires are infrequent because the leaf litter is normally saturated and will not burn, and the green vegetation normally is not very flammable. Many of the pocosin shrub species are known to be volatile and to burn more readily when wax-covered fresh leaves have emerged in the spring. Nevertheless, the frequent fires burning in adjacent longleaf pine communities generally do not ignite pocosins, and fire will not carry far through the vegetation at most times.

In times of drought, however, plants, leaf litter, and surface peat dry and become flammable. When fires occur, they are intense and uncontrollable, generally killing most or all the above-ground vegetation, often consuming all but the trees and larger stems of shrubs. Peat may ignite locally and smolder for weeks or months. In areas with artificial drainage, peat may burn more extensively and a foot or two of material may be lost. Ignition and sustained burning of peat depend on complex relationships of moisture content, bulk density, and mineral content (Reardon et al. 2007). Hummocks may be an important factor in igniting peat since they are drier and less compact and, once ignited, fire can spread to deeper layers.

Pocosin vegetation is well adapted to recovering from catastrophic fire. *Pinus serotina* is able to survive and recover from fires severe enough to kill all its branches, producing new twigs and needles through epicormic sprouting. It has serotinous cones that store seeds on the tree for several years and release them when heated; it thus can establish seedlings on newly burned surfaces. All of the characteristic shrubs, hardwoods, vines, and herbs sprout vigorously after being top killed. Christensen et al. (1981) reported that a burned pocosin regained 20% of its prefire biomass in the first growing season. They reported that some species, such as *Zenobia* and various herbs, recover particularly quickly and dominate for several years after a fire, until they are out-competed by *Lyonia.* Species diversity is generally highest right after a fire and declines gradually. Pocosin vegetation can be observed to be back to its characteristic height and density just a few years after a fire. As time since fire increases, an increasing load of dead twigs and vines can be found on the standing shrubs. This presumably increases the flammability of the vegetation.

Where fire burns into the peat deeply enough to kill the roots of shrubs, a long-lasting wet basin may form. Deep peat burn patches are widely believed to be the origin of the patches of Pocosin Opening communities. These depressions are presumed to slowly fill with organic matter until they can support Low Pocosin shrubland vegetation. These particular communities may therefore form a shifting mosaic over time. However, in observing a number of pocosins that have had intense fires, the author has not seen an increase in Pocosin Openings and their associated plants after fire. Most deeper peat burning occurred in peripheral areas near drainage ditches rather than in the Low Pocosin interior where most Pocosin Opening patches occur.

As is characteristic of bogs, pocosins are limited not just by wetness but by extremely low availability of plant nutrients. Nutrients are not released by decomposition, both because of the saturated soil and because of the high carbon and low nutrient content of most of the litter. Phosphorous has been found to be the limiting nutrient (Wilbur and Christensen 1983). The rapid growth following fire presumably is because of the sudden release of phosphorous and other nutrients in the ash. In pocosins that contain it, *Zenobia pulverulenta* often grows particularly quickly after a fire and dominates the vegetation for a time. In a few years, the taller but slower growing shrubs such as *Lyonia lucida* overtop it. Simms (1987) demonstrated experimentally that *Zenobia pulverulenta* is better able to respond to addition of nutrients with increased growth.

Otte (1981) described the longer-term dynamics of the large pocosin complexes, inferred from peat sampling. Most peatlands originated in blocked drainage systems, which are indicated by channel-like bands of deeper peat. Through paludification, the organic layer thickened and spread out from the channel across the flat uplands; some even spread across drainage divides. Peat accumulation, and presumably the blockage, began 10,000-12,000 years ago. Sea level was about 25 meters lower then, and the coast was distant enough that coastal processes probably were not involved. The cause of blockage is unknown, but channels appear to end at areas of sandy sediment, so sand movement may have been involved. Most peat deposits started as herbaceous marsh, and changed to cypress or white cedar swamp, leaving numerous logs in the peat. Shrubby pocosin vegetation developed relatively late in the accumulation of most peatlands, though still presumably millennia ago and apparently driven by natural causes. Otte also indicated that peatland pocosins were still expanding, peat deepening, and thus central pocosin vegetation getting lower at present, or at least they were until artificial drainage and soil disruption at the edges put an end to the process.

Otte (1981) mentioned the possibility of secondary pocosins -- pocosin shrub vegetation that has developed in historical times after swamp forest was logged and was unable to regenerate. This may be possible because the loss of evapotranspiration would increase the wetness after logging. However, he also noted that peatland swamp forests occurred on peats with higher mineral content, especially clay, and in places where some overland flow brought nutrients into the site, rather than being indistinguishable from pocosin sites. Historical records sometimes cited to support the idea of recently developed, anthropogenic pocosins lack specific locations and details. As an example, a large volume of timber was removed from the Green Swamp, a place where conservation lands are now dominated by pocosin vegetation. However, the area known as the Green Swamp was much larger and most of it had different soils. It is likely that swamp forests on other soils were logged and converted, while pocosin that existed at the time of logging was ignored in descriptions because it lacked merchantable timber. The treeless pocosin is the only part of the former vast Green Swamp that lacks logging roads. This pattern is typical of peatlands, where logging roads are in the forested peripheral portions while the treeless interior is roadless and could not have been accessed for logging. Though local areas of Pond Pine Woodland may not regenerate following logging and may remain shrub-dominated for years, this does not appear to be the origin of large open pocosins.

Frost (2000) suggested it was likely there was short vegetation resembling Low Pocosin on shallower peats, kept low by frequent fire. Given the greater frequency of fire in the past, this is possible. Wells (1946) also thought that a fire interval of 4-6 years would keep shrubs low, while not allowing *Zenobia* to become dominant. However, no existing Peatland Pocosin vegetation appears to behave in this way at present. Pocosin vegetation seems to need time to become flammable after fires, and all but the canebrakes seem to be incapable of burning frequently.

There is a more general concept of a potential long-term shifting mosaic of communities on shallow organic soils. Pond Pine Woodland, Bay Forest, Peatland Atlantic White Cedar Forest, Nonriverine Swamp Forest, Peatland Canebrake, even High Pocosin and Low Pocosin, are suggested to be results of different disturbance histories, with an implication that their sites could readily become any of the other communities. Various sources describe bay forests as an end stage of succession for Peatland Atlantic White Cedar Forest, Pond Pine Woodland, or shrubby pocosins with the long absence of fire (Buell and Cain 1943; Kologiski 1977). Christensen (1988) suggests that shallow peat burns may allow either *Chamaecyparis* or *Pinus serotina* establishment. This appears reasonable, but evidence is hard to find. These two species generally do not coexist in a range of proportions, and the author has not observed any examples of conversion in areas burned either by prescribed fires or wildfires. Landscape patterns of existing occurrences do not resemble patch mosaics but look more like zonation based on site characteristics. Those site factors may include chronic disturbance regimes, influenced by natural fire breaks or connections to more flammable vegetation, but are less likely to change over time. However, disturbance history has more potential to influence communities in transitional areas, potentially shifting boundaries over time.

Comments: The primary terminology and concepts of types used here follow Otte (1981) and are little changed from those published in Weakley and Schafale (1991). A competing terminology of "tall pocosin" and "short pocosin," not used, is based on the same gradient of peat depth and vegetation stature. Otte (1981) made extensive observations of vegetation as well as site conditions while sampling peat in pocosins. Despite its never being formally published, this work has been widely cited. Except where noted, I have corroborated most of his observations of the patterns of Low Pocosin, High Pocosin, and Pond Pine Woodland. Though using other terminology, Snyder (1980), Wells (1946), and Dachnowski-Stokes and Wells (1929) noted similar patterns. Pocosins are often called evergreen shrub bogs in literature, but as Christensen et al. (1981) noted, some are dominated by deciduous species.

Descriptions of pocosins in literature are often confusing, partly because of different uses of terminology and partly because of confusion of boundaries by alterations such as logging and fire exclusion. The term "bay forest" has been used in a variety of ways, many of which are much broader than used here. With long absence of fire, pocosin shrubs spread into adjacent longleaf pine communities. The difficulty of penetrating pocosin sometimes leads to samples being taken in uncharacteristic areas on the edges. Many of the CVS plots, for example, contain species not characteristic of well-developed pocosins. Christensen et al. (1981) even mention *Pinus palustris* as potentially present in pocosins, but this species requires mineral soil to germinate. It would be present only in overgrown mineral soil edges that have come to deceptively resemble pocosins.

The linking of canebrakes to pocosins is somewhat uncertain. Westward, "canebrake" refers to stands of *Arundinaria gigantea* in large river bottoms. Eastern and central North Carolina contain only *Arundinaria tecta*. In the Coastal Plain of North Carolina, despite the presence of *Arundinaria* along rivers, the definitive historical references to canebrakes appear to have been associated with extensive organic-soil wetlands. Most of the few remnants are associated with pocosins. However, the best documented historical canebrake, The Green Sea, appears associated with Coastal Plain Nonalluvial Wetlands and other examples may also have been. Bay Forest too is sometimes associated with Nonalluvial Wetlands rather than with other Peatland Pocosin communities.

KEY TO PEATLAND POCOSINS

1. Vegetation with substantial tree cover, more than 25% cover when not recently burned and under normal conditions; trees not greatly stunted; occurring on shallow organic layers or on peats with higher mineral content
  2. Canopy dominated by evergreen hardwoods: *Gordonia lasianthus, Magnolia virginiana*, and *Persea palustris*. *Pinus serotina*, if present, not codominant. .... **Bay Forest**
  2. Canopy dominated by *Pinus serotina*, sometimes with *Gordonia lasianthus* codominant and equal in abundance. *Magnolia* and *Persea* present in smaller amounts and generally not in the canopy.
    3. Shrub layer dominated by *Arundinaria tecta*. Broadleaf shrubs a small minority, but may increase with time since fire. .... **Pond Pine Woodland (Canebrake Subtype)**
    3. Shrub layer dominated by broadleaf evergreen shrubs.
      4. Located north of Albemarle Sound; shrub layer always lacking *Cyrilla racemiflora*;....... .... **Pond Pine Woodland (Northern Subtype)**
      4. Located south of Albemarle Sound; shrub layer usually with *Cyrilla racemiflora*............ .... **Pond Pine Woodland (Typic Subtype)**
1. Vegetation without substantial tree cover, persistently less than 25% cover even when not recently burned; trees, if present, substantially stunted, usually of much smaller size than the same species reach in other communities; occurring on deeper organic layers with low mineral content (or shallow peat in Peatland Canebrake).
  5. Shrub layer dominated by *Arundinaria tecta*; broadleaf shrubs a minority, but may increase with time since fire... **Peatland Canebrake**
  5. *Arundinaria tecta* not dominant; generally absent but may be present as a minor component.
    6. Shrub layer persistently shorter than 1.5 meters tall over most of its area (small taller patches may be interspersed); peat generally deeper than 1.5 meters and very low in mineral content.
      7. Shrub layer dominated by upright shrubs, generally *Zenobia pulverulenta, Cyrilla racemiflora, Lyonia lucida*, or *Ilex glabra*.
        8. Shrub layer with a large component of *Cyrilla racemiflora*, in addition to *Zenobia, Lyonia lucida*, and *Ilex glabra*; located in the outer Coastal Plain south of the Neuse River .... **Low Pocosin (Titi Subtype)**
        8. Shrub layer lacking *Cyrilla racemiflora*, dominated by *Zenobia, Lyonia*, or *Ilex*; located in the middle or inner Coastal Plain or in the outer Coastal Plain north of the Neuse River. .... **Low Pocosin (Gallberry—Fetterbush Subtype)**
      7. Shrub layer dominated by trailing shrubs, primarily *Chamaedaphne calyculata* or *Vaccinium macrocarpon*; upright shrubs present in smaller amounts.
        9. Community containing significant amounts of *Vaccinium macrocarpon*, though not necessarily dominant.. **Pocosin Opening (Cranberry Subtype)**
        9. Community lacking *Vaccinium macrocarpon*.
          10. Community containing significant amounts of *Sarracenia* spp., though other herbs may have more cover .... **Pocosin Opening (Pitcher Plant Subtype)**
          10. Community lacking *Sarracenia* spp., or having less than 1% cover of them; *Anchistea virginica*, *Carex striata*, and other herbs dominate .... …………………………………………… **Pocosin Opening (Sedge-Fern Subtype)**

6. Shrub layer generally taller than 1.5 meters over most of the community, unless recently burned; trees stunted but larger and more abundant; peats generally less than 1.5 meters deep, or with higher mineral content.

11. Shrub layer dominated by evergreen shrubs, generally *Lyonia lucida, Cyrilla racemiflora, Ilex glabra*, or *Ilex coriacea*......................**High Pocosin (Evergreen Subtype)**

11. Shrub layer dominated by deciduous shrubs, generally *Zenobia pulverulenta, Vaccinium* spp., or *Ilex laevigata*.. **High Pocosin (Deciduous Subtype)**

LOW POCOSIN (GALLBERRY–FETTERBUSH SUBTYPE)

Concept: Low Pocosins are communities of short upright shrubs on the deepest peats, with a prevailing shrub height of less than 1.5 meters tall in the absence of fire, due to low fertility and wetness. Most occur in the centers of domed peatlands, but they may also occur in Carolina bays or smaller peat basins. The Gallberry–Fetterbush Subtype covers the more northern and more inland examples, in which *Cyrilla racemiflora* is absent or only a minor component. *Lyonia lucida*, *Ilex glabra*, and *Zenobia pulverulenta* generally dominate.

Distinguishing Features: Low Pocosins are distinguished from most other pocosin communities by a shrub layer persistently less than 1.5 meters tall, consisting of upright broadleaf shrubs. Most Low Pocosins do contain patches of taller shrubs and scattered, stunted *Pinus serotina*, but these are a minor part of the area. Peatland Canebrakes have *Arundinaria tecta* shrub layers rather than broadleaf shrubs, while Pocosin Opening communities have trailing shrubs (*Chamaedaphne calyculata*) and herbs dominating. High Pocosin and Pond Pine Woodland may have shrubs less than 1.5 meters tall for a few years after a fire, but evidence of prevalence of taller shrubs before the fire, along with larger pines, distinguish them. The transition to High Pocosin sometimes occurs as an increase in abundance of tall shrub patches so that the average vegetation height increases, but more often occurs with a gradual increase in prevailing shrub height.

The Gallberry–Fetterbush Subtype is distinguished from the Titi Subtype by the absence of *Cyrilla racemiflora* and corresponding geographic location. *Cyrilla racemiflora* may be present in nearby Pond Pine Woodland communities or even in scattered tall shrub patches, but is scarce or absent within the Low Pocosin itself.

Crosswalks: *Ilex glabra - Lyonia lucida - Zenobia pulverulenta* Wet Shrubland (CEGL003944).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).
Short pocosin (general usage).

Sites: Low Pocosins generally occur in the central, deepest parts of domed peatlands on poorly drained interstream flats, but also occur in peat-filled Carolina bays and deep peat-filled swales. Peat deposits tend to be greater than 1 meter deep, sometimes 3-4 meters deep. The Gallberry–Fetterbush Subtype occurs in more northern and more inland locations.

Soils: Soils are Histosols, most typically Dare (Typic Haplosaprist), sometimes Croatan or Pamlico (Terric Haplosaprist).

Hydrology: Sites are saturated all year in all but drought periods. The peat generally is deep and saturated enough that plant roots never reach mineral soil (Otte 1981). However, during droughts, the peat may dry out enough to burn. Most Low Pocosins occupy the centers of domed peatlands, are higher than the surrounding lands, and have no surface or ground water draining into them, making them truly ombrotrophic. A number of examples occur in the interior of Carolina bays. It is less clear if these are ombrotrophic, but it is likely that they are.

Vegetation: Low Pocosin vegetation is a short shrubland, with the prevailing shrub height less than 1.5 meters tall even in the absence of recent fire. The shrub layer in the Gallberry-Fetterbush Subtype is dominated by combinations of *Lyonia lucida, Ilex glabra,* or *Zenobia pulverulenta*. *Smilax laurifolia* is often prominent, draping over the shrubs. In shorter or less dense areas, *Chamaedaphne calyculata* is often abundant, and *Vaccinium crassifolium*, occasionally *Vaccinium macrocarpon,* may occur. Other shrubs that may be abundant in some examples, but are less constant, include *Persea palustris, Ilex coriacea*, *Kalmia carolina*, *Kalmia cuneata*, *Aronia arbutifolia*, *Vaccinium fuscatum, Vaccinium formosum*, and *Morella caroliniana*. *Pinus serotina* is present as very stunted, scattered individuals. *Persea palustris*, *Magnolia virginiana*, and occasionally *Gordonia lasianthus* are similarly present as small trees or shrubs. The trees often occur in scattered patches a few meters across, where shrubs are also taller. *Sphagnum* spp. may be fairly abundant. Most herbs are in associated Pocosin Opening patches, but *Carex striata* and *Anchistea virginica* may be abundant in places in Low Pocosin. *Sarracenia flava*, *Sarracenia purpurea*, and other herbs of Pocosin Openings may be present in small numbers. *Andropogon glomeratus* is often abundant shortly after fires.

Low Pocosins often contain small patches of taller vegetation dotted through the area. These typically are dominated by the taller dominant shrub species and are more likely to contain *Pinus serotina*.

Range and Abundance: Ranked G2. Low Pocosins represent the extreme of peatland development. There are many fewer occurrences than High Pocosins or Pond Pine Woodlands. However, where they occur, they often are very extensive, some occupying multiple square miles. A few examples are at low enough elevation to be affected by rising sea level in next century.

In North Carolina, the Gallberry–Fetterbush Subtype occurs in more inland Carolina bays, such as those of Bladen and Cumberland counties, and in more northerly peatlands. It makes up most or all of the Low Pocosins north of the Neuse River. The equivalent association is reported to be in South Carolina, in Francis Marion National Forest. This pattern deserves further investigation, given its contrast with the more northern and inland distribution in North Carolina. Most examples and an even larger fraction of the acreage of this community occurs in North Carolina.

Associations and Patterns: Low Pocosins are large patch communities. They may occupy large areas but do not form a typical repeated part of the landscape. However, they might be regarded as matrix communities in deep peatlands, where patches are very large. They often occur in a fine-scale mosaic with Pocosin Opening communities. Low Pocosins and Pocosin Openings occur in the central parts of peatlands, those areas that are raised above their surroundings or are most isolated from bay rims, and thus are most completely ombrotrophic. They grade to High Pocosin toward the edge, where peats are shallower.

Variation: No variants are named. Stature of vegetation increases with decreasing peat depth. Dominance, stature, and diversity also vary with time since fire. A distinctive version of vegetation in Bushy Lake may warrant recognition as a variant, or even a subtype, but needs more investigation.

Dynamics: Low Pocosins, along with Pocosin Openings, are the most nutrient-poor pocosin communities. The low stature of the vegetation results from extreme nutrient limitation as well as wetness. Because they are on the highest parts of domed peatlands, they may not be the wettest sites. Most of the species will grow taller in other communities, and Low Pocosin communities that are drained or fertilized lose their characteristic short vegetation.

Most Low Pocosins contain interspersed patches of taller vegetation a few meters across, where most of the trees occur and where shrubs are also taller. They are often striking on aerial photos, where they appear to be regularly distributed. The origin and dynamics of these patches are not well known. They have less compact peat because of the structure provided by the tree roots, and they appear to be slightly raised. They thus represent slightly more favorable microsites. They may grow in a kind of feedback process, with greater productivity increasing accumulation of organic matter. It has been suggested that, being raised and less compact, they are more prone to ignition of the peat, which presumably would destroy them when it occurred.

Comments: Pocosins are difficult to characterize with vegetation plots. The interior of peatlands, where Low Pocosin communities occur, is particularly difficult to access. Of the relatively few plots that have been sampled, many are in marginal or uncharacteristic areas. Many contain species not found in the interior of Low Pocosins. However, presumably because of their openness, Low Pocosins do sometimes contain unexpected species considered more characteristic of mineral soil, such as *Vaccinium crassifolium* or *Lysimachia asperulifolia*.

The relationship between the Gallberry–Fetterbush Subtype and Titi Subtype needs further investigation. In North Carolina, they seem to have fairly distinct geographic ranges, and it is presumed that something about latitude or climate would be responsible. However, *Cyrilla racemiflora* is present in other communities within the range of this subtype, so the mechanism would need to be something other than a simple range limit. The question is made more complex but the attribution of the association related to this subtype to South Carolina. If it is really the same community, it suggests some other factors are in play.

Rare species:
Vascular plants – *Lysimachia asperulifolia, Peltandra sagittifolia, Rhynchospora alba*, and *Vaccinium macrocarpon*.

Nonvascular plants – *Sphagnum fitzgeraldii.*

Invertebrate animals – *Hemipachnobia monochromatea*.

LOW POCOSIN (TITI SUBTYPE)

Concept: Low Pocosins are communities of short upright shrubs on the deepest peats, with a prevailing shrub height of less than 1.5 meters tall in the absence of fire, due to low fertility and wetness. The Titi Subtype covers more southern examples in which *Cyrilla racemiflora* is a major component along with *Zenobia pulverulenta*, *Lyonia lucida*, and *Ilex glabra*.

Distinguishing Features: Low Pocosins are distinguished from other pocosin communities by a shrub layer persistently less than 1.5 meters tall, consisting of upright broadleaf shrubs. Most Low Pocosins do contain patches of taller shrubs and scattered, stunted *Pinus serotina*, but these cover a minor part of the area. Peatland Canebrakes have *Arundinaria tecta* shrub layers rather than broadleaf shrubs, while Pocosin Opening communities have trailing shrubs (*Chamaedaphne calyculata*) and herbs dominating. High Pocosin and Pond Pine Woodland may have shrubs less than 1.5 meters tall for a few years after a fire, but evidence of prevalence of taller shrubs before the fire, along with larger pines, distinguish them. The transition to High Pocosin sometimes occurs as an increase in abundance of tall shrub patches so that the average vegetation height increases, but more often occurs with a gradual increase in prevailing shrub height.

The Gallberry–Fetterbush Subtype is distinguished from the Titi Subtype by the absence of *Cyrilla racemiflora* and corresponding geographic location.

Crosswalks: *Cyrilla racemiflora - Zenobia pulverulenta* Wet Shrubland (CEGL003943).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).
Short Pocosin (general usage).

Sites: Low Pocosins generally occur in the central, deepest parts of domed peatlands on poorly drained interstream flats, but also occur in peat-filled Carolina bays and deep peat-filled swales. Peat deposits tend to be greater than 1 meter deep, sometimes 3-4 meters deep. The Titi Subtype occurs in more southern outer Coastal Plain locations in North Carolina.

Soils: Soils are Histosols, most typically Dare (Typic Haplosaprist), sometimes Croatan or Pamlico (Terric Haplosaprist).

Hydrology: Sites are saturated all year in all but drought periods. The peat generally is deep and saturated enough that plant roots never reach mineral soil (Otte 1981). However, during droughts, the peat may dry out enough to burn. Most Low Pocosins occupy the centers of domed peatlands, are higher than the surrounding lands, and have no surface or ground water draining into them, making them ombrotrophic. A number of examples occur in the interior of Carolina bays. It is less clear if these are ombrotrophic, but it is likely that they are.

Vegetation: Low Pocosin vegetation is a short shrubland, with the prevailing shrub height less than 1.5 meters tall even in the absence of recent fire. The Titi Subtype shrub layer is dominated by combinations of *Cyrilla racemiflora, Lyonia lucida, Zenobia pulverulenta,* and *Ilex glabra*. *Smilax laurifolia* is often prominent, draping over the shrubs. In shorter or less dense areas, *Chamaedaphne calyculata* is often abundant, and *Vaccinium crassifolium* may occur. Other shrubs that may be abundant in some examples, but are less constant, include *Persea palustris, Gordonia lasianthus, Ilex coriacea*, *Kalmia carolina*, *Kalmia cuneata*, *Morella carolinensis,* and *Ilex coriacea*. Most herbs are in associated Pocosin Opening patches, but *Carex striata* and *Anchistea virginica* may be abundant in places. *Sarracenia flava*, *Sarracenia purpurea*, and other herbs of Pocosin Openings may be present in small numbers. *Andropogon glomeratus* is often abundant shortly after fires.

Low Pocosins often contain small patches of taller vegetation dotted through the area. These typically are dominated by the taller dominant shrub species and are more likely to contain *Pinus serotina*.

Range and Abundance: The equivalent association is ranked G2G3, but the community appears similar to the G2-ranked Gallberry–Fetterbush Subtype in abundance. Like it, this subtype is present only in the deepest peatlands, but often covers large expanses in the peatland interiors where it is present. In North Carolina, the Titi Subtype occurs in the outer Coastal Plain south of the Neuse River. The association is questionably attributed to South Carolina, but most, if not all, of it is in North Carolina.

Associations and Patterns: Low Pocosins are large patch communities. They may occupy large areas but do not form a typical repeated part of the landscape. However, they might be regarded as matrix communities in deep peatlands, where patches are very large. They often occur in a fine-scale mosaic with Pocosin Opening communities. Low Pocosins and Pocosin Openings occur in the central parts of peatlands, those areas that are raised above their surroundings or most isolated from bay rims, and thus are most completely ombrotrophic. They grade to High Pocosin toward the edge, where peats are shallower.

Variation: No variants are named. Stature of vegetation increases with decreasing peat depth. Dominance, stature, and diversity also vary with time since fire.

Dynamics: Low Pocosins are the most nutrient-poor pocosin communities. The low stature of the vegetation results from extreme nutrient limitation as well as wetness. Because they are on the highest parts of domed peatlands, they may not be wettest sites. Most of the species will grow taller in other communities, and Low Pocosin communities that are drained or fertilized lose their characteristic short vegetation.

As with the Gallberry–Fetterbush Subtype, most examples of this subtype contain interspersed patches of taller vegetation a few meters across, where most of the trees occur and where shrubs are also taller. They often appear striking on aerial photos, where they appear to be regularly distributed. The origin and dynamics of these patches are not well known.

Comments: Pocosins are difficult to characterize with vegetation plots. The interior of peatlands, where these communities occur, is particularly difficult to access. Of the relatively few plots that have been sampled, many are in marginal or uncharacteristic areas. Many contain species not found in the interior of Low Pocosins. However, presumably because of their openness, Low Pocosins do sometimes contain unexpected species considered more characteristic of mineral soil, such as *Vaccinium crassifolium* or *Lysimachia asperulifolia*.

The relationship between the Gallberry–Fetterbush Subtype and Titi Subtype needs further investigation. In North Carolina, they seem to have fairly distinct geographic ranges, and it is presumed that something about latitude or climate would be responsible. However, *Cyrilla racemiflora* is present in other communities within the range of this subtype, so the mechanism would need to be something other than a simple range limit.

Rare species:
Vascular plants – *Lysimachia asperulifolia, Peltandra sagittifolia,* and *Rhynchospora alba.*

Invertebrate animals – *Hemipachnobia monochromatea*.

POCOSIN OPENING (SEDGE-FERN SUBTYPE)

Concept: Pocosin Openings are small patch communities of deep peats, with herbaceous or dwarf shrub dominance, occurring within a Low Pocosin or occasionally High Pocosin matrix. Individual patches are usually small but sometimes abundantly intermixed with Low Pocosin shrub vegetation. The Sedge–Fern Subtype covers the common openings, dominated by the species listed but lacking abundant *Vaccinium macrocarpon* or *Sarracenia* spp.

Distinguishing Features: Pocosin Openings are distinguished from Low Pocosins by the cover of *Chamaedaphne calyculata, Anchistea virginica, Carex striata*, *Sphagnum*, and other smaller plants persistently exceeding that of *Zenobia* and other taller shrubs. Recognition of Pocosin Opening communities is heavily dependent on the spatial scale. Patches are generally small and are always closely intermixed in a mosaic with Low Pocosin communities. While very small openings can exist in any community, the Pocosin Opening community should be recognized only where patches at least 10 meters across are present and where multiple patches add up to more than one acre.

The Sedge–Fern Subtype is distinguished by a lack of significant amounts of *Vaccinium macrocarpon* or *Sarracenia* spp.

Crosswalks: *Chamaedaphne calyculata / Carex striata var. striata - Woodwardia virginica* Wet Dwarf-shrubland (CEGL004163).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Pocosin Openings occur in the central, deepest parts of domed peatlands on poorly drained interstream flats, occasionally in peat-filled Carolina bays and deep peat-filled swales. They occur in local patches that are slightly lower and wetter than the surrounding pocosin. Peat deposits tend to be greater than 1 meter deep, sometimes 3-4 meters deep.

Soils: Soils are Histosols, most typically Dare (Typic Haplosaprist), sometimes Croatan or Pamlico (Terric Haplosaprists). This community may represent small inclusions in these soil series but would still be classified as Typic or Terric Haplosaprists.

Hydrology: Soils are typically saturated all year but may become dry in drought periods. They may hold shallow standing water seasonally. Conditions are at least somewhat wetter than in surrounding Low Pocosin communities. These communities most often occur in the centers of large peat domes, where they receive only rainwater input and are truly ombrotrophic. Examples in Carolina bays likely also are ombrotrophic.

Vegetation: Vegetation in the Sedge–Fern Subtype is dominated by dwarf shrubs and herbs, though stunted upright shrubs may also be a significant component. *Chamaedaphne calyculata* characteristically dominates. Other shrubs, particularly *Zenobia pulverulenta*, but also stunted *Cyrilla racemiflora, Lyonia lucida*, *Ilex glabra*, or *Persea palustris* are common. Most other shrubs of Low Pocosin may be present. *Smilax laurifolia* often forms a layer on top of the shrubs. *Sphagnum* spp., *Anchistea virginica*, and *Carex striata* are the dominant herbs. *Andropogon* *glomeratus* may be abundant, especially soon after fires. Other herbs present in small numbers or with low constancy may include *Sarracenia flava, Sarracenia purpurea* var. *venosa, Drosera intermedia*, *Rhynchospora chalarocephala, Rhynchospora fascicularis, Xyris fimbriata*, *Utricularia subulata*, other *Utricularia* species, *Peltandra sagittifolia*, and in a couple of sites, *Lysimachia asperulifolia*.

Range and Abundance: Ranked G1G2. This community apparently is endemic to North Carolina. The full abundance and range are not well known, though this clearly is the most abundant subtype. It is not clear that it is present in well-developed form in all large peatlands, although it may be.

Associations and Patterns: Pocosin Openings occur as series of small patches embedded in Low Pocosins, occasionally with a few patches also in High Pocosins. The Sedge–Fern Subtype may be the only subtype present, but it generally is also present where either of the other two subtypes occur. It may occur with either subtype of Low Pocosin.

Variation: Examples vary in wetness and amounts of the component species. No variants are recognized.

Dynamics: The relationship of Low Pocosin and Pocosin Openings needs further investigation. Pocosin Openings are believed by many to result from peat burns that kill established shrubs and create lower, wetter patches. However, peat burn patches generally appear to be bare or to be colonized by weedy species immediately after the fire, and they become difficult to distinguish as time passes. Some plants of Pocosin Openings, such as *Andropogon* and *Rhynchospora*, often appear in newly bare areas, but other characteristic species do not seem to invade newly opened sites so readily. Large, severe fires in many of the large peatlands since 1980 have not obviously resulted in an expansion of Pocosin Opening vegetation.

Pocosin Openings similarly are believed to succeed back to shrubby vegetation, and thus to represent secondary successional patches disturbed by the fire. This too is difficult to observe and has not been definitively documented. It is reasonable to expect, but the rate of succession is unclear. The wetter conditions in the openings, and the lower standing biomass, suggest slower organic matter accumulation than in the surrounding pocosin, which may allow them to persist for many years. Openings may be observed in pocosins that have not burned in decades. An alternative explanation, not widely considered, is that openings result from a feedback process wherein minor low areas become deeper and wetter due to slower accumulation of peat compared to the adjacent taller shrub areas.

However, there are accounts of more extensive Pocosin Opening vegetation in peatlands in the past. No such large openings appear in more recent aerial photos. This may suggest they are being lost through succession; however, some process other than post-fire succession may be driving their disappearance. It is difficult to eliminate the possibility that qualitative perceptions of their extent may differ between observations from airplanes, on the ground, and in aerial photos.

Comments: Pocosin Opening communities usually occur in small patches in a matrix of shrubby Low Pocosin communities. The 3rd Approximation considered them part of the heterogeneity of Low Pocosin, as did most earlier literature. They were recognized as distinct associations in the

NVC. The decision to recognize them here is uncertain, because patches tend to be very small and are always associated with the same matrix. However, they can aggregate to a significant area, they appear to have different dynamics, they do not occur in every pocosin, and they may be declining. These factors argue in favor of tracking as a separate community entity. The distinctions among different subtypes are also somewhat uncertain.

Rare species:
Vascular plants – *Lysimachia asperulifolia* and *Peltandra sagittifolia*.

POCOSIN OPENING (PITCHER PLANT SUBTYPE)

Concept: Pocosin Openings are small patch communities of deep peats, with herbaceous or dwarf shrub dominance, occurring within a Low Pocosin or occasionally High Pocosin matrix. The Pitcher Plant Subtype covers the uncommon openings in which *Sarracenia* spp. are abundant.

Distinguishing Features: Pocosin Openings are distinguished from Low Pocosins by the cover of *Chamaedaphne calyculata, Anchistea virginica, Carex striata*, *Sphagnum*, and other smaller plants persistently exceeding that of *Zenobia* and other taller shrubs. Recognition of Pocosin Opening communities is heavily dependent on the spatial scale. Patches are generally small and are always closely intermixed in a mosaic with Low Pocosin communities. While very small openings can exist in any community, the Pocosin Opening community should be recognized only where patches at least 10 meters across are present and where multiple patches add up to more than one acre.

The Pitcher Plant Subtype is distinguished by *Sarracenia flava* or *Sarracenia purpurea* var. *venosa* being abundant. *Sarracenia* generally dominate the aspect of the community, but they may not dominate in absolute cover. *Vaccinium macrocarpon* is absent or scarce.

Crosswalks: *Chamaedaphne calyculata / Carex striata - Sarracenia (flava, purpurea, rubra ssp. rubra)* Wet Dwarf-shrubland (CEGL004164).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Pocosin Openings occur in the central, deepest parts of domed peatlands on poorly drained interstream flats, occasionally in peat-filled Carolina bays and deep peat-filled swales. They occur in local patches that are slightly lower and wetter than the surrounding pocosin. Peat deposits tend to be greater than 1 meter deep, sometimes 3-4 meters deep.

Soils: Soils are Histosols, most typically Dare (Typic Haplosaprist), sometimes Croatan or Pamlico (Terric Haplosaprists). This community may represent small inclusions in these soil series but would still be classified as Typic or Terric Haplosaprists.

Hydrology: Soils are typically saturated all year but may become dry in drought periods. They may hold shallow standing water seasonally. Conditions are at least somewhat wetter than in surrounding Low Pocosin communities. These communities most often occur in the centers of large peat domes, where they receive only rainwater input and are truly ombrotrophic. Examples in Carolina bays likely also are ombrotrophic.

Vegetation: Vegetation in the Pitcher Plant Subtype is dominated by dwarf shrubs and herbs, though upright shrubs may also be a significant component. *Chamaedaphne calyculata* characteristically is the dominant shrub. Other shrubs, particularly *Zenobia pulverulenta* but also stunted *Cyrilla racemiflora, Lyonia lucida*, *Ilex glabra*, or *Persea palustris,* are common. Most other shrubs of Low Pocosin may be present. *Smilax laurifolia* often forms a layer on top of the shrubs. *Sphagnum* spp., *Anchistea virginica*, *Carex striata, Sarracenia flava*, and *Sarracenia purpurea* are the dominant herbs. *Andropogon glomeratus* may be abundant, especially soon after fires. Other herbs present in small numbers or with low constancy may include *Drosera intermedia*, *Rhynchospora chalarocephala, Rhynchospora fascicularis, Xyris fimbriata*, *Utricularia subulata*, other *Utricularia* species, *Peltandra sagittifolia*, or, rarely, *Lysimachia asperulifolia*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina. The full abundance and range are not well known, but it clearly is much less extensive and has fewer occurrences than the Sedge–Fern Subtype.

Associations and Patterns: Pocosin Openings occur as series of small patches embedded in Low Pocosins, occasionally with a few patches also in High Pocosins. The Pitcher Plant Subtype usually cooccurs with the Sedge–Fern Subtype and is also present in the one location with the Cranberry Subtype. It may occur with either subtype of Low Pocosin.

Variation: Examples vary in wetness and amounts of the component species. No variants are recognized.

Dynamics: As discussed for the Sedge–Fern Subtype, the dynamic relationship between Low Pocosin and Pocosin Opening communities needs further investigation. The relationship between the Sedge–Fern Subtype and Pitcher Plant Subtype also needs further investigation. Where they cooccur, it is not clear if they are distinguished by different microenvironments, by different successional ages, or by accidents of plant establishment.

There are accounts of more extensive Pocosin Opening vegetation in peatlands in the past, with reports of "acres of pitcher plants" seen from airplanes in remote peatlands in the 1970s. No such large openings appear in more recent aerial photos, and openings of the Pitcher Plant Subtype appear much less numerous than the Sedge–Fern Subtype in current ground level surveys. This may suggest they are being lost through succession. However, large, severe fires in many of the large peatlands since 1980 have not apparently resulted in an expansion of them. Thus, some process other than post-fire succession may be driving their disappearance, or qualitative perceptions of their extent may differ between observations from airplanes, on the ground, and in aerial photos.

Comments: In addition to considerations of whether Pocosin Openings should be considered separate entities from the surrounding Low Pocosins, as discussed for the Sedge–Fern Subtype, there is a question how distinctive the Pitcher Plant Subtype is. It is accepted for the 4th Approximation but would merit further investigation. The abundance of *Sarracenia* spp. is the only known difference between them, and the cause of it is not well known.

Rare species:
Vascular plants – *Lysimachia asperulifolia* and *Peltandra sagittifolia.*

Invertebrate animals – *Exyra ridingsii*.

POCOSIN OPENING (CRANBERRY SUBTYPE)

Concept: Pocosin Openings are small patch communities of deep peats, with herbaceous or dwarf shrub dominance, occurring within a Low Pocosin or occasionally High Pocosin matrix. The Cranberry Subtype covers the uncommon openings in which *Vaccinium macrocarpon* is abundant.

Distinguishing Features: Pocosin Openings are distinguished from Low Pocosins by the cover of *Chamaedaphne calyculata, Anchistea virginica, Carex striata*, *Sphagnum*, and other smaller plants persistently exceeding that of *Zenobia* and other taller shrubs. Recognition of Pocosin Opening communities is heavily dependent on the spatial scale. Patches are generally small and are always closely intermixed in a mosaic with Low Pocosin communities. While very small openings can exist in any community, the Pocosin Opening community should be recognized only where patches at least 10 meters across are present and where multiple patches add up to more than one acre.

The Cranberry Subtype is distinguished by having appreciable cover of *Vaccinium macrocarpon*. It is known only in Dare County.

Crosswalks: *Chamaedaphne calyculata - Vaccinium macrocarpon / Carex striata* Wet Dwarf-shrubland (CEGL004165).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Pocosin Openings occur in the central, deepest parts of domed peatlands on poorly drained interstream flats, occasionally in peat-filled Carolina bays and deep peat-filled swales. The one well-developed example of this subtype appears to be a Carolina bay that is buried beneath a domed peatland, and therefore has very deep peat. The peat is grounded below present sea level. This community occurs in local patches that are slightly lower and wetter than the surrounding pocosin.

Soils: Soils are mapped as Pungo (Typic Haplosaprist). This community may represent small inclusions in these soil series but would still be classified as Typic or Terric Haplosaprists.

Hydrology: Soils are typically saturated all year but may become dry in drought periods. They may hold shallow standing water seasonally. Conditions are at least somewhat wetter than in surrounding Low Pocosin communities. These communities most often occur in the centers of large peat domes, where they receive only rainwater input and are truly ombrotrophic.

Vegetation: Vegetation in the Cranberry Subtype is dominated by dwarf shrubs and herbs, though upright shrubs may also be a significant component. *Chamaedaphne calyculata* and *Vaccinium macrocarpon* dominate the woody vegetation. Other shrubs, particularly *Zenobia pulverulenta*, but also stunted *Lyonia lucida*, *Ilex glabra*, or *Persea palustris,* are common. Most other shrubs of Low Pocosin may be present. *Smilax laurifolia* often forms a layer on top of the shrubs. *Sphagnum* spp. is extensive in the ground cover. *Anchistea virginica* and *Carex striata* are the dominant herbs. *Andropogon glomeratus* may be abundant soon after fires. Other herbs include *Rhynchospora alba, Rhynchospora fascicularis* var. *fascicularis, Sarracenia flava*, *Sarracenia purpurea,* *Drosera intermedia, Xyris ambigua*, *Calopogon barbatus, Peltandra virginica, Rhynchospora plumosa*, and *Utricularia subulata*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina and is known only from a single, albeit extensive, occurrence in Dare County.

Associations and Patterns: Pocosin Openings occur as series of small patches embedded in Low Pocosins, occasionally with a few patches also in High Pocosins. The Cranberry Subtype is associated with the Sedge-Fern Subtype and potentially with the Pitcher Plant Subtype. The only example is associated with the Gallberry Fetterbush Subtype of Low Pocosin.

Variation: Examples vary in wetness and amounts of the component species. No variants are recognized.

Dynamics: As discussed for the Sedge-Fern Subtype, the dynamic relationship between Low Pocosin and Pocosin Opening communities needs further investigation. The relationships among the subtypes also need further investigation. Where they cooccur, it is not clear if they are distinguished by different microenvironments, by different successional ages, or by accidents of plant establishment.

Comments: This subtype appears to be associated with a distinctive biogeographic history. The occurrence of *Vaccinium macrocarpon* presumably is relict. The species is present at several other sites in Dare County and nearby counties. Other than a single collection from the Green Swamp, where it has not been found again, *Vaccinium macrocarpon* is not known to be present in or near other Low Pocosins. The Dare County Pocosin where it occurs appears to have been an open pocosin much longer than most peatlands in the state. It also appears to be wetter and more extensive than Pocosin Openings in other peatlands. However, it is less clear that it is wetter than patches of other subtypes in the same pocosin.

Rare species:
Vascular plants – *Rhynchospora alba* and *Vaccinium macrocarpon*.

Invertebrate animals – *Hemipachnobia monochromatea*.

HIGH POCOSIN (EVERGREEN SUBTYPE)

Concept: High Pocosins are shrub bog communities of intermediate-depth peats, with a prevailing shrub height greater than 1.5 meters but with a sparse, poorly-developed tree canopy. The Evergreen Subtype covers the typical examples dominated strongly by evergreen shrubs, generally *Lyonia lucida*, *Ilex glabra*, and *Cyrilla racemiflora*.

Distinguishing Features: High Pocosins are distinguished from other peatland pocosins by having dense shrub layers persistently greater than 1.5 meters tall (except immediately after fire) but lacking a well-developed tree canopy (cover less than 25 percent and trees stunted). Pond Pine Woodlands that have recently burned may have similar tree stature and cover, but generally will show evidence of having supported larger and denser trees before the fire. However, Pond Pine Woodland that has been logged may be difficult to distinguish, and other forests with evergreen shrubs may also come to deceptively resemble High Pocosin if clearcut.

High Pocosins are distinguished from Streamhead Pocosins by not occurring in seepage-fed drainages in sandhill terrain. They lack *Liriodendron tulipifera, Toxicodendron vernix*, and other characteristic streamhead species and often have *Gordonia lasianthus* as a component. They are distinguished from Small Depression Shrub Border by occurring on peats, not being associated with small depressions, and lacking other characteristic species such as *Ilex myrtifolia* and *Nyssa biflora*.

The Evergreen Subtype is distinguished from the Deciduous Subtype by having only a minor amount of deciduous shrubs such as *Zenobia pulverulenta* and *Vaccinium* spp. It is distinguished from Peatland Canebrake by having broadleaf shrubs dominant, though *Arundinaria tecta* may be present in small amounts.

Crosswalks: *Pinus serotina / Lyonia lucida - Ilex glabra - (Cyrilla racemiflora)* Wet Shrubland (CEGL003846).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).
Pine-Ericalean Pocosin (Kologiski 1977) (in part).
Short pocosin (some common usage).
Tall pocosin (other common usage).

Sites: High Pocosins occur on peats that are typically about 1.5 meters deep, in the intermediate parts of the deeper domed peatlands, in centers of shallower peatlands, or in peat-filled Carolina bays and swales. Peat deposits may be deeper or shallower in other conditions that give similar nutrient levels.

Soils: Soils are usually Terric Haplosaprists, most often mapped as Pamlico or Croatan. A few are mapped as Dare (Typic Haplosaprist) and a few are mapped as deeper or shallower peats. Soil mapping often does not distinguish different soils for High Pocosin and Low Pocosin.

Hydrology: Soils are usually saturated at the surface seasonally or all year. High Pocosins occurring in domed peatlands are slightly higher than the surrounding lands and the only surface or ground water that drains into them comes from other pocosins, making them largely ombrotrophic. High pocosins in Carolina bays and swales occupy low areas that lack mineral input, or occur in the interior of peat-filled depressions where any nutrients in incoming water are filtered out by peat on the periphery. The peat is deep and saturated enough that plant roots can reach mineral soil only during droughts (Otte 1981). Small, permanently flooded depressions may occur, but are less common than in Low Pocosin.

Vegetation: High Pocosin vegetation is a dense tall shrubland with stunted trees widespread but with less than 25% overall cover even with no recent fire. The shrub layer is 1.5 to 3 meters tall, except when recovering from fire. The open canopy consists almost exclusively of *Pinus serotina*, though *Gordonia lasianthus*, *Magnolia virginiana*, or *Persea palustris* may occur in small numbers. The shrub layer is dominated by *Lyonia lucida*, *Cyrilla racemiflora*, *Ilex glabra, Ilex coriacea*, and the hardwoods listed above. *Smilax laurifolia* is frequent and often forms large tangles. *Arundinaria tecta* may be present but does not dominate. Other shrub species, such as *Zenobia pulverulenta, Aronia arbutifolia*, *Vaccinium fuscatum*, or *Vaccinium formosum*, may occur in small numbers. Herbs are sparse. *Anchistea virginica* is most frequent. In small openings created by peat consumption in fires or sometimes by mechanical disturbance, a few other herbs may be common: *Carex striata*, *Andropogon glomeratus*, and the rare *Peltandra sagittifolia*. *Sphagnum* spp. may occur in small amounts.

Range and Abundance: Ranked G3. Most High Pocosins are the Evergreen Subtype. They range throughout the outer terraces of the Coastal Plain, where they are present in all larger peatlands and many of the peat-filled Carolina bays. The equivalent association ranges southward to Florida, but North Carolina appears to have most of the occurrences and acreage.

Associations and Patterns: High Pocosins occur as large patch communities. They may dominate the center of a large peatland or Carolina bay, or they may be a broad to narrow intermediate zone outside of a Low Pocosin center. They almost always grade to Pond Pine Woodland on the outer edges with shallower organic deposits. Other Peatland Pocosin communities, such as Bay Forest or Peatland Canebrake, may also occur in the mosaic. The Deciduous Subtype usually is in different Carolina bays than the Evergreen Subtype, but they can co-occur.

Variation: Stature of vegetation increases with decreasing peat depth. Dominance, stature, and diversity also vary due to fire cycles. Theoretically, differences in hydrology, fire regime, and other site factors between large peatlands and Carolina bays might create differences in pocosins in these settings, but such differences have not been documented.

Dynamics: High Pocosins are intermediate in nutrient levels and productivity, between Low Pocosins and Pond Pine Woodlands. Nutrient shortages limit the size and density of trees, which remain small and generally low in density even with the long absence of fire. There is some question about the range of density. An extensive High Pocosin in Holly Shelter Swamp, which had a sparse pine canopy, regenerated with a much denser pine canopy after a severe wildfire. This needs further investigation. Recovery from fire may be somewhat slower than in Low Pocosin because of the higher normal biomass, but productivity is also higher. Some species, such as *Zenobia* and various herbs, recover particularly quickly and dominate several years after a fire, until they are out-competed by *Cyrilla* and *Lyonia* (Christensen et al. 1981; Wilbur and Christensen

1983). Species diversity is generally highest right after a fire and declines gradually. Some species, such as *Peltandra sagittifolia*, appear to be exclusively associated with severely disturbed patches.

Tree regeneration is driven by fires, which create bare ground and release seeds from serotinous cones. Tree density and stature in the long term presumably are driven by nutrient limitation. However, a fire can significantly change the tree density in either direction in a High Pocosin or Pond Pine Woodland, and this may lead to apparent changes in the boundary between the two in transitional areas.

The natural dynamic relationship of High Pocosin and Peatland Canebrake is not well known. It is reasonable, as suggested by Frost (2000), that canebrakes might be invaded by shrubs and come to resemble High Pocosin in the long absence of fire, though others are known to have been invaded by hardwood trees. Any High Pocosin that contains *Arundinaria* may have the potential to become dominated by it with frequent burning, and *Arundinaria* will support burning more frequently than broadleaf shrubs will. However, it is unclear if these communities interchanged on a regular basis, or if they occurred as a stable mosaic with each in areas that promoted different fire frequency. Both shrubs and cane appear capable of promoting the fire regime that benefits them, so feedback between vegetation and fire may have stabilized both communities.

Comments: Much of the literature on pocosin ecosystems is general and does not distinguish High Pocosins specifically. Their location relative to the terminology of tall and short pocosin is also sometimes unclear.

Similar vegetation occurs in southern Virginia on small peat bodies along tidal rivers. No similar vegetation is known in North Carolina in such a setting.

The placement of the synonymized association in the G037 Southern Coastal Plain Mixed Evergreen Swamp Group in the NVC is problematic. It is much more closely related to other pocosins floristically and ecologically.

Rare species:
Vascular plants – *Lysimachia asperulifolia* and *Peltandra sagittifolia*.

HIGH POCOSIN (DECIDUOUS SUBTYPE)

Concept: High Pocosins are shrub bog communities of intermediate-depth peats, with a prevailing shrub height greater than 1.5 meters but with a sparse, poorly-developed tree canopy. The Deciduous Subtype covers uncommon, poorly known examples with a significant deciduous shrub component, usually *Zenobia pulverulenta* but sometimes *Vaccinium* spp. or other species.

Distinguishing Features: High Pocosins are distinguished from other peatland pocosins by having dense shrub layers persistently greater than 1.5 meters tall (except immediately after fire) but lacking a well-developed tree canopy (cover less than 25 percent and trees stunted). Pond Pine Woodlands that have recently burned may have similar tree stature and cover, but generally will show evidence of having supported larger and denser trees before the fire. However, Pond Pine Woodland that has been logged may be difficult to distinguish.

The Deciduous Subtype is distinguished from the Evergreen Subtype by having more than a minor amount of deciduous shrubs such as *Zenobia pulverulenta* and *Vaccinium* spp.

Crosswalks: *Pinus serotina / Zenobia pulverulenta - Cyrilla racemiflora - Lyonia lucida* Wooded Wet Shrubland (CEGL004458).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: The Deciduous Subtype is known to occur only in peat-filled Carolina bays.

Soils: Almost all examples are mapped as Pamlico (Terric Haplosaprist).

Hydrology: Sites are saturated at the surface seasonally or all year. Though occurring in the basins of Carolina bays, these communities presumably do not receive runoff from adjacent mineral soil areas. However, periodic ponding of water may have some influence on their character. Many examples are in bays that were impounded in the past, but it is not clear that all are, and it is not clear what effect this has on vegetation long after ponds were drained.

Vegetation: High Pocosin vegetation is a dense thicket of shrubs, with sparse and small trees. Shrubs are over 1.5 meters tall, but often only reach 2 meters tall, and thus are a bit shorter than in many examples of the Evergreen Subtype. In the Deciduous Subtype, *Zenobia pulverulenta* usually dominates and is often accompanied by *Ilex laevigata, Vaccinium formosum*, *Kalmia carolina*, *Kalmia cuneata*, and *Clethra alnifolia*. Less frequent shrubs listed in site reports include *Lyonia ligustrina*, *Ilex coriacea, Lyonia lucida, Cyrilla racemiflora*, *Vaccinium fuscatum*, *Rhododendron viscosum, Amelanchier obovalis*, and *Gaylussacia frondosa*. *Smilax laurifolia* can be abundant. Several sites have been noted to have *Chamaedaphne calyculata* beneath the tall shrubs. Scattered trees include *Pinus serotina*, but many examples have *Acer rubrum*. It is unclear if this is a natural component, but it is more widespread than in other pocosins. *Persea palustris, Gordonia lasianthus*, and *Magnolia virginiana* are also frequent. Herbs are sparse. A few surveys noted *Carex striata*, *Anchistea virginica*, and *Sphagnum* spp.

Range and Abundance: Ranked G2? In North Carolina, this subtype is known only in the Bladen Lakes areas, with all occurrences confined to Bladen and Cumberland counties. The equivalent association is also attributed to South Carolina.

Associations and Patterns: The Deciduous Subtype is a large patch community. Examples occur in association with other pocosin communities, especially High Pocosin (Evergreen Subtype) and Pond Pine Woodland (Typic Subtype).

Variation: Variation is not well known. Some different examples have drastically different dominant shrubs, but the meaning of these differences is not apparent.

Dynamics: Dynamics of this subtype are probably similar to other pocosins, but specifics are not well known. In the Evergreen Subtype and High Pocosin, *Zenobia* dominates soon after fires, but is overgrown by evergreen shrubs after a few years. It is unclear why *Zenobia* dominance seems to persist in this subtype. All of the examples were observed long after the last fire but showed no sign of transition to evergreen shrub dominance.

Comments: The factors that create this subtype are particularly poorly known. Brian van Eerden (personal communication 1994), after visiting numerous Bladen Lakes area pocosins, called them "tall low pocosin," noting that they were intermediate between typical *Zenobia*-dominated Low Pocosin and the typical Evergreen Subtype, and suggested they resembled a fire-suppressed state of Low Pocosin. Besides having *Zenobia* dominance, they often have *Chamaedaphne calyculata*, a species typical of Low Pocosin and Pocosin Opening communities but not of High Pocosin. However, fire-suppressed Low Pocosins in other areas, including other nearby Carolina bays, do not seem to grow tall. The Deciduous Subtype also has other species that are absent or scarce in other pocosins, including *Ilex laevigata, Vaccinium formosum, Vaccinium fuscatum*, and *Clethra alnifolia*. These species are often more abundant in Small Depression Pocosins and other small depression communities, suggesting something in hydrology or fire dynamics may be transitional to the environment of those communities. Other species, such as *Kalmia carolina* and *Kalmia cuneata*, are shared with the Evergreen Subtype of High Pocosin in the Bladen Lakes area but seldom elsewhere.

The known existence of past impoundments in some examples suggests a possibility of anthropogenic origin for the Deciduous Subtype. *Acer rubrum* is more often present and abundant in them than in most pocosin communities, which may support this idea. However, not all examples have this history, and a mechanism for that history to create this composition has not been suggested. The composition of known examples appears to be stable. They also have a distinct geographic range. It thus seems likely that they are a distinct natural community.

Rare species: No rare species are known to be specifically associated with this community.

POND PINE WOODLAND (TYPIC SUBTYPE)

Concept: Pond Pine Woodlands are pocosin communities of shallow peats or mucky mineral soils, with a well-developed, though usually open, canopy of *Pinus serotina*, with or without *Gordonia lasianthus*. The Typic Subtype covers all examples with broadleaf shrub layers, except those at the northern end of the range, where *Cyrilla racemiflora* is absent. This subtype includes the previously recognized subtypes codominated by *Gordonia lasianthus* and those otherwise similar examples that lack it in the canopy.

Distinguishing Features: Pond Pine Woodlands are distinguished from High Pocosins by the presence of a significant tree canopy (greater than 25 percent cover except shortly after fires). They are distinguished from Streamhead Pocosins by occurring on organic deposits in domed peatlands or in shallow basins. Streamhead Pocosins occur in seepage-fed drainages in sandhill terrain and typically contain *Liriodendron tulipifera*, *Toxicodendron vernix*, *Oxydendrum arboreum*, and other species that are absent in Pond Pine Woodlands. Pond Pine Woodlands are most readily distinguished from Small Depression Pocosins by occurring in contiguous patches larger than 5 acres; they also lack appreciable amounts of species more typical of basins, such as *Vaccinium* spp. Pond Pine Woodlands are distinguished from the Pond Pine Subtype of Estuarine Fringe Pine Forest by having a shrub layer dominated by typical pocosin shrubs rather than by *Morella cerifera*. Transitional communities showing a mix of species of these two communities are common between tidal areas and typical Pond Pine Woodlands and can be expected to develop into typical Estuarine Fringe Pine Forests in just a few years.

Where fire has long been excluded, shrubs and trees from Pond Pine Woodlands can spread into adjacent longleaf pine communities. There they can eventually become as tall and dense as in a typical Pond Pine Woodland. These overgrown savannas or flatwoods may be difficult to distinguish, but they should not have a well-developed organic layer in the soil. Any presence, even just traces, of species typical of mineral soils, such as *Ctenium aromaticum*, *Aristida stricta*, or *Pinus palustris,* is an indication of this situation, though care must be taken that the species are not on small mineral soil inclusions. Shrub species more characteristic of longleaf pine communities and ecotones may also indicate this, if present in the interior in large numbers. Such species include *Gaylussacia frondosa, Clethra alnifolia*, *Morella cerifera*, *Kalmia carolina*, or *Rhododendron atlanticum*.

The Typic Subtype is distinguished from the Canebrake Subtype by having broadleaf shrubs substantially exceeding *Arundinaria tecta* in cover. Because fire exclusion has led to invasion of canebrakes by shrubs, any substantial presence of *Arundinaria* is likely an indication of the Canebrake Subtype. The Northern Subtype is distinguished from the Typic Subtype by occurring in the northernmost parts of the state and by lacking *Cyrilla racemiflora* as a significant component. However, depauperate examples lacking *Cyrilla* farther south are treated as the Typic Subtype.

Crosswalks: *Pinus serotina - Gordonia lasianthus / Lyonia lucida* Swamp Woodland (CEGL003671).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Pond Pine Woodlands occur near the edges of domed peatlands, in Carolina bays, and in swales in aeolian sand deposits and irregular sandy surfaces such as high stream terraces. They may occur on shallow organic deposits or on deeper peats with some input of mineral sediment.

Soils: Pond Pine Woodlands occur on shallow Histosols or oligotrophic mineral soils with organic surface layers. The most common series are Murville (Umbric Endoaquod) and Lynn Haven (Typic Alaquod). Other series mapped for them include Croatan (Terric Haplosaprist), Torhunta (Typic Humaquept), Ponzer (Terric Haplosaprist), Roper (Histic Humaquept), and Pungo (Typic Haplosaprist).

Hydrology: Sites are semipermanently saturated and possibly briefly flooded. The water table is believed to regularly drop to underlying mineral sediment during the dry season, allowing plants to root there (Otte 1981). Water comes from rainfall and sheet flow. Most sheet flow comes from adjacent peatland and brings little nutrient input, but there may be limited influx of slightly less oligotrophic water from adjacent upland areas.

Vegetation: Pond Pine Woodlands exhibit an open to nearly closed canopy of *Pinus serotina*, sometimes codominant with *Gordonia lasianthus*, and with lesser amounts of *Magnolia virginiana* and *Persea palustris*. The understory is of the same evergreen hardwood species, generally at low density. In more altered examples, *Acer rubrum* var. *trilobum* or *Pinus taeda* may be present in the canopy or understory. The shrub layer is tall and very dense, often 4-5 meters tall in examples that are not recently burned. Dominant shrubs are usually *Lyonia lucida*, *Ilex coriacea*, *Ilex glabra*, and *Cyrilla racemiflora*. Other shrubs that may occur in smaller numbers include *Aronia arbutifolia*, *Lyonia ligustrina*, *Vaccinium fuscatum*, *Vaccinium formosum*, *Morella caroliniensis*, *Eubotrys racemosus*, and *Arundinaria tecta*. *Smilax laurifolia* is usually abundant, but few other vines are present. Herbs are generally sparse. *Anchistea virginica* is the only very constant or abundant species, and *Sphagnum* spp. may occur in small amounts.

Where Pond Pine Woodland borders Wet Pine Flatwoods or upland communities, a distinct ecotonal zone often occurs, where the more frequent fire of the uplands interacts with the wetter, organic-surfaced soil of the Pond Pine Woodland. This ecotone, while too small to be classified as a separate community, often contains herbs of Pine Savanna communities, including potentially a number of rare species such as *Dionaea muscipula* and *Lysimachia asperulifolia*. Where fire is inadequate, shrubs become dense at the ecotone and the distinctive herbs are lost.

Range and Abundance: Ranked G3. The Typic Subtype is widespread in the outer Coastal Plain and in the Bladen Lakes region and is rare to occasional elsewhere in the Coastal Plain. It occurs in South Carolina but does not reach Virginia. North Carolina has most of the occurrences and most of the acreage of this community.

Associations and Patterns: Pond Pine Woodlands can occur as large patches, covering hundreds or even thousands of acres, where they may be associated with pocosin communities on deeper peats. Typically they will grade to High Pocosin toward the interior of the domed peatland or Carolina bay and may be seen as an outer ring zone. However, in other places, such as the Alligator River area, they may be bordered by Nonriverine Swamp Forests through a mosaic of both communities that may reflect fire history. Bay Forests may also occur with them, sometimes centered on incipient drainage systems on the edges of peatlands, but sometimes in mosaics. Pond Pine Woodlands may also occur as large patches without other pocosin communities, or as stringers or irregular patches of a few acres, in mosaics with Wet Pine Flatwoods or other longleaf pine communities, in relict dune fields or other irregular flat landscapes.

Variation: Two variants are recognized.

1. Loblolly Bay Variant has *Gordonia lasianthus* codominant in the canopy.

2. Shrub Variant has a canopy dominated solely by *Pinus serotina*, though *Gordonia* may be present in the understory.

These variants are recognized as distinct associations in the NVC and were recognized as subtypes in early drafts of the 4th approximation. However, they appear not to be distinctive enough to recognize as subtypes. The presence or complete absence of *Gordonia* does not appear to correlate with any other aspect of the communities.

Otte (1981) divided the vegetation covered by this community into categories of Pond Pine Woodland and Pond Pine Forest, varying in structure and correlated organic matter depth. The author believes this distinction is not useful or practical because differences in soil are small and vegetation stature varies much more in response to disturbance history.

Dynamics: These communities are saturated without appreciable surface flooding, and are nutrient poor, though less so than Low Pocosin or High Pocosin. Otte (1981) emphasized the importance of the water table dropping below the bottom of the organic layer, allowing roots to reach a greater supply of nutrients below. This nutrient supply presumably is a legacy of the geologic past and consists mainly of exchangeable cations such as calcium, as this underlying horizon presumably is anoxic and must have virtually no nutrient cycling at present.

As with other peatland communities, Pond Pine Woodlands are susceptible to fires during dry periods. Many examples border longleaf pine communities or marshes; they would naturally have been exposed to fire every few years but may not have been flammable enough to burn at all of those times. The natural fire frequency is not well known. The large amount of fuel makes current fires intense in Pond Pine Woodlands. Complete top-kill of all shrubs is common, and the pine canopy often is also killed or reduced to epicormic sprouts on charred trunks.

The dominant species sprout readily after fire, and only a few years are apparently required for the dense shrub layer to reach its former height. *Pinus serotina* usually recovers quickly by epicormic and basal sprouts as well as reproduction by seed from serotinous cones. If the pine canopy is killed, recovery of the canopy may take much longer than for the shrub layer. Rare fires may consume soil organic matter and kill the roots of shrubs, leading to a stage of weedy herbaceous cover that may persist some years before the characteristic species reestablish. This has been observed in recent wildfires, especially near artificial drainage, but it is unclear if it would typically occur in more natural conditions. Otte (1981) suggested that fires that reduced the thickness of peat enough to allow more ready access of roots to underlying mineral soil might result in faster growth and taller stature in a recovered community, but the author has not observed this.

Frequent fire, probably more often than every 10 years, is more favorable to *Arundinaria tecta* than to broadleaf shrubs and may lead to the development of the Canebrake Subtype, or even to an open Peatland Canebrake community. Conversely, some examples of the Typic Subtype may have developed from the Canebrake Subtype by exclusion of fire. Frost (1989) suggests that in southeastern Virginia, Pond Pine Woodland-type sites with fire every 3-5 years would support dense, pure canebrake vegetation. With fire every 6-12 years they would alternate between canebrake and shrubby pocosin vegetation, while with less frequent fire *Pinus serotina* would dominate. Which fire regimes prevailed under natural conditions in these sites in North Carolina is uncertain. Because *Arundinaria* is more flammable than the broadleaf shrubs, canebrakes, once established, might maintain themselves by promoting more frequent burning. This could only occur, however, if sources of frequent ignition existed adjacent to the community.

Adjacent to mineral soil areas, especially those supporting longleaf pine communities that would expose them to frequent ignition, it is thought Pond Pine Woodlands might occur as an open pond pine savanna with ground cover of sedges and ferns. In some places where prescribed burning is frequent, possible early development of this kind of vegetation can be observed. However, it is certain that the vegetation is capable of burning this frequently in the long run. It is unlikely *Pinus serotina* would be able to reproduce in this situation and it is unclear what long term equilibrium vegetation might occur under this regime.

It has been suggested that, in the absence of fire, Pond Pine Woodlands would succeed to bay forest (Buell and Cain 1943; Monk 1968) (though their concept of bay forest may or may not be the same as the Bay Forest in this document). Abundant canopy *Gordonia* is often interpreted as being a result of long fire suppression. However, large *Gordonia* are quite resilient to fire, and they readily sprout after fire. Atlantic White Cedar Forests too might be established by the occurrence of the right intensity of fire. It may thus be possible that Pond Pine Woodlands can occur in a shifting mosaic with these other communities and also perhaps with Nonriverine Swamp Forest. However, observing a number of wildfires of varying intensity over the last several decades, as well as a number of examples where no fire has occurred in many decades, such a process has not been documented. In the long absence of fire, most examples appear to stagnate or to be invaded by *Acer rubrum*.

As discussed for dynamics of the theme in general, in the absence of fire, pocosin shrubs often spread into adjacent wet longleaf pine communities. *Pinus serotina* too can establish. Over time, a broad band of vegetation can come to strongly resemble long-term Pond Pine Woodland, though the presence of even sparse *Pinus palustris*, *Aristida stricta*, or other herbs of savannas indicates its history. The absence of a soil organic layer also suggests that a location is not a long term Pond Pine Woodland. However, it is possible for an organic soil surface to develop fairly quickly, making the past community boundary impossible to discern. Frost (2000) and Frost (2020) report studies showing that an organic layer thick enough to change soil classification from Leon (a typical soil of Wet Pine Flatwoods and Wet Sandy Pine Savanna) to Murville (typical of Pond Pine Woodland) had, in places, accumulated in 30 years.

Comments: *Pinus serotina / Cyrilla racemiflora - Lyonia lucida - Ilex glabra* Swamp Woodland (CEGL003670) was defined as a counterpart to the synonymized association, with the sole difference being absence of *Gordonia lasianthus* in the canopy. This distinction has been retained as the basis for the two variants, to promote further consideration of the importance of this distinction. *Gordonia* is sometimes codominant or abundant in the canopy, sometimes present in the understory but not the canopy, and sometimes completely absent. It is not clear that this correlates with any other characteristics of the communities.

Rare species:
Vascular plants – Ecotones only – *Dionaea muscipula*.

Vertebrate animals – *Crotalus adamanteus* and *Dryobates borealis.*

Invertebrate animals – *Franclemontia interrogans* and *Triodopsis soelneri*.

POND PINE WOODLAND (NORTHERN SUBTYPE)

Concept: Pond Pine Woodlands are pocosin communities of shallow peats or mucky mineral soils, with a well-developed, though usually open, canopy of *Pinus serotina*. The Northern Subtype covers examples at the northern end of the range of Pond Pine Woodland, north of Albemarle Sound, in which *Cyrilla racemiflora* is absent and *Acer rubrum* and *Clethra alnifolia* become important components.

Distinguishing Features: Pond Pine Woodlands are distinguished from High Pocosins by the presence of a significant tree canopy (greater than 25 percent cover except shortly after fires). See the Typic Subtype description for additional distinguishing features.

The Northern Subtype is distinguished by the combination of northern location with the absence of *Cyrilla racemiflora*. All known examples are north of Albemarle Sound, where the Typic Subtype has not been found. It is unclear if the abundance of *Acer rubrum*, *Clethra alnifolia*, *Gaylussacia frondosa, Morella* spp., and *Eubotrys racemosus* is characteristic of the Northern Subtype in all potential occurrences or if it is a result of alterations or marginal conditions in the few remaining examples that have been sampled or described.

The Northern Subtype is distinguished from the Canebrake Subtype by having broadleaf shrubs substantially exceeding *Arundinaria tecta* in cover. Because fire exclusion has led to invasion of canebrakes by shrubs, any substantial presence of *Arundinaria* is likely an indication of the Canebrake Subtype.

Crosswalks: *Pinus serotina / Ilex glabra / Woodwardia virginica* Swamp Woodland (CEGL004652).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Pond Pine Woodlands occur near the edges of domed peatlands, in Carolina bays, and in swales in aeolian sand deposits and irregular sandy surfaces such as high stream terraces. They may occur on shallow organic deposits or deeper peats with some input of mineral sediment.

Soils: The few remaining examples of the Northern Subtype occur on deep organic soils: Dorovan, Dare, Pungo, Ponzer, and Belhaven, which are all Terric or Typic Haplosaprists, though presumably less oligotropohic than those that support High Pocosins or Low Pocosins. It is possible examples could occur on shallower organic deposits, as is more common for the Typic Subtype.

Hydrology: Sites are semipermanently saturated and possibly temporarily flooded. Given the prevalence of deep organic soils, it seems unlikely that the water table would drop into the underlying mineral soil, as suggested by Otte (1981) for most Pond Pine Woodlands.

Vegetation: The Northern Subtype has an open to nearly closed canopy of *Pinus serotina*, sometimes codominant with *Acer rubrum* var. *trilobum* or *Magnolia virginiana* in existing examples. An open understory of the same hardwood species, along with *Persea palustris*, may be present. The shrub layer is tall and generally dense, with *Ilex glabra*, *Lyonia lucida*, or *Clethra alnifolia* dominant. Other species noted in examples include *Morella caroliniensis*, *Gaylussacia frondosa*, *Eubotrys racemosus*, *Morella cerifera*, *Lyonia ligustrina* var. *foliosiflora*, and *Vaccinium formosum*. *Smilax laurifolia* is often large and dense. Herbs are few, with *Anchistea virginica* most characteristic. *Sphagnum* spp. may be present in small amounts.

Range and Abundance: Ranked G2? This subtype is limited to northeastern North Carolina and adjacent Virginia. All examples are north of Albemarle Sound, where no examples of the Typic Subtype are known. Large peatlands are few in this region.

Associations and Patterns: The few remaining examples occur as large patches on edges of large peatland swamps (Great Dismal Swamp) and in peatlands embedded in wind tidal river valleys. These examples grade to Nonriverine Swamp Forest and Estuarine Fringe Pine Forest (Pond Pine Subtype) respectively. At least one is on the edge of a large, historically documented canebrake — the Green Sea.

Variation: Known examples are too few and too altered to characterize natural variation.

Dynamics: As with other subtypes, this subtype may depend on fire at a low to moderate frequency to maintain it, but it may not. In addition, examples embedded in wind tidal river valleys are often completely surrounded by very wet Tidal Swamps that are not flammable, so the chances of them burning naturally are low. Fire frequency may be less in the geographic range of this subtype than farther south. If they do not burn as frequently, the ecological factors that maintain them and prevent their succeeding to Nonriverine Swamp Forest are unclear.

Comments: This community was first documented in Virginia, where it is the only kind of Pond Pine Woodland, but it appears to apply to the few North Carolina examples north of Albemarle Sound. It is accepted provisionally. Beyond the absence of *Cyrilla* and other southern species, it is unclear how much of its distinctness is natural and how much is a result of the greater alteration in the area where it occurs. Many of the species that contrast with the Typic Subtype — *Acer rubrum*, *Clethra alnifolia*, *Gaylussacia frondosa, Morella* spp., and *Eubotrys racemosus* — are common further south but occur in less oligotrophic conditions than are typical of Pond Pine Woodlands. If found in Pond Pine Woodland (Typic Subtype), they might indicate unnatural spread of pocosin vegetation into mineral soils with long absence of fire. Fire regimes have been altered longer and more thoroughly in the range of the Northern Subtype than farther south, but fire is also likely to have been somewhat less frequent in this area than farther south. Some species are shared with the anomalous Deciduous Subtype of Low Pocosin, which does not occur in the same region, but the reason for the connection is not known.

Some depauperate Pond Pine Woodland vegetation, lacking *Cyrilla racemiflora*, occurs near Lake Worth on the Dare County peninsula, in close proximity to large examples of the Typic Subtype. This could possibly be a disjunct occurrence but may be a result of some kind of alteration.

Rare species:
Vertebrate animals – *Dryobates borealis.*

POND PINE WOODLAND (CANEBRAKE SUBTYPE)

Concept: Pond Pine Woodland (Canebrake Subtype) communities are *Pinus serotina*-dominated woodlands or savannas with a shrub layer naturally dominated by *Arundinaria tecta*, presumably resulting from more frequent fire than that occurring in other Pond Pine Woodlands.

Distinguishing Features: Pond Pine Woodlands are distinguished from High Pocosins by the presence of a significant tree canopy (greater than 25 percent cover except shortly after fires). See the Typic Subtype description for additional distinguishing features.

The Canebrake Subtype is distinguished from other Pond Pine Woodlands by having a shrub layer dominated by *Arundinaria tecta* rather than by broadleaf shrubs. Given the pervasive alteration of fire regimes, recognition of subtypes can often be only tentative. Some examples that once were the Canebrake Subtype may have had the cane completely eliminated in the absence of fire and now be unrecognizable. Others may exist with a small amount of cane mixed with shrubs. In practice, this subtype should be recognized if *Arundinaria* is abundant and it seems likely that it would dominate with a more natural fire regime. In the absence of abundant *Arundinaria*, this subtype should be recognized only if there is historical information indicating its past dominance at the site.

Crosswalks: *Pinus serotina / Arundinaria tecta* Swamp Woodland (CEGL004433).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: This subtype occurs in sites similar to other Pond Pine Woodlands, on shallow organic deposits or deeper peats with some input of mineral sediment, on the edges of domed peatlands, and potentially in peat-filled Carolina bays, swales in aeolian sand areas, or other irregular surfaces in the outer Coastal Plain.

Soils: Soils are shallow Histosols or oligotrophic mineral soils with organic surface layers, potentially any of the series listed for the Typic Subtype. It has been suggested in some earlier site descriptions that canebrakes may be more likely to occur on soils with higher mineral content than typical Pond Pine Woodland, but it is unclear if this is true.

Hydrology: Sites are semipermanently saturated and possibly briefly flooded. The water table is believed to regularly drop to underlying mineral sediment during the dry season, allowing plants to root there (Otte 1981). Water comes from rainwater and sheet flow. Most sheet flow comes from adjacent peatland and brings little nutrient input, but there may be limited influx of slightly less oligotrophic water from adjacent upland areas.

Vegetation: The Canebrake Subtype has an open woodland or savanna canopy of *Pinus serotina*, potentially codominant with *Gordonia lasianthus*, and with lesser amounts of *Magnolia virginiana* and *Persea palustris*. There generally is little or no understory. Below is a dense shrub layer with *Arundinaria tecta* dominant or abundant. Frequently burned examples may have little else in the shrub or herb layer. In the present, infrequently burned examples, broadleaf shrubs are present in moderate to large amounts, with *Lyonia lucida*, *Ilex coriacea*, *Ilex glabra*, and *Cyrilla racemiflora* most common. *Smilax laurifolia, Anchistea virginica*, and *Sphagnum* spp. may be present. Other species of the Typic Subtype may be expected to occur. In the one CVS plot taken in this subtype, *Clethra alnifolia* was abundant, and *Morella cerifera, Morella caroliniensis*, and *Lorinseria areolata* were also present. *Clethra alnifolia* was abundant in another well-documented example. Given the apparent heavy alteration to all or most remaining examples, the details of natural vegetation are not well known.

Range and Abundance: Ranked G1. Historical references suggest canebrakes once were common, when fire was more common. All remnant examples known are in outer Coastal Plain peatlands, most on the Pamlimarle Peninsula. It is unclear how extensively examples occurred in other regions of the state. The Canebrake Subtype likely once ranged into Virginia.

Associations and Patterns: Natural patterns and associations are poorly known. This subtype probably occurred as a large patch community, similar to most pocosins. Remnant examples are associated with Pond Pine Woodland (Typic Subtype) and with pocosin communities. In more natural landscapes, this subtype may have occurred on edges where peatlands bordered flammable vegetation.

Variation: Too little is known about natural patterns to distinguish variants. The few examples vary in the amounts and species of broadleaf shrubs, but it is unclear if this represents natural variation.

Dynamics: These communities are wet and nutrient poor, though less so than Low Pocosin or High Pocosin. There are suggestions that the Canebrake Subtype may be less nutrient poor than the Typic Subtype.

The natural dynamics of this subtype are not well known, but it is clear that its occurrence depends on fire and that it needs to burn more often than the Typic Subtype or Northern Subtype. *Arundinaria* replaces its biomass much more rapidly than typical shrubs after burning, giving it a competitive advantage over them for a few years after fire. Broadleaf shrubs will grow to predominate and suppress cane after several years if they are present. Frost (1989) suggests that in southeastern Virginia, Pond Pine Woodland-type sites that burned every 3-5 years would support dense, pure canebrake vegetation. With fire every 6-12 years they would alternate between canebrake and shrubby pocosin vegetation, while with less frequent fire *Pinus serotina* with dense shrubs would dominate.

However, feedback and persistent states can be expected to be important. Persistent frequent fire would eventually eliminate broadleaf shrubs, while persistent infrequent fire would lead to elimination of cane from sites. Neither shrubs nor cane would establish easily in sites dominated by the other, leading to stable states for each subtype over a broader range of fire regimes. Cane, in particular, fruits rarely and primarily reproduces vegetatively. Establishment of new populations where cane is absent must be very rare. Cane is more flammable than shrubs and will burn under a wider range of conditions. Cane, once established, would promote the more frequent fire that it needs, if sources of ignition are present. In practice, the remnant examples of the Canebrake Subtype occur where there has been some recent fire, but far less frequently than suggested by

Frost. Most have abundant broadleaf shrubs, but some have shrubs atypical of the Typic Subtype; it is not clear if this is a natural situation or an artifact of fire exclusion.

The relationship of the Canebrake Subtype of Pond Pine Woodland with treeless Peatland Canebrake communities is unclear. Treeless canebrakes could be created from this subtype by frequent and intense enough fire to prevent pond pine regeneration. Given the fire tolerance of established trees, they might persist with infrequent regeneration events when there were breaks in the regularity of fires. However, some historical canebrakes appear to have been on different soils that have not developed Pond Pine Woodlands with exclusion of fire.

It is possible that the Canebrake Subtype existed in a shifting mosaic where it alternated with the Typic or Northern Subtype and with Peatland Canebrake. However, both cane and broadleaf shrubs form dense stands, and both affect fire behavior in ways that would stabilize their dominance once established. It is perhaps more likely that the subtypes occupied different parts of a more stable landscape, responding to differences in prevailing fire frequency created by fire compartment size and by the configuration of more flammable vegetation.

It is also possible that this subtype represents a natural or unnatural transitional state with a relict canopy that is unable to regenerate. However, given the apparent different environment and a plausible mechanism for persistence, it seems best to regard it as a natural community.

Comments: Canebrakes in general apparently were abundant and extensive in early settlement times, but it is unclear how extensive Pond Pine Woodland canebrakes were.

Pinus serotina / Arundinaria gigantea ssp. tecta Wooded Wet Shrubland (CEGL003851) is another similar NVC association, but this distinction between woodland and wooded shrubland does not appear useful, given the rapid changes in structure that can accompany fires or succession following fire.

Bachman's warbler (*Vermivora bachmanii*) has been believed to be associated with cane stands. It is primarily associated with inland cane in bottomland hardwood, and it is unclear if it would have used these communities.

Rare Species:
Invertebrate animals – *Amblyscirtes reversa* and *Chlorochroa dismalia*.

PEATLAND CANEBRAKE

Concept: Peatland Canebrakes are treeless or sparsely treed vegetation dominated by *Arundinaria tecta* (less than 25 percent tree cover) in peatland and nonriverine wetland settings.

Distinguishing Features: Peatland Canebrakes are distinguished from all other peatland and nonriverine wetland communities by the dominance of *Arundinaria tecta* associated with tree cover less than 25 percent. Examples with more trees are included in the Canebrake Subtype of Pond Pine Woodland. Peatland Canebrakes are distinguished from Streamhead Canebrakes by occurring in flat or basin peatlands or nonriverine wetlands where rainfall and sheetflow, rather than seepage, are the main sources of water.

Crosswalks: *Arundinaria gigantea ssp. tecta* Wet Shrubland (CEGL003843).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).
Southern Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood Forest Ecological System (CES203.304).

Sites: Peatland Canebrakes are believed to occur in sites similar to those supporting Pond Pine Woodlands. Historically documented large examples are on shallow organic deposits or deeper peats with some input of mineral sediment. Canebrakes could potentially occur in peat-filled Carolina bays or swales in aeolian sand areas or other irregular surfaces in the outer Coastal Plain. Historical support for occurrence in these settings is less clear, but smaller patches may not have attracted comment. It is possible that Peatland Canebrakes occurred in a broader range of sites.

Soils: The full range of soils is not well known. It has been suggested in some earlier site descriptions that canebrakes may be more likely to occur on soils with higher mineral content than typical Pond Pine Woodland, but it is unclear if this is true. The few remnants in places where Peatland Canebrakes are historically documented include soils ranging from Terric Haplosaprists (Belhaven and Ponzer) to Histic Humaquepts (Wasda and Roper), to a Typic Endoaqualf (Hydeland).

Hydrology: Sites are seasonally to semipermanently saturated, but the full range of possible hydrology is not known.

Vegetation: Vegetation under natural conditions is believed to be a dense stand of *Arundinaria tecta*, likely 2-3 meters tall. Other details are poorly known. The few remnants tend to have abundant *Acer rubrum* var. *trilobum*, though presumably this species would quickly be eliminated under a natural fire regime. *Pinus serotina* is also abundant in some examples. Broadleaf pocosin shrubs such as *Lyonia lucida, Ilex glabra*, and *Cyrilla racemiflora* may be present, as may less typical pocosin shrubs such as *Clethra alnifolia*.

Range and Abundance: Ranked G1. Only small remnants, highly altered by exclusion of fire, remain. Historic references suggest this community once was common, or at least locally extensive, when fire was more common in peatlands. Hughes (1957), Biswell and Foster (1942), and some earlier writers described vast canebrakes on the wetlands of the Coastal Plain. Byrd

(1728) describes one called The Green Sea that took several days to cross. The most plausible remnant examples known are in outer Coastal Plain peatlands, but at least one possible example is reported on a stream terrace in the Sandhills. West (1934) described cane as abundant in the Embayed Region but did not mention dense canebrakes. However, he reported extant canebrakes in southeastern North Carolina. Both he and Wells (1946) mention *Arundinaria* in Holly Shelter, but it is not clear if it was this community. Peatland Canebrakes once ranged into Virginia, but occurrence in states to the south is less clear.

Associations and Patterns: Natural patterns and associations are poorly known. Most of the few remnants are associated with pocosins. However, the best documented historical canebrake, The Green Sea, appears associated with Coastal Plain Nonalluvial Wetland Forests, and other examples may also have been. Peatland Canebrakes at least sometimes occurred as large patch communities, similar to most pocosins. Remnant examples are associated with Pond Pine Woodland (Typic Subtype) and with various other pocosin communities. In more natural landscapes, this subtype may have occurred on edges where peatlands bordered more flammable vegetation.

Variation: Too little is known to recognize natural variation. The strong dominance of cane may have allowed little variation.

Dynamics: See the more extensive discussion under Pond Pine Woodland (Canebrake Subtype). Even more than that community, Peatland Canebrakes presumably depend on frequent fire. Frost (1989, 2000) suggests that Pond Pine Woodland-type sites with fire every 3-5 years would support dense, pure canebrake vegetation. With fire every 6-12 years they would alternate between canebrake and shrubby pocosin vegetation, while with less frequent fire *Pinus serotina* with dense shrubs would dominate. Peatland Canebrakes are often viewed as likely to have occurred in a shifting mosaic with other peatland communities. However, feedback presumably could help stabilize communities, with canebrakes promoting the frequent fire they need while broadleaf shrubs would reduce fire frequency. In addition, both cane and shrubs, if strongly dominant, would inhibit establishment by the other, allowing them to persist over a broader range of fire frequency.

Comments: This is one of the rarest and most altered natural communities in North Carolina, and therefore one of the hardest to understand. No substantial intact examples remain; the few unconverted remnants in places historically documented to be canebrakes are heavily altered by exclusion of fire and past land uses.

While vegetation called canebrake is believed to have been abundant in early settlement times throughout the Southeast, much was not comparable to these peatland communities of eastern North Carolina. The canebrake literature and descriptions reviewed by Platt and Brantley (1987) largely applies to very different communities of areas west of the Appalachians, where canebrakes are associated with large river bottoms and are dominated by *Arundinaria gigantea*. In the North Carolina Coastal Plain, however, despite the presence of abundant *Arundinaria tecta* along rivers, true canebrakes appear to have been associated with peatlands and streamheads.

Cane was widely regarded as excellent forage, and overgrazing apparently led to its demise in many places (Hughes 1957, Biswell and Foster 1942). Where cane remains abundant, canebrakes potentially could be restored simply by burning frequently.

Bachman's warbler (*Vermivora bachmanii*) has been believed to be associated with cane stands. This species is primarily associated with inland cane in bottomland hardwood, and it is unclear if it would have used these communities.

Rare species:
Invertebrate animals – *Amblyscirtes reversa*.

BAY FOREST

Concept: Bay Forests are natural peatland forests and woodlands dominated by varying combinations of *Gordonia lasianthus*, *Magnolia virginiana,* and *Persea palustris*.

Distinguishing Features: Bay Forest is distinguished from Pond Pine Woodland, Peatland Atlantic White Cedar Forest, High Pocosin, and other pocosin communities by canopy dominance of *Gordonia lasianthus*, *Magnolia virginiana,* or *Persea palustris* without an appreciable component of *Pinus serotina, Chamaecyparis thyoides,* or other canopy species.

Crosswalks: *Gordonia lasianthus – Magnolia virginiana – Persea palustris / Sphagnum* spp. Swamp Forest (CEGL007044).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).

Sites: Bay Forests occur near the edges of domed peatlands, in peat-filled Carolina bays, and in swales in aeolian sand areas or irregular sandy surfaces such as high stream terraces. Some seem to be associated with incipient drainage systems on the edges of peatlands. They may occur on shallow organic deposits or deeper peats with some input of mineral sediment.

Soils: Bay Forests occur on a wide variety of organic soils and mucky Spodosols, with no prevailing type. Series mapped for examples include Murville (Umbric Endoaquod), Lynn Haven (Typic Alaquod), Roper (Histic Humaquept), Ponzer, Belhaven and Croatan (Terric Haplosaprists), Pungo and Dorovan (Typic Haplosaprists). They may represent inclusions in some of these map units.

Hydrology: Sites are permanently or semipermanently saturated. As in Pond Pine Woodland, the water table probably regularly drops to underlying mineral sediment during the dry season, allowing plant roots to reach it (Otte 1981). Water comes from rainfall and sheet flow. Most sheet flow is from pocosins, but there may be limited influx of less oligotrophic water from adjacent areas. Snyder (1980) suggested an association with the beginnings of streams draining outward from peatlands, and this appears to be true for many examples. Stream flooding is unlikely in those areas, but they may have slightly better drainage.

Vegetation: The vegetation is a woodland or forest with a canopy dominated by evergreen hardwoods. *Gordonia lasianthus* is usually most abundant and sometimes strongly dominant. *Magnolia virginiana* and *Persea palustris* may be codominant or only a minor component. *Nyssa biflora, Acer rubrum* var. *trilobum*, *Pinus serotina, Pinus taeda*, or *Chamaecyparis thyoides* may also be minor components. There is not usually a differentiated understory, and, if there is, it consists of the same species. The shrub layer usually is dense, though it may be more open under denser canopy. Besides shrub-size individuals of the canopy species, *Lyonia lucida, Ilex coriacea, Ilex glabra, Cyrilla racemiflora, Clethra alnifolia,* or *Leucothoe axillaris* are likely to be dense. Other shrubs may include *Vaccinium fuscatum*, *Vaccinium formosum, Aronia arbutifolia*, and *Morella caroliniensis*. *Smilax laurifolia* often forms dense tangles, and a few other vines, including *Toxicodendron radicans*, *Muscadinia rotundifolia*, and other *Smilax* spp. may be present. Herbs are generally sparse. *Anchistea virginica, Lorinseria areolata*, and *Sphagnum* spp. are most frequent, but *Osmundastrum cinnamomeum* and even *Neottia bifolia (Listera australis)* may occur.

Range and Abundance: Ranked G4 but possibly rarer. Bay Forests may occur wherever there are peatlands or peat-filled Carolina bays, but are not known to be present in most of them. They probably are sometimes overlooked and are presumed to be more abundant than the number of records indicates. Their abundance is also confused by use of the term "bay forest" for a wider range of vegetation (Pond Pine Woodland, Nonriverine Swamp Forest, Natural Lake Shoreline Swamp, and altered vegetation). The equivalent association ranges southward to Florida. It may be more abundant in other states, but they may be using a broader definition than here.

Associations and Patterns: Bay Forests usually occur in association with Pond Pine Woodland and may also be associated with Peatland Atlantic White Cedar Forest or Nonriverine Swamp Forest. Many examples are associated with the beginnings of drainage channels on the edges of peatlands, grading into Cypress–Gum Swamp or Coastal Plain Small Stream Swamp downstream.

Variation: Examples vary with gradation to other communities. No variants are recognized.

Dynamics: The dynamics of Bay Forests are not well known. Various sources describe them as an end stage of succession for Peatland Atlantic White Cedar Forest, Pond Pine Woodland, or shrubby pocosins with the long absence of fire (Buell and Cain 1943; Kologiski 1977). Christensen (1988) suggests that shallow peat burns may allow *Chamaecyparis* or *Pinus serotina* establishment in Bay Forests. Many of these sources may be using the term more broadly, but it is a reasonable belief that the relatively shade-tolerant evergreen hardwoods, already present, would increase in the absence of natural disturbance. Trees that depend on catastrophic fire to regenerate, as *Pinus serotina* and *Chamaecyparis thyoides* do, would be succeeded by something else if they died out before a regenerating disturbance occurred.

However, field evidence for this is hard to find, despite both numerous wildfires in peatlands and numerous peatlands that have not burned. Peatland Atlantic White Cedar Forest that does not regenerate before the trees die, or that has lost its trees through logging, tends to be invaded by pines or deciduous hardwoods, and more resembles Nonriverine Swamp Forest. Pond Pine Woodlands that are logged and do not regenerate usually remain shrub dominated. Despite modern fire suppression, most large peatlands have burned well before the life span of *Pinus serotina*. Peatlands and Carolina bays that appear not to have burned since the era of modern fire suppression do not generally support Bay Forests in larger amounts than those that have burned. The author has observed several cases where an intense fire killed *Pinus serotina* in a Pond Pine Woodland and sprouting of evergreen hardwoods led to their dominance of the succeeding forest — Bay Forest was thus created by disturbance rather than by absence of disturbance.

The vegetational composition of Bay Forests, often containing a few species not found in other Peatland Pocosin communities but shared with more minerotrophic wetlands, suggests that site and soil factors may be important in their occurrence.

Rare species:
Vertebrate animals – *Dendroica virens waynei.*

STREAMHEAD POCOSINS THEME

Concept: Streamhead Pocosins are saturated wetlands of seepage-fed drainages in sandhill terrain, with mucky soils and with distinctive vegetation characterized by *Pinus serotina* or *Chamaecyparis thyoides* and a suite of mostly evergreen shrub species. The dominant shrub species are also characteristic of Peatland Pocosins, but some additional species are present. Most examples are in the Sandhills Region, but examples may occur in sandy areas elsewhere.

Distinguishing Features: Streamhead Pocosins are distinguished by the occurrence of pocosin, canebrake, or Atlantic white cedar vegetation in seepage-fed sandhill drainages in dissected topography. The suite of characteristic pocosin species consists of *Lyonia lucida, Ilex glabra, Ilex coriacea,* and *Cyrilla racemiflora,* along with the vine *Smilax laurifolia*, and the trees *Pinus serotina, Liriodendron tulipifera, Magnolia virginiana*, and *Persea palustris*. Alternatively, *Arundinaria tecta* may dominate the shrub layer. Peatland Pocosin communities have somewhat similar vegetation but occur in other environments: peatlands on broad flats, Carolina bays, and shallow swales in relict dune fields. *Liriodendron tulipifera*, *Oxydendrum arboreum*, and *Toxicodendron vernix* are common in Streamhead Pocosins but generally absent in Peatland Pocosins, as are rare species such as *Lindera subcoriacea*. *Chamaecyparis thyoides* may dominate the canopy, in association with these species.

Sandhill Streamhead Swamps also occur in seepage-fed sandhill drainages and share many of the characteristic pocosin shrubs. However, their canopy is dominated by different trees — *Nyssa biflora*, sometimes with *Pinus taeda* and *Acer rubrum* var. *trilobum*.

Sandhill Seeps often occur adjacent to the various Streamhead Pocosin communities, and the transition between them can be gradual. Sandhills Seeps are distinguished by a diverse herbaceous flora and a broader range of shrubs, though potentially sharing the pocosin shrubs. In the absence of fire, pocosin shrubs can spread and proliferate in them and obscure the natural boundary.

Sites: Streamhead Pocosins occur in the bottoms of narrow valleys in dissected sandhill terrain.

Soils: Soils are muck-rich mineral soils. The most frequently mapped soil series is Johnston (Cumulic Humaquept). Many are mapped as a complex of Bibb (Typic Fluvaquent) with Johnston, while many examples are mapped as upland soil units but represent inclusions. The few outer and middle Coastal Plain examples are generally mapped as Lynn Haven (Typic Alaquod), Murville (Umbric Endoaquod), or Torhunta (Typic Humaquept).

Hydrology: Soils are saturated most or all of the year but do not have standing water more than briefly. Though occurring in small floodplains, flood inundation is rare and short-lived. A distinct stream channel with a sandy bed generally is present, but other floodplain features generally absent. The surrounding sandy soils have rapid infiltration, and rainfall reaches the valleys gradually as shallow ground water. The streams show much less fluctuation in flow than other streams in North Carolina. The water is acidic and low in nutrients, because of the low mineral content of the sands through which it moves.

Vegetation: Vegetation is characterized by a dense shrub layer consisting of *Lyonia lucida, Ilex glabra, Ilex coriacea, Cyrilla racemiflora, Toxicodendron vernix, Persea palustris,* and *Magnolia virginiana,* rarely *Arundinaria tecta*, along with the vine *Smilax laurifolia.* It can be nearly impenetrable. Less common shrubs include *Vaccinium fuscatum, Vaccinium formosum, Morella caroliniana, Kalmia cuneata,* and *Lindera subcoriacea*. The canopy varies among communities, with *Pinus serotina* dominant in most, *Chamaecyparis thyoides* in the rarer Streamhead Atlantic White Cedar Forest, and with almost no canopy in Streamhead Canebrake communities. In all, *Liriodendron tulipifera, Persea palustris, Magnolia virginiana,* and occasionally *Oxydendrum arboreum* may be present and even abundant. *Acer rubrum* var. *trilobum* may invade in the long absence of fire, and *Nyssa biflora* may be present in examples transitional to Sandhill Streamhead Swamp. Herbs typically are sparse, with the most frequent species being *Anchistea virginica, Osmundastrum cinnamomeum, Lorinseria areolata*, and clumps of *Sphagnum* spp. Less common species include *Sarracenia flava, Sarracenia purpurea, Lycopus cokeri, Carex collinsii,* and *Carex austrodeflexa*. When intense fires repeatedly penetrate Streamhead Pocosins, herbs may become abundant, with *Osmundastrum cinnamomeum, Andropogon glomeratus*, *Erianthus* sp., and *Sphagnum* spp. becoming abundant.

The ecotone at the edge of Streamhead Pocosin communities, if regularly subject to fire from the adjacent uplands, has a diverse herbaceous flora. Many species shared with Sandhill Seep and Pine Savanna communities may be present in a narrow band, sometimes including *Ctenium aromaticum, Muhlenbergia expansa, Sporobolus brevipilis*, as well as most of the above herbs. Rare species such as *Lysimachia asperulifolia* and *Dionaea muscipula* may be present.

Dynamics: The perennial saturation caused by seepage from the adjacent sandy uplands appears to be the crucial environmental driver for the Streamhead Pocosins communities. Inhibition of decomposition by saturation presumably leads to low nutrient levels in the soil and accumulation of organic matter. The low availability of nutrients in the seeping water prevents it from supporting a richer community such as Low Elevation Seep. However, nutrients released by fires in the uplands, whether the streamhead burns or not, must periodically enrich the pocosin to some degree.

All communities in the Streamhead Pocosins theme are naturally shaped by fire, but the details of their natural dynamics are not well known. As narrow bands of vegetation bordering sandhill communities that burn very frequently, they would not lack for ignition under natural conditions. However, occurring downhill from them and having wet soils, flammability is limited, and ignition must depend on particular weather conditions. The conditions chosen for contemporary prescribed burns may be different enough from times of natural fire that the fire regime is quite altered even in landscapes where the adjacent longleaf pine vegetation is well maintained by fire. The three communities within this theme vary substantially in the fire regime that would sustain them, and variation in fire dynamics may be the only thing determining which occurs in a given place. Their relationship to Sandhill Streamhead Swamp may be similarly determined by fire dynamics.

Different streamhead communities can give way to each other along the length of a single drainage, and do not necessarily occur in a consistent order. It is unclear if streamhead communities represent a shifting mosaic or a stable landscape pattern. The vegetation could represent the recent fire history, with any community capable of changing into any other if subjected to a different kind of fire. Alternatively, predominant natural fire behavior may be substantially controlled by topography and wetness, leading to stable mosaics of different communities. Feedback of vegetation on fire behavior might also stabilize the patterns. *Arundinaria tecta* tends to promote the frequent fire that it needs to maintain dominance, while pocosin shrubs are flammable but under a narrow range of conditions. Atlantic White Cedar Forest is less flammable, while swamp vegetation reduces flammability even further.

Many streamheads are also subject to impoundment by beavers. Thus, Coastal Plain Semipermanent Impoundment communities are also part of a potential shifting mosaic. However, as with fire, site characteristics may make some locations subject to impoundment while others are not. Ponds modify the site conditions for a long time even after the pond is drained, and these changes along with vegetation will affect fire regimes. Beavers, rather than fire, may be the primary cause of the mosaics in streamhead sites.

As with Pond Pine Woodland, the herb-rich ecotone of Streamhead Pocosins with adjacent longleaf pine communities is very vulnerable to changes caused by inadequate fire. The pocosin shrubs and trees can quickly become dense in the ecotone and can spread beyond the ecotone for some distance into the adjacent uplands, obscuring the natural boundary of the communities. Remnant *Pinus palustris*, *Aristida stricta*, or other plants of longleaf pine communities will indicate this situation, but without them it may be impossible to determine. The number of places where Streamhead Pocosin vegetation extends well uphill of the flat stream bottom may suggest that such shifting of boundaries is widespread, though there is no reason these seepage-dominated communities could not naturally extend some distance upslope. In the past, fire managers often placed firebreaks or plow lines in the ecotone, which led to a sharpening of the boundary as shrubs quickly overgrew the unburned side. Even in places where ecotones have not been plowed in many years and where prescribed burning is frequent, prescription conditions can be too moist for Streamhead Pocosins to ever ignite. The observations of Frost (2000) that an organic soil surface layer can accumulate in wet longleaf pine communities in just several decades without fire likely would apply to Streamhead Pocosin borders as well. The confusion of natural boundaries of Streamhead Pocosins is further confounded when Sandhill Seep communities occur adjacent to them. Sandhill Seeps are extremely prone to proliferation of pocosin shrubs and when not burned can quickly become indistinguishable from Streamhead Pocosin vegetation.

In a few places, Streamhead Pocosin communities have been subjected to annual or near-annual burning. In this situation, fires penetrate parts of the community frequently, leading to boggy herbaceous vegetation which appears to be a mix of successional species (e.g. *Andropogon glomeratus*, *Rhynchospora* spp.) and longer lived species (e.g. *Osmundastrum cinnamomeum*) along with dense sprouts of shrubs. Other parts of these streamheads retain the tall shrub layer typical of less frequently burned examples. It is unclear how much this resembles a natural situation. The vegetation does not appear to be at equilibrium, as trees are not able to reproduce with such frequent fire and the canopy gradually becomes sparser. It is unclear what the long term resulting vegetation would look like. If *Arundinaria* were able to establish, a canebrake may be a likely end point, but it is not seen in some areas that have been burned annually for many years.

KEY TO STREAMHEAD POCOSINS

1. Tree canopy absent or total cover of trees and broadleaf shrubs less than 25% under natural conditions, and *Arundinaria tecta* dominant .... **Streamhead Canebrake**
1. Tree canopy present, or total cover of trees and broadleaf shrubs >25%; *Arundinaria tecta*, if present, not dominant in the shrub layer.
   2. Tree canopy dominated by *Pinus serotina*, with or without *Liriodendron tulipifera* ……… …………………………………………………………………… **Streamhead Pocosin**
   2. Tree canopy not dominated by *Pinus serotina*.
      3. Tree canopy dominated by *Chamaecyparis thyoides*…………………………………… ………………………………………………... **Streamhead Atlantic White Cedar Forest**
      3. Tree canopy dominated by *Nyssa biflora* or *Acer rubrum*, sometimes with *Pinus taeda* (*Chamaecyparis* or *Pinus serotina* may be present in small numbers). .... **Sandhill Streamhead Swamp in Coastal Plain Floodplains theme**

STREAMHEAD POCOSIN

Concept: Streamhead Pocosins are pocosin woodlands or shrublands occurring in mucky, seepage-fed drainages in the Sandhills Region and rarely elsewhere in the Coastal Plain in similar dissected uplands with sandy soils and seepage-fed streams.

Distinguishing Features: Streamhead Pocosins are distinguished from other pocosin communities by their occurrence in drainages in dissected sandhill terrain, with flowing or seepage water, rather than on peat domes or in depressions fed mainly by rain water. *Liriodendron tulipifera* is often, but not always, a component of this type and is never present in other pocosin types. *Clethra alnifolia, Toxicodendron vernix,* and *Oxydendrum arboreum* are often present in this type and seldom present in other types of pocosins. *Gordonia lasianthus*, common in various Peatland Pocosins, is absent in Streamhead Pocosins. Streamhead Pocosins are distinguished from Streamhead Atlantic White Cedar Forest and Sandhill Streamhead Swamp by canopy predominance of *Pinus serotina*. Streamhead Pocosins that have repeatedly burned through have boggy herbaceous vegetation. In places with long absence of fire, vegetation resembling Streamhead Pocosin spreads uphill into Sandhill Seep sites and even into less wet areas and be difficult to distinguish.

Crosswalks: *Pinus serotina - (Liriodendron tulipifera) / Lyonia lucida - Clethra alnifolia - Ilex glabra* Swamp Woodland (CEGL004435).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Streamhead Seepage Swamp, Pocosin and Baygall Ecological System (CES203.252).

Sites: Streamhead Pocosins occur along mucky headwater and small stream bottoms in dissected sandhill areas, where soils are kept saturated by seepage.

Soils: Soils are mucky mineral soils, most often mapped as Johnston (Cumulic Humaquept).

Hydrology: Hydrology is typical of the theme as a whole, with long-term saturation by nutrient-poor water but with little or no stream flooding or standing water.

Vegetation: Vegetation structure is generally a shrubby woodland or savanna. The tree canopy can range from sparse to dense, depending on recent fire history. Understory trees generally are sparse. The shrub layer is generally dense and tall, and herbs are sparse. The canopy is dominated by *Pinus serotina*. *Liriodendron tulipifera* is often present and sometimes abundant. *Nyssa biflora* or *Acer rubrum* var. *trilobum* may be present in small numbers, larger where fire has long been suppressed. Other trees, usually in the understory but occasionally in the canopy, include *Persea palustris*, *Magnolia virginiana*, and *Oxydendrum arboreum*. The dense shrub layer generally is dominated by *Lyonia lucida*, *Ilex coriacea*, *Cyrilla racemiflora, Ilex glabra*, and *Clethra alnifolia.* Other shrubs include *Toxicodendron vernix, Vaccinium fuscatum, Vaccinium formosum*, *Aronia arbutifolia,* and the rare shrub *Lindera subcoriacea. Arundinaria tecta* may be present in small to moderate amounts. *Smilax laurifolia* often forms dense tangles. Other vines are few and limited to acid-tolerant wetland species such as *Smilax rotundifolia* and *Muscadinia rotundifolia*. The most frequent herbs are *Anchistea virginica* and *Osmundastrum cinnamomeum*. Other herbs may include *Steinchisma areolata*, *Carex lonchocarpa*, *Carex collinsii*, *Carex austrodeflexa*, *Carex* species, *Hexastylis sorriei, Sarracenia flava*, and *Sarracenia purpurea*. Clumps of *Sphagnum* spp. are usually present. Streamhead Pocosins that have repeatedly burned through may have areas of boggy herbaceous vegetation dominated by species such as *Osmundastrum cinnamomeum*, *Andropogon glomeratus*, and *Erianthus* spp. CVS plot data show a high frequency for *Gaylussacia frondosa* and show presence of a large number of other species that clearly are associated with the edges and are not characteristic of the community as a whole.

Where Streamhead Pocosin borders upland communities, a distinct ecotonal zone often occurs, where the more frequent fire of the uplands interacts with the wetter soils of the pocosin. This ecotonal zone, while too small to be classified as a separate community, often resembles a Pine Savanna or Sandhill Seep, with a high diversity of herbaceous plants and some shrubs absent from both of the adjoining communities. *Osmundastrum cinnamomeum* often is dominant, and *Ctenium aromaticum, Rhynchospora* spp., *Oxypolis ternata, Sarracenia flava, Sarracenia rubra, Sarracenia purpurea*, and many other species may occur. This ecotone is the primary habitat for a number of rare plant species in the Sandhills Region, including *Lysimachia asperulifolia, Dionaea muscipula,* and *Lilium pyrophilum*, as well as uncommon species such as *Kalmia cuneata*, *Fothergilla gardenii*, and *Calamovilfa brevipilis*.

Range and Abundance: Ranked G4. Streamhead Pocosins are abundant through the Sandhills region of North Carolina and South Carolina. They rarely are recognized in dissected sandhill-like terrain in the outer Coastal Plain. They range into South Carolina, where they probably are also abundant throughout the Sandhills region.

Associations and Patterns: The ecological relationship among the different communities of Sandhills streamheads is not entirely clear. While there is a general trend from Streamhead Pocosin upstream to Sandhill Streamhead Swamp downstream, these communities, along with Streamhead Atlantic White Cedar Forest, Streamhead Canebrake, and Coastal Plain Semipermanent Impoundment, may alternate along the length of a given drainage.

Streamhead Pocosins are sometimes bordered by Sandhill Seeps. Their boundary can be gradual and can be blurred by the effects of fire exclusion. Otherwise, Streamhead Pocosins generally are bordered by Pine/Scrub Oak Sandhill communities, less commonly by Xeric Sandhill Scrub.

Variation: No variants have been defined. Examples vary in structure and composition over a wide range, apparently in response to fire history.

Dynamics: Dynamics are similar to the theme as a whole, with fire playing an important role, but with appropriate fire regimes not well known. As in other pocosin communities, fire is needed to allow regeneration of *Pinus serotina*. It is unclear how often fire in adjacent sandhill communities would penetrate into Streamhead Pocosins under natural conditions. Prescribed fires are often done under mild conditions where it does not penetrate at all, sometimes deliberately using the pocosins as firebreaks. When fires occur in this community, they tend to be patchy, leaving unburned shrub patches, patches of top-killed or consumed shrubs, and patches with dead or scorched trees. Repeated fires in the same area can create more persistent herbaceous dominance. This variation in fire causes variable vegetation structure in some examples. Trees may also blow down in wind storms, but fire is likely the predominant cause of tree mortality where it occurs.

Even when Streamhead Pocosins do not burn with the adjacent uplands, they are affected by scorching along the ecotone, and by input of nutrients released in the ash. The combination of more frequent disturbance and somewhat more nutrients may account for the higher shrub and tree diversity in these communities than in other pocosin types.

Comments: Many general writings on pocosins mention streamheads as a site for pocosin vegetation, without describing them specifically in detail (e.g., Otte 1981; Sharitz and Gibbons 1982). It is not clear how much of the general information on pocosins applies to them. The smaller size, different hydrology, nutrient availability, and fire dynamics make them distinct from the peatland pocosins.

Rare species:
Vascular plants – *Carex austrodeflexa, Eupatorium resinosum, Hypoxis rigida,* and *Lindera subcoriacea*. Ecotones only – *Carex exilis, Dionaea muscipula, Eriocaulon texense, Lilium pyrophilum, Lysimachia asperulifolia, Parnassia caroliniana, Platanthera nivea, Rhynchospora macra,* and *Xyris scabrifolia*.

Vertebrate animals – *Hyla andersonii*.

STREAMHEAD ATLANTIC WHITE CEDAR FOREST

Concept: Streamhead Atlantic White Cedar Forests are forests dominated by *Chamaecyparis thyoides* in mucky, seepage-fed drainages in the Sandhills Region and rarely in similar Coastgal Plain terrain with sandy uplands and seepage-fed streams.

Distinguishing Features: Streamhead Atlantic White Cedar Forests are distinguished from Streamhead Pocosin and Sandhill Streamhead Swamp by having canopies with over 50 percent *Chamaecyparis thyoides* cover or basal area. They are distinguished from Peatland Atlantic White Cedar Forests by occurring in mucky, seepage-fed drainages in sandhill terrain. *Liriodendron tulipifera* is often, but not always, present, and additional species characteristic of streamheads and not peatlands, such as *Toxicodendron vernix* or *Oxydendrum arboreum*, may be present.

Crosswalks: *Chamaecyparis thyoides - (Liriodendron tulipifera) / Lyonia lucida* Swamp Forest (CEGL007563).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Streamhead Seepage Swamp, Pocosin and Baygall Ecological System (CES203.252).

Sites: Streamhead Atlantic White Cedar Forests occur along mucky headwater and small stream bottoms in dissected sandhill areas, where soils are kept saturated by seepage.

Soils: Soils are wet and acidic, with an organic layer overlying or interbedded with clay or sand. They are usually mapped as Johnston (Cumulic Humaquept), occasionally as Torhunta (Typic Humaquept) or other series.

Hydrology: Hydrology is typical of the theme as a whole, with long-term saturation by nutrient-poor water but with little or no stream flooding or standing water.

Vegetation: Streamhead Atlantic White Cedar Forests have *Chamaecyparis thyoides* dominant or codominant, unless recently disturbed. *Acer rubrum* var. *trilobum*, *Pinus serotina, Pinus taeda*, and *Liriodendron tulipifera* are frequently present and may codominate. *Nyssa biflora* may also occur. The understory is usually open. In CVS plot data and in site descriptions, *Persea palustris* and *Magnolia virginiana* occur with high constancy, and canopy species, especially *Acer rubrum*, may also be present. Other understory species may include *Oxydendrum arboreum, Ilex opaca*, and occasional trees from adjacent upland communities. The shrub layer is generally moderate to dense. *Lyonia lucida* is the most constant dominant shrub in CVS plot data, but *Clethra alnifolia, Ilex coriacea*, *Arundinaria tecta*, and *Leucothoe axillaris* are frequent and sometimes dominant. Though less frequent in plot data, *Ilex glabra* and *Cyrilla racemiflora* are often observed to be abundant. Less dominant shrubs with high or moderate frequency in plot data and observations include *Viburnum nudum, Vaccinium formosum, Vaccinium fuscatum, Toxicodendron vernix, Vaccinium virgatum, Aronia arbutifolia, Morella caroliniensis, Rhododendron viscosum, Symplocos tinctoria*, and, in parts of Fort Liberty, *Kalmia latifolia*. Vines, particularly *Smilax laurifolia*, may be abundant. *Smilax rotundifolia, Smilax glauca, Muscadinia rotundifolia*, and *Gelsemium sempervirens* are also at least moderately frequent. Herbs are generally low in cover, but *Osmundastrum cinnamomeum* is highly constant and sometimes abundant. Sphagnum spp.

may have moderate cover in patches. Oher herbs, at moderate to low frequency, include *Osmunda spectabilis, Pteridium pseudocaudatum, Uvularia puberula, Dichanthelium* sp,, *Mitchella repens, Hexastylis sorriei,* and *Orontium aquaticum*.

Range and Abundance: Ranked G1. More than 20 occurrences are known in North Carolina, suggesting G2 or even G3 would be appropriate. However, they are under high threat from logging as well as from loss due to natural blowdown, fire, and, potentially, impoundment by beavers. The small size of stands and limited amount available in the region where they occur makes them less attractive for systematic logging than Peatland Atlantic White Cedar Forests, but stands are generally more accessible. In North Carolina, Streamhead Atlantic White Cedar Forests are primarily in the Sandhills region, but scattered examples occur elsewhere in the inner and middle Coastal Plain. This community ranges southward to Georgia.

Associations and Patterns: Streamhead Atlantic White Cedar Forests are small to large patch communities that occur along drainage systems that also support Streamhead Pocosin, Sandhills Streamhead Swamp, Streamhead Canebrake, or Coastal Plain Semipermanent Impoundment. These communities often are interspersed along the drainage in an unpredictable pattern. On the upland side, they may be bordered by any upland community, but Pine/Scrub Oak Sandhill (Blackjack Subtype) is the most common. The largest occurrences are up to 40 acres, but many occurrences are less than 10 acres.

Variation: No systematic pattern of variation has been identified, other than areas transitional to adjacent communities. Vegetation varies in the short term in response to fire.

Dynamics: The dynamics of Streamhead Atlantic White Cedar Forests are not well studied. It is unclear how much the distinctive dynamics of Peatland Atlantic White Cedar Forests apply to them. The shade intolerance, intolerance of fire, and ability to regenerate rapidly after fire in some circumstances likely lead to even-aged stands in streamheads as they do in peatlands. However, Moore and Carter (1987) observed both even-aged and uneven-aged stands of this type. They noted that as stands age, the cedar canopy becomes more open and the hardwoods listed above begin to invade. Although *Chamaecyparis thyoides* is generally regarded as being intolerant of fire, they also noted charred bases on some of the older trees. It is unlikely, however, that these communities burn more than rarely.

As with their peatland counterparts, it is possible that Streamhead Atlantic White Cedar Forests existed naturally as a shifting mosaic. Streamhead Pocosin might develop if fire was frequent in any area, Streamhead Canebrake if it was very frequent, and Sandhill Streamhead Swamp if too much time passed without a fire. Moore and Carter (1987) also noted that cedar was able to invade adjacent wet grassy areas when fire was suppressed. Coastal Plain Semipermanent Impoundment would appear in random places if beavers moved into an area. Possibly Sandhill Streamhead Swamp rather than the other communities would develop after beaver ponds were abandoned. Alternatively, the observed mosaics may be long-term patterns, created by the ease of fire spread into the drainage and the desirability of the area to beavers.

Comments: Streamhead Atlantic White Cedar Forests have had very little study in comparison with Peatland Atlantic White Cedar Forests. Many of the summaries and reviews address the two together, but streamheads are generally mentioned only in passing as an additional habitat for the species.

Streamhead Atlantic White Cedar Forest was included with the Peatland Atlantic White Cedar Forest type in the 2nd Approximation, but they were distinguished in the 3rd Approximation. The distinction between them is parallel to the distinction between Streamhead Pocosin and Pond Pine Woodland. The two types differ in hydrology, fire dynamics, and successional trajectories. Of particular note is the importance of *Liriodendron tulipifera* in the Streamhead Atlantic White Cedar Forest, though it is unclear what aspect of the environment or dynamics leads to its frequent presence.

Rare species:
Vascular plants – *Carex austrodeflexa, Eupatorium resinosum, Lindera subcoriacea, Sagittaria isoetiformis, Scirpus etuberculatus*, and *Xyris chapmanii*.

Invertebrate animals – *Callophrys hesseli* and *Hypagyrtis brendae*.

STREAMHEAD CANEBRAKE

Concept: Streamhead Canebrakes are treeless or sparsely treed communities dominated by *Arundinaria tecta* in seepage-fed drainages. Tree plus broadleaf shrub cover is generally less than 25 percent in good examples but may be higher if fire frequency has been reduced. Most of this rare community type is in the Sandhills Region, but it might occur in relict sand dune areas elsewhere in the Coastal Plain.

Distinguishing Features: Streamhead Canebrakes are distinguished from other communities of seepage-fed streamheads by the dominance of *Arundinaria tecta* combined with low cover of trees and other shrubs (less than 25 percent). They are distinguished from Peatland Canebrakes by occurring in streamheads rather than in flat or domed peatlands, Carolina bays, or shallow outer Coastal Plain swales.

Crosswalks: *Arundinaria gigantea ssp. tecta* Wet Shrubland (CEGL003843) (not distinguished from Peatland Canebrake in NVC).
G186 Southeastern Coastal Pocosin & Shrub Bog Group.
Atlantic Coastal Plain Streamhead Seepage Swamp, Pocosin and Baygall Ecological System (CES203.252).

Sites: Streamhead Canebrakes occur along mucky headwater and small stream bottoms in dissected sandhill areas, where soils are kept saturated by seepage.

Soils: Soils are mucky mineral soils, most often mapped as Johnston (Cumulic Humaquept).

Hydrology: Hydrology is typical of the theme as a whole, with long-term saturation by nutrient-poor water but with little or no stream flooding or standing water.

Vegetation: Vegetation consists of a dense thicket of *Arundinaria tecta* and limited cover of broadleaf shrubs. *Pinus serotina, Liriodendron tulipifera, Pinus taeda*, *Nyssa biflora*, and *Magnolia virginiana* may form a sparse canopy. Any of the species of Streamhead Pocosin may be present in moderate numbers. *Lyonia lucida* is the most abundant other shrub in limited CVS plot data. *Clethra alnifolia, Viburnum nudum,* and *Toxicodendron vernix* have high constancy, and *Ilex glabra* is abundant in some plots. *Smilax laurifolia* is universally present but not extensive, *Muscadinia rotundifolia* is usually present, and *Smilax rotundifolia* is sometimes abundant. Herbs may be sparse to moderate in density in the interior. *Osmundastrum cinnamomeum, Lorinseria areolata,* and *Anchistea virginica* are fairly frequent and abundant. Gray et al. (2016), working with whole-site species lists for a larger number of sites (13), found *Osmundastrum cinnamomeum* and *Pinus serotina* to be the most constant species, along with *Arundinaria. Sphagnum* spp., *Acer rubrum, Magnolia virginiana, Liriodendron tulipifera, Nyssa biflora,* and *Toxicodendron vernix* are other species that were in more than half the sites. As in other streamhead communities, a narrow ecotone zone in the transition to adjacent sandhills is often diverse and contains species not otherwise present in either community. Any of the species many occur in the ecotone of any of the streamhead communities. Additional species in more than half of Gray et al.'s (2016) sites, and presumably ecotone species, are *Lysimachia asperulifolia, Eupatorium resinosum, Eupatorium rotundifolium,* and *Polygala lutea*. Other edge species in their study included *Ctenium* *aromaticum, Dionaea muscipula, Pogonia ophioglossoides, Carex glaucescens, Dichanthelium scabriusculum, Sarracenia rubra, Zigadenus glaberrimus, Drosera capillaris, Erianthus giganteus,* and *Xyris platylepis*.

Range and Abundance: Ranked G1. Streamhead Canebrakes are not distinguished from Peatland Canebrakes in the NVC, but they clearly occur in South Carolina and Georgia as well as North Carolina (Gray et al. 2016). All known examples are in the Sandhills Region, but occasional examples could occur in other dissected sandy areas of the outer Coastal Plain. Given the number of examples reported, the G1 rank may warrant revisiting, but most examples are in altered condition or only recently restored.

Associations and Patterns: Streamhead Canebrakes are associated with other streamhead communities, potentially including Streamhead Pocosin, Streamhead Atlantic White Cedar Forest, Sandhill Streamhead Swamp, and Coastal Plain Semipermanent Impoundment. Often several streamhead communities can be found along the length of a stream valley, not always in the same order.

Along the upland edges, Streamhead Canebrakes are sometimes bordered by Sandhill Seeps. Otherwise, they generally are bordered by Pine/Scrub Oak Sandhill communities, less commonly by Xeric Sandhill Scrub.

Variation: No variants have been defined. Examples vary in structure and composition over a wide range, apparently in response to fire history.

Dynamics: Dynamics are generally similar to the theme as a whole, but Streamhead Canebrakes clearly burn more frequently than other streamhead communities and undoubtedly depend on frequent fire for their maintenance. *Arundinaria* recovers more rapidly from fire than broadleaf shrubs, and frequent fire gives it a competitive advantage. At the same time, *Arundinaria* is more flammable and likely promotes more frequent spread of fire from the frequently burned uplands. Gray et al. (2016) found that about 2 years was the optimal fire return interval for *Arundinaria* dominance and noted that mean fire return interval was more important than time since last fire. This is more frequent than has generally been suggested as optimal for cane. They also noted that Sandhills region cane is shorter than that elsewhere, and that this may make frequent fire more important in retaining its dominance.

Peatland Canebrakes occur only in landscapes that have had frequent fire for some decades, such as on Fort Liberty and the Sandhills Game Land. However, the increase in prescribed burning in recent years has led to apparent formation or revival of examples. Gray et al. (2016) found that canebrakes they studied on frequently burned military bases had increased in size since the 1940s and 1950s. Examples observed on the Sandhills Game Land clearly developed from Streamhead Pocosin vegetation in the last few decades, having remnant canopy trees and patches of broadleaf shrubs. However, even in frequently burned landscapes, canebrakes are a small part of streamhead systems; Streamhead Pocosin or Sandhill Streamhead Swamp communities are more extensive. It is not clear if this set of communities forms a shifting mosaic driven by fire history, or if each is tied to subtly distinct sites within the landscape.

Comments: The NVC does not distinguish between Streamhead and Peatland Canebrakes. However, given the substantial environmental differences and the presence of floristic differences comparable to those between other streamhead and peatland communities, the author believes they should be treated as distinct. The lists of associated species included in Gray et al. (2016) includes numerous species not found in Peatland Canebrakes, though most may be in ecotones. Streamhead Canebrake dynamics and conservation status are quite different. Streamhead Canebrakes appear to be increasing, and they appear to be readily recoverable in many sites if there is frequent fire.

Rare Species:
Vascular plants – *Carex austrodeflexa, Dionaea muscipula, Lilium pyrophilum, Lysimachia asperulifolia,* and *Parnassia caroliniana*.

Invertebrate animals – *Apameine* new genus 2 sp. 3 and *Leucania calidior*.

WET PINE SAVANNAS THEME

Concept: Wet Pine Savannas occur in seasonally saturated sites in the Coastal Plain and lower Piedmont, where the frequent natural fire that once occurred could promote open woodland or savanna vegetation structure dominated or codominated by *Pinus palustris* or, less often, *Pinus serotina*, along with a dense herbaceous layer.

Distinguishing Features: Wet Pine Savannas in natural condition are distinguished by a dense herbaceous layer dominated by characteristic grasses and species of grass-like growth form, including *Aristida stricta, Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa, Calamovilfa brevipilis, Rhynchospora* spp., *Andropogon cretaceus* (*glaucopsis*)*, Pleea tenuifolia*, and *Sporobolus teretifolius*. Dry Longleaf Pine Communities are dominated by *Aristida stricta* but lack most of the other species entirely. In the few rare subtypes of Mesic Pine Savanna in which some of them occur, they cooccur with scrub oaks which are absent in Wet Pine Savannas. The Wet Pine Savannas canopy is usually dominated by *Pinus palustris* but may be dominated by *Pinus serotina* or may be largely absent. With long absence of fire, wetland shrubs may become dense, so that it may become difficult to distinguish savannas from Pond Pine Woodland. However, with the exception of *Rhynchospora* and *Andropogon*, the presence of even small numbers of the above species indicates that a site was an open Wet Pine Savanna, as does the presence of remaining *Pinus palustris*.

Within this theme, communities are differentiated by environmental gradients of moisture and soil texture, as well as by biogeography. Wet Pine Flatwoods, with lower species richness, occur on the marginally wet coarse sandy soils, while the various Pine Savanna communities, most with high species richness, are either clearly wetter or occur on loamy soils. Some communities have distinctive subtypes confined to the Sandhills or to various parts of the Coastal Plain. A couple are differentiated by dominance by species of limited geographic range: *Pleea tenuifolia* and *Kalmia (Leiophyllum) buxifolia*. Otherwise, most of the dominant species are shared by multiple communities and type and subtype distinctions are made based on broader floristic differences.

Sites: Wet Pine Savannas were naturally extensive in flatter parts of the Coastal Plain. Remnants occur on relict dunes and sand sheets, on ridges embedded in peatlands, and on flat upland terraces. In the Sandhills, they occur in small wet swales and in sloping seeps. The rare Piedmont examples occur on wet upland flats.

Soils: Wet Pine Savannas can occur on a wide variety of wet Ultisols and on wet Spodosols such as the Leon series.

Hydrology: Wet Pine Savannas are seasonally saturated to near the ground surface but rarely hold standing water. In most, saturation comes from a seasonal high water table. A few, especially in the Sandhills, are saturated by groundwater discharge induced by clay layers in the substrate.

Vegetation: Wet Pine Savannas characteristically have an open to very open canopy, usually consisting solely of *Pinus palustris* but sometimes dominated or codominated by *Pinus serotina*. The herb layer is dense. The dominant species may be *Aristida stricta* or may be any one or combination of several other characteristic wetland graminoids: *Sporobolus pinetorum, Ctenium* *aromaticum, Muhlenbergia tenuifolia, Sporobolus teretifolius, Pleea tenuifolia*, and several *Rhynchospora* species. These may be patchy within a savanna, or one may dominate across the entire community. In many Wet Pine Savanna communities, the herb layer in examples that are in good condition has very high species richness, with many associated graminoids and forbs, including multiple insectivorous species, several orchids, numerous composites, but few or no legumes. Species richness values at fine scales (10 meters and less) are some of the highest recorded in the world (Walker and Peet 1983). A few of the sandy communities have lower species richness even when in the best condition.

Wet Pine Savannas generally have no more than sparse midstory trees, except where regenerating pines are growing up in canopy gaps. Scrub oaks are absent, but other hardwood species may proliferate in the absence of fire. When frequently burned, shrubs are sparse or patchy, but examples with a history of fire suppression may have extensive cover of shrubs or the trailing *Vaccinium crassifolium*.

Dynamics: See the extensive discussion of dynamics for the Dry Longleaf Pine Communities theme. Most of the processes and patterns are common to Wet Pine Savannas as well, including the crucial role of frequent fire, the population structure and behavior of *Pinus palustris*, the conservative life histories of much of the flora, and the difficulty of restoration. Indeed, a significant portion of the research cited there was done in wet savannas.

Wet Pine Savannas may differ from Dry Longleaf Pine Communities in several ways that may increase complexity. Production of biomass is faster than in the drier sandhills, though it probably is not greater than in Mesic Pine Savannas. In both wet and in drier communities, soil texture is an important driver of differences in communities (Palmquist et al. in prep. a, Taggart 1990, Peet et al. 2014). Since production is more limited by nutrients (Christensen 1977, Walker and Peet 1983) and less by lack of water in the wetland communities, nutrient holding capacity is probably more important than water holding capacity as a cause for the differences in communities between sandy and loamy soils. However, soil saturation may limit productivity in wetter years, and sandy soils may possibly become dry in seasons when the water table is low.

More than in drier systems, the variety in dominants in the herb layer may potentially affect fire dynamics. It also raises questions about the interactions among dominants. Patchiness in the herb layer may be readily observed, some clearly related to microsite differences but some perhaps having other causes. At least a few of the characteristic dominants (*Rhynchospora* and *Andropogon*) appear to be less conservative than most herbs of longleaf pine communities, and this suggests a possibility of shifting patterns over time or of a role for more severe disturbance. As detailed by Palmquist et al. (2015), the interaction of soil environment with fire regime and changes in fire regime may be quite complex and may play out differently at different spatial scales. The higher productivity of loamy soils may allow for faster changes, and though the dominant herbs are quite stable, changes in fine-scale species richness can happen quickly.

Additionally, *Pinus palustris* may interact with other potential canopy tree species, usually *Pinus serotina*. Though this species is present in some of the apparently least altered wet savannas, it is unclear if this is a natural state or is the result of past fire suppression and logging. *Pinus serotina* is usually present in adjacent communities. It is well adapted to surviving fire as mature trees but is less well suited to reproducing with frequent fire. Pond pine regeneration would depend on a longer fire-free interval than the 2-3 years thought to prevail under more natural conditions, but such intervals may have occurred frequently enough to allow it to coexist in some sites. In addition, more than in drier systems, some relatively unaltered Wet Pine Savannas have little or no tree cover, a situation that may be related to fire intensity created by the dense herb layer, to intense fires in adjacent Pond Pine Woodlands, or to difficultly of pine regeneration because of wetness.

Wet Pine Savannas may contain minor amounts of hardwoods shared with pocosins, particularly *Persea palustris* and *Magnolia virginiana*. Tall shrubs such as *Cyrilla racemiflora* and *Vaccinium fuscatum*, even *Ilex myrtifolia*, may also occur. These species likely existed in small patches and wetter microsites, but with long suppression of fire they have often proliferated. A great variety of shrubs also tends to proliferate in the absence of fire, including most of those found in Peatland Pocosins as well as most of those in Dry Longleaf Pine Communities. *Arundinaria tecta* may also occur and become dense or widespread. While a sandhill community altered by lack of fire remains dominated by scrub oaks and is recognizable as an altered example, Wet Pine Savannas may become so dominated by shrubs and *Pinus serotina* that they are difficult to distinguish from Pond Pine Woodland. The productive vegetation and inhibited decomposition in the saturated soil may even change the nature of the soil fairly quickly. Frost (2000) and Frost (2020) report observations showing that an organic layer thick enough to change soil classification from Leon (a typical soil of Wet Pine Flatwoods and Wet Sandy Pine Savanna) to Murville (typical of Pond Pine Woodland) had, in places, accumulated in 30 years.

Comments: See the comments for Dry Longleaf Pine Communities, many of which apply here as well.

The terms "savanna" and "flatwoods" have had been widely used in ecological literature in two different ways, applying to both pine and hardwood-dominated communities. At times, they refer simply to vegetation structure, with savannas being grassy and flatwoods being shrubby. In other usages, particularly in the Southeastern U.S., they refer to moisture regimes, with savannas being wetter and flatwoods somewhat drier. Savannas have also often been assumed to have high species richness, flatwoods low. In the 3rd approximation, the terms were used to indicate moisture regimes, with Mesic Pine Flatwoods and Wet Pine Flatwoods drier than Pine Savanna, which was always wet. Because this usage caused confusion, leading some users to expect that the flatwoods communities should naturally be shrubby, the usage in names has been shifted in the 4th Approximation. The species-rich mesic longleaf pine communities that are not naturally more shrubby have been renamed to use the term "savanna." "Flatwoods" is now reserved for marginally wet communities of sandy Spodosols, previously known as Wet Pine Flatwoods, which are low in species richness. Whether Wet Pine Flatwoods are naturally shrubbier under optimal fire regimes is unclear, though it was suggested by Gliztenstein et al. (2003).

As in the Dry Longleaf Pine Communities, most of the subtypes in this theme were recognized as variants in the 3rd Approximation, after being recognized in natural heritage surveys of longleaf pine communities. Most were confirmed by early analysis of CVS data. Recent thorough analysis of CVS plot data (Palmquist et al. in prep. d, e), supplemented by data ranging from Virginia to Florida, confirmed the identity of these units. Most of the descriptions here are based on that analysis but are supplemented by other observations.

KEY TO WET PINE SAVANNAS

1. Community in the Piedmont Region............................. **Wet Piedmont Longleaf Pine Forest**
1. Community not in the Piedmont Region
   2. Community north of the natural range of *Aristida stricta* dominance (a short distance north of the Neuse River).. .... **Northern Wet Pine Savanna**
   2. Community within the natural range of *Aristida stricta* (whether the species is present or not)
      3. Community saturated by seepage, occurring on a gentle to steep slope where a clay layer underlying sand induces ground water seepage; primarily in the Sandhills region but potentially elsewhere where similar conditions occur.
         4. Community with high species richness, sharing many species with Wet Loamy Pine Savanna, such as *Ctenium aromaticum, Chaptalia tomentosa, Coreopsis linifolia, Erigeron vernus, Xyris ambigua, Bigelowia nudata, Viola primulifolia, Aletris farinosa, Eryngium integrifolium, Triantha racemosa,* and many others; well-developed examples known only in Fort Liberty .... **Sandhill Seep (Savanna Subtype)**
         4. Community with moderate to low species richness, sharing only a few species with Wet Loamy Pine Savanna; the above species scarce or generally absent .... **Sandhill Seep (Typic Subtype)**
      3. Community saturated by a seasonal high water table, occurring on flat, poorly drained uplands or in gentle swales; primarily in the outer Coastal Plain but potentially in the middle Coastal Plain and Sandhills.
         5. Community on sand substrate, with little fine material; soil generally mapped as a Spodosol. Vegetation largely or completely lacking the suite of species typical of loamy soils, such as *Coreopsis lancifolia, Marshallia graminifolia, Scleria minor, Rhexia lutea, Polygala ramosa*, *Aletris farinosa, Eupatorium rotundifolium*, *Bigelowia nudata*, *Chaptalia tomentosa*, *Cirsium virginianum*, *Helianthus heterophyllus, Helianthus angustifolius, Lysimachia loomisii,* and *Eryngium integrifolium*. While *Rhynchospora plumosa, fascicularis*, and *ciliaris* may be present in wetter communities, most other *Rhynchospora* are absent or scarce.
            6. Community marginally wet; herb layer low in species richness even when frequently burned and in good condition; herb species limited to the most widespread species of wet longleaf pine communities such as *Aristida stricta, Pteridium pseudocaudatum, Pyxidanthera barbulata, Carphephorus* spp., and species shared with non-wetland communities; herbs of wetter sites, if present at all, limited to wet microsites or ecotones.
               7. Community containing *Kalmia* (*Leiophyllum*) *buxifolia* along with more widespread shrubs; geographically limited community occurring in Brunswick County and as small disjunct examples in eastern Carteret County and Cumberland County. .... **Wet Pine Flatwoods (Sand Myrtle Subtype)**
               7. Community lacking *Kalmia buxifolia*; shrub layer consisting solely of widespread shrubs such as *Ilex glabra, Gaylussacia* spp., etc.; geographically widespread community, throughout the southern half of the Coastal Plain
                  8. Community occurring in a distinct basin in drier sandy terrain; trees sparse or absent; vegetation consisting of few species, primarily *Hypericum tenuifolium* and *Aristida stricta*. .... **Wet Pine Flatwoods (Depression Subtype)**

8. Community not occurring in a distinct basin, or if so, with more diverse herbaceous and shrub vegetation and generally with pines if not recently disturbed........................ .... **Wet Pine Flatwoods (Typic Subtype)**

6. Community wetter; herb layer fairly diverse if frequently burned, containing species of wetter sites, such as *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, *Andropogon cretaceus* (*glaucopsis*), *Osmundastrum cinnamomeum, Pleea tenuifolia*, and carnivorous plants, along with more widespread species of wet longleaf pine communities.

9. Herb layer dominated or codominated by *Pleea tenuifolia* over most of the community. .... **Wet Sandy Pine Savanna (Rush Featherling Subtype)**

9. Herb layer not dominated or codominated by *Pleea tenuifolia*, though the species may be present in smaller amounts; generally dominated by *Aristida stricta* or *Sporobolus pinetorum* when frequently burned............ **Wet Sandy Pine Savanna (Typic Subtype)**

5. Community on loamy soil, with finer material present in addition to sand; soil generally mapped as an Ultisol. Vegetation containing many species of a suite typical of loamy soil, such as *Coreopsis lancifolia, Marshallia graminifolia, Scleria minor, Rhexia lutea, Polygala ramosa*, *Aletris farinosa, Eupatorium rotundifolium*, *Bigelowia nudata*, *Chaptalia tomentosa*, *Cirsium virginianum*, *Helianthus heterophyllus, Helianthus angustifolius, Lysimachia loomisii,* and *Eryngium integrifolium*. A wide suite of *Rhynchospora* species may be present. Widespread wet savanna species such as *Aristida stricta, Sporobolus pinetorum, Rhexia alifanus, Xyris caroliniana, Osmundastrum cinnamomeum*, and *Dionaea muscipula* may be in either set of communities.

10. Community containing, in addition to the above species, a suite of species of very wet sites, such as *Rhynchospora latifolia, Sporobolus teretifolius, Eryngium yuccifolium, Stenanthium (Zigadenus) densum, Carex lutea, Thalictrum cooleyi, Scleria bellii, Coreopsis aristulata,* and *Allium* sp. 1; dominant herbs usually *Ctenium aromaticum, Muhlenbergia expansa, Sporobolus pinetorum, Sporobolus teretifolius*, or *Rhynchospora* spp.; *Aristida stricta* never dominant and often absent; very rare community known in small portions of Pender, Brunswick, and Columbus County. .... **Very Wet Loamy Pine Savanna**

10. Community, if in good condition, containing a diverse herb layer, but lacking the specialized suite of species of wetter sites; herb layer dominated by *Aristida stricta, Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, or *Andropogon* spp.; less rare community throughout the southern half of the Coastal Plain, possibly in the Sandhills (but consider Sandhill Seep (Savanna Subtype) if the community is sloped and has seepage). .... **Wet Loamy Pine Savanna**

WET PIEDMONT LONGLEAF PINE FOREST

Concept: Wet Piedmont Longleaf Pine Forests are wetland woodlands or forests of the eastern Piedmont (primarily the Uwharries and areas adjacent to the Sandhills) in which *Pinus palustris* naturally dominates or codominates. *Pinus serotina* is sometimes also present. They may be seepage-fed or have perched water tables. *Pinus palustris* may be scarce in examples where past logging and fire suppression have removed it and allowed other pines and hardwoods to expand. *Pinus serotina* may also be abundant.

Distinguishing Features: Wet Piedmont Longleaf Pine Forests are distinguished from all other Wet Pine Savannas by their occurrence in the Piedmont, on Piedmont geological substrates, and in all but one case, by the apparently natural absence of *Aristida stricta*. Northern Wet Pine Savannas also lack *Aristida stricta*, but they can contain a number of Coastal Plain species absent in the Piedmont. However, because all examples of both communities have been heavily altered by past fire suppression, remaining herbs are often too few to define the differences.

Wet Piedmont Longleaf Pine Forests are distinguished from Dry Piedmont Longleaf Pine Forests by having a substantial component of wetland herbs and shrubs, such as *Rhynchospora* spp., *Calamagrostis coarctata (cinnoides)*, *Cinna arundinacea, Erianthus* spp., and *Osmundastrum cinnamomeum*. However, the boundary between wet and dry can be subtle, perhaps because of the effects of fire suppression or perhaps because of heterogeneous wetness. Many upland woody and herbaceous species are found mixed with wetland species and a smaller number of wetland species can occur in the dry community. Thus, occasionally, decisions may need to be based on which predominates, and on whether contrasting patches are large enough to recognize.

Wet Piedmont Longleaf Pine Forests can co-occur with Hillside Seepage Bogs or Piedmont Boggy Streamheads, with a similarly subtle boundary. *Pinus palustris* may occur in any community but is scarce in the boggy communities. Hillside Seepage Bogs and Piedmont Boggy Streamheads are both distinctly wetter. While the most water-tolerant species, such as *Osmundastrum cinnamomeum, Osmunda spectabilis*, *Sarracenia* spp., *Drosera* spp., *Sphagnum* spp., *Sophronanthe pilosa, Alnus serrulata*, and *Viburnum nudum* may occur in Wet Piedmont Longleaf Pine Forest, they are a minor component; they generally occur with much greater cover in Hillside Seepage Bog and Piedmont Boggy Streamhead. Other species of wetter sites, such as *Lycopus virginicus*, are common in Piedmont Boggy Streamheads but are unlikely in Wet Piedmont Longleaf Pine Forest.

Crosswalks: *Pinus palustris - Pinus taeda - Pinus serotina / Chasmanthium laxum - Panicum virgatum* Piedmont Woodland (CEGL003663).
G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Southeastern Interior Longleaf Pine Woodland Ecological System (CES202.319).

Sites: Wet Piedmont Longleaf Pine Forests occur on flat or gently sloping upland areas. One example is in a Triassic basin; the others are in or near the Uwharrie Mountains but in flatter terrain, primarily on metasedimentary rocks.

Soils: Wet Piedmont Longleaf Pine Forests are often small areas that are inclusions in soil map units. Soils mapped for occurrences include Biscoe (Aeric Epiaquult), Badin (Typic Hapludult), Herndon (Typic Kanhapludult), Lignum (Aquic Hapludult), Worsham (Typic Endoaquult), Mayodan (Typic Hapludult), and Claycreek (Oxaquic Hapludalf).

Hydrology: Sites are seasonally saturated but have little or no surface water. Wetness in some sites appears to come from seepage, in other sites from a perched water table produced by an impermeable soil.

Vegetation: All remaining examples of Wet Piedmont Longleaf Pine Forest were heavily altered by logging and long fire suppression, and the best examples have been recently thinned and otherwise treated for restoration. The natural structure of Wet Piedmont Longleaf Pine presumably is an open woodland or savanna with *Pinus palustris* dominant or codominant with *Pinus taeda* or possibly *Pinus echinata*. Remaining examples have, or recently had, a significant hardwood component, primarily *Acer rubrum, Liquidambar styraciflua,* and *Liriodendron tulipifera*, but also including upland species such as *Quercus marilandica, Quercus stellata, Quercus alba, Carya glabra*. These, along with understory species such as *Oxydendrum arboreum, Nyssa sylvatica,* and *Sassafras albidum*, often remain as dense sprouts if not as larger trees. They presumably would have been absent or sparse in more frequently burned natural conditions. The shrub layer also often is dense but would be more open with ongoing regular burning. Species that are frequent in CVS plot data or site descriptions include *Gaylussacia frondosa, Vaccinium formosum, Vaccinium fuscatum, Aronia arbutifolia, Amelanchier obovalis,* and *Amelanchier canadensis*. A number of other wetland and upland shrubs occur occasionally, including *Gaylussacia dumosa, Vaccinium tenellum, Vaccinium pallidum, Lyonia mariana, Rhododendron viscosum, Eubotrys racemosus, Viburnum nudum*, and *Alnus serrulata*. *Toxicodendron radicans, Gelsemium sempervirens, Smilax rotundifolia, Smilax glauca, Smilax laurifolia*, and *Muscadinia rotundifolia* are fairly frequent and, in current conditions, can dominate patches.

The herb layer presently is moderate to sparse, but presumably was once dense, more dominated by grasses, and more continuous. Most frequently dominant in patches in the most intact present vegetation are *Pteridium pseudocaudatum, Vaccinium crassifolium, Chasmanthium laxum, Danthonia sericea,* and *Andropogon glomeratus*. Other constant or frequent species in CVS plot data or site descriptions include *Schizachyrium scoparium, Panicum virgatum, Osmundastrum cinnamomeum, Eupatorium pilosum, Eupatorium rotundifolium, Rhexia* spp., *Rhynchospora* (including *debilis, glomerata, recognita, gracilenta, chalarocephala,* and *ciliaris*), *Lobelia nuttallii, Erianthus* spp., *Polygala lutea, Juncus dichotomus, Juncus coriaceus, Scleria nitida* or *triglomerata, Symphyotrichum pilosum, Uvularia puberula, Sophronanthe pilosa, Hieracium gronovii, Calamovilfa brevipilis, Eryngium yuccifolium, Sericocarpus linifolius,* and *Aletris farinosa*. A number of other species are less frequent at present but are indicative of the conditions or of Coastal Plain affinities and may once have been more frequent, including *Calamagrostis coarctata, Cinna arundinacea, Danthonia epilis, Helianthus angustifolius, Helianthus atrorubens, Xyris caroliniana, Viola primulifolia, Lespedeza hirta, Lespedeza capitata, Lespedeza angustifolia, Eupatorium leucolepis, Scleria ciliata, Scleria elliottii, Polygala cruciata, Polygala curtisii, Lycopodiella alopecuroides, Iris verna, Aristida virgata, Oxypolis rigidior, Osmunda spectabilis, Pycnanthemum flexuosum,* and *Eleocharis* sp. *Aristida stricta* is reported to be present in a single example, the most altered one but the one closest to the Sandhills.

Range and Abundance: Ranked G1. Five occurrences are known. Most are in the Uwharrie Mountains area, but the largest is in the Wadesboro Triassic basin in Anson County. The NVC association is also questionably attributed to South Carolina.

Associations and Patterns: Wet Piedmont Longleaf Pine Forest is a large patch community. One large example is over 600 acres, but all other examples are around 20 acres. Given the unusual sites, it is unlikely that many large examples ever existed. Where natural boundaries exist, Wet Piedmont Longleaf Pine Forests are associated with Dry Piedmont Longleaf Pine Forests. Some may also grade into Piedmont Boggy Streamhead or Piedmont Headwater Stream Forest.

Variation: Two variants are recognized, based on the setting. Floristic differences are not well known.

1. Seepage Variant occurs in sloping terrain and appears to have seepage or concentration of upland runoff as a significant source of water. The examples in the Uwharries Mountains area appear to be this variant.

2. Flat Variant occurs in flatter upland terrain where a perched or seasonal high water table appears to be the cause of wetness. The example in Anson County is this variant.

Dynamics: As with other longleaf pine communities, Wet Piedmont Longleaf Pine Forest depends on frequent fire to maintain its ecological character. Without fire, shrubs quickly proliferate, and hardwood trees gradually establish a dense canopy that eliminates the characteristic herbs. However, natural fire may have been somewhat less frequent than in the Coastal Plain, and this, along with the substrate, may be responsible for the different flora and different character of this community.

Because the hydrology is dependent on local seepage and perched water tables, Wet Piedmont Longleaf Pine Forests are particularly subject to changes in weather from year to year. During dry periods, they can become very dry.

Comments: Wet Piedmont Longleaf Pine Forests are one of the less well-known natural communities. All known examples are recovering from long suppression of fire. Prescribed burning and selective thinning are now reversing its effect, but communities are altered enough that it is difficult to observe details of their natural character. Other than site descriptions in Natural Heritage Program files and a handful of CVS plots, a single published paper describes the Anson County example (Culpepper et al. 2017). The vegetation description is based on plots from two sites and thorough species lists for two different sites. The heterogeneity of examples, with drier and wetter microsites, and the unclear boundaries with adjacent communities, add further difficulties to describing the vegetation.

Hillside Seepage Bogs are often associated with Dry Piedmont Longleaf Pine Forest. It is possible that *Pinus palustris* once occurred in them, potentially blurring the distinction between them and Wet Piedmont Longleaf Pine Forest. However, Hillside Seepage Bogs contain a more specialized wetland flora that indicates that they are wetter.

Rare species:
Vascular plants – *Carex vestita, Fothergilla major, Iris prismatica,* and *Trillium pusillum sensu lato*.

Vertebrate animals – *Dryobates borealis*.

WET PINE FLATWOODS (TYPIC SUBTYPE)

Concept: Wet Pine Flatwoods are longleaf pine communities of seasonally wet, coarse sandy Spodosols, less wet than the Wet Sandy Pine Savanna type, and typically lower in species richness. This type may possibly have more shrub cover than the various Pine Savanna communities under natural conditions, but still is naturally more dominated by grasses than by shrubs. The Typic Subtype covers the common examples of the Coastal Plain in which *Kalmia* (*Leiophyllum*) *buxifolia* is not a major component. Instead, *Gaylussacia frondosa, Ilex glabra, Hypericum tenuifolium, Arundinaria tecta, Rhododendron atlanticum*, or other wetland shrubs are present with low to high cover. *Aristida stricta* dominates a dense but low-diversity herb layer, sometimes with codominant *Pteridium aquilinum* or *Vaccinium crassifolium*.

Distinguishing Features: Wet Pine Flatwoods are distinguished from Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill by a characteristic lack of scrub oaks and lack of obligate upland herbs (however, scrub oaks may "stray" into them, especially in sites that have long lacked fire). Wet Pine Flatwoods are distinguished from both Wet Sandy Pine Savannas and Wet Loamy Pine Savannas by the absence of plant species typical of richer or wetter sites, such as *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, *Andropogon cretaceous* (*glaucopsis*), *Osmundastrum cinnamomeum* and carnivorous plants. They are distinguished from Mesic Pine Savanna by coarse sandy soil and by a low-diversity herbaceous flora that largely lacks legumes and has some wetland species. While Wet Pine Flatwoods are sometimes regarded as naturally having more shrub cover than wetter or more fertile savannas, the amount of shrubs cannot be used to distinguish them as defined here. Both mesic and wetter savannas contain the shrubs characteristic of Wet Pine Flatwoods and all can become dominated by them in the absence of fire. If herb diversity is lost, they can be difficult to distinguish. Similarly, the abundance of *Aristida stricta* cannot be used to distinguish among these community types, as it may dominate in all. Wet Pine Flatwoods are distinguished more by the absence of species characteristic of other communities than by the presence of any distinctive plants. Caution is needed because the less conservative species of wetter communities, such as *Andropogon cretaceus*, can appear in artificial wetter microsites such as old fire plow lines and rutted forest roads. Additionally, many species of wetter savanna can occur on the ecotone where Wet Pine Flatwoods grades to Pond Pine Woodland.

The Typic Subtype is distinguished from the Sand Myrtle Subtype by the absence or scarcity of *Kalmia buxifolia*. It is distinguished from the Depression Subtype by a richer herb and shrub layer, characteristic greater density of *Pinus palustris*. The Depression Subtype generally occurs in dry limesink basins, possibly in swales. The Typic Subtype occurs on low flats, subtype ridges in peatlands, or, if in swales or depressions, very gently sloped ones.

Crosswalks: *Pinus palustris / Ilex glabra / Aristida stricta* Woodland (CEGL003648).
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Wet Pine Flatwoods (Wet Spodosol Variant) (3rd Approximation).
Wet Sandy Pine Savanna (earlier 4th Approximation guide early drafts).

Sites: Wet Pine Flatwoods (Typic Subtype) occurs on upland flats or terraces, on low rises or gentle swales in relict dune fields or relict beach ridge systems, and on lower parts of Carolina bay rims. It occurs in areas with seasonal high water tables.

Soils: Soils are sandy Spodosols. The soils are low in nutrient holding capacity because of the lack of fine particles. The majority of examples are mapped as the Leon series (Aeric Alaquod), a unit that can support several different communities. Some are mapped as Lynn Haven (Typic Alaquod). A number of other series are sometimes mapped, but the community probably represents inclusions with them. However, examples mapped as Ultisols or Alfisols may suggest that the community is an overgrown Mesic Pine Savanna or Wet Loamy Pine Savanna.

Hydrology: Soils are saturated at or near the surface during wet seasons; the coarse sand has little water holding capacity, but it is unclear if drought stress is significant when water tables drop in drier seasons. Hydrology is palustrine, but these sites may not be recognized as wetlands because the sandy soils do not show many of the redoximorphic features used to recognize wetland soils.

Vegetation: Vegetation structure is similar to most longleaf pine communities, with an open woodland to savanna canopy dominated by *Pinus palustris*, a dense grassy herb layer, and a shrub layer that varies with fire history. There is some argument that these marginally wet sandy soils retain more shrub cover naturally under conditions of frequent fire than do those of finer textured soils (Glitzenstein 2003), but this needs further evidence. There generally is little midstory and few canopy hardwoods except in cases of severe alteration by fire exclusion. The canopy sometimes is codominated by *Pinus serotina*. It is not certain if this is natural or is an effect of past logging and altered fire regime; it also could result from mass effects in small patches surrounded by pocosins.

The shrub layer may potentially include a large number of species. Frequent abundant species in CVS data (Palmquist et al. in prep. d) are *Ilex glabra, Vaccinium tenellum,* and *Gaylussacia dumosa*. *Gaylussacia frondosa* is frequent and often dominant in site observations. Less frequent in plots but sometimes observed to be locally dominant are *Rhododendron atlanticum, Hypericum tenuifolium, Kalmia carolina*, and in more altered places, *Lyonia lucida* or *Ilex coriacea*. Often present in smaller numbers are *Aronia arbutifolia, Lyonia mariana, Morella pumila, Persea palustris, Magnolia virginiana*, and *Arundinaria tecta*. The herb layer is strongly dominated by *Aristida stricta* or is codominated by *Vaccinium crassifolium* or *Pteridium pseudocaudatum*. Other frequent herbs in plot data as well as other observations include *Schizachyrium scoparium, Andropogon virginicus* var. *virginicus, Pityopsis graminifolia, Liatris* sp., *Scleria ciliata, Carphephorus bellidifolius*, and *Ionactis linariifolia*. Wetter examples may share a few additional species with wetter pine savannas, including *Xyris caroliniana, Rhexia alifanus, Polygala lutea*, and *Lachnocaulon anceps*. The wetter ecotone on the edge of peatland communities may have some additional wet savanna species, including *Lysimachia asperulifolia, Anchistea virginica, Dionaea muscipula,* and *Drosera* spp.

Range and Abundance: Ranked G3. This type is the most common remaining longleaf pine community type of the outer Coastal Plain in the state, but it too is rare globally. It occurs only in North Carolina and northern South Carolina.

Associations and Patterns: Wet Pine Flatwoods usually occur on sandy landscapes in mosaics with Xeric Sandhill Scrub and Pond Pine Woodland, sometimes also with Pine/Scrub Oak Sandhill (Coastal Fringe Subtype or Mixed Oak Subtype) or Wet Sandy Pine Savanna. In these mosaics, a few inches difference in elevation relative to the water table can separate the different communities. In the range of the Sand Myrtle Subtype, that community may also occur in mosaics with the Typic Subtype. Where Wet Pine Flatwoods borders a Pond Pine Woodland or other pocosin community, a wet ecotone may harbor species characteristic of Wet Sandy Pine Savanna in a narrow band.

Variation: Examples are variable and often heterogeneous within patches. The shrub species that are present which dominate are particularly variable. The herb layer is less variable, though examples vary substantially in amount of *Vaccinium crassifolium* and *Pteridium latiusculum*. These variations probably reflect fire history more than site differences. Analysis of CVS plot data (Palmquist et al. in prep. d) identified three distinct groups within the Typic Subtype. These may warrant recognition as variants but the differences among them are subtle.

Dynamics: Dynamics are similar to most longleaf pine communities. Glitzenstein et al. (2003) suggest, based on fire experiments in South Carolina and Georgia, that communities of wet Spodosols, such as our Wet Pine Flatwoods, may retain substantial shrub cover even with very frequent fire. It is not clear how widely this principle applies, and whether it applies to the original natural examples as well as to examples that had experienced periods of longer fire exclusion. The lower herb diversity or lower grass productivity may possibly allow more shrubs to persist. Conversely, however, the low fertility makes these communities slower than most wet longleaf pine communities to become overgrown by shrubs and lose their grass cover in the absence of fire. Their species richness, lower to begin with, is altered less by exclusion of fire.

Comments: Wet Pine Flatwoods represents the marginally wet portion of the moisture gradient on coarse sandy soils. The moisture gradient on these soils appears to be compressed when compared with that of loamy soils. While loamy or clayey soils sometimes have a distinctive mesic savanna community that develops between the oak-rich sandhill communities and the wet savannas, there is no apparent mesic segment of the moisture gradient on coarse sandy soils. Wet Pine Flatwoods often grade directly into Xeric Sandhill Scrub or Pine/Scrub Oak Sandhill; scrub oaks and wetland shrubs can intermix in ecotonal areas and become more intermixed with long fire exclusion. The lack of moisture-holding capacity in the sand, which leads to dry conditions whenever the water table is not high, may be the reason, but the low fertility of these soils may also be involved. The seasonal high water table is presumably the reason for exclusion of scrub oaks and the preponderance of facultative wetland shrubs and trees in Wet Pine Flatwoods when fire is suppressed for long periods.

Wet Pine Flatwoods is closely related to the suite of communities that are called Pine Savannas, sharing frequent fire and dominance by longleaf pine and wiregrass. However, while most wet longleaf pine communities are known for their high fine-scale plant species richness, Wet Pine Flatwoods tend to have low species richness. In some other usages, the term “flatwoods” implies more shrub cover than “savanna,” whether natural or artificial. However, all of the wet longleaf pine communities become shrubby if they are not burned frequently, so shrub abundance is a poor basis for naming communities. Indeed, shrub cover can be very transient, changing drastically over the course of a 3-year burn rotation.

Naming conventions for this community type have been problematic. In earlier drafts of the 4th Approximation, it was named as a kind of Pine Savanna, but there is a confusing array of Pine Savanna names even without it, so it has been returned to the 3rd Approximation name of Wet Pine Flatwoods.

The 3rd Approximation recognized a Wet Ultisol Variant of Wet Pine Flatwoods, and this was recognized as a subtype in the earliest drafts of the 4th Approximation. However, it has been dropped. It was concluded that shrubby low-diversity communities on Ultisols likely are overgrown or depauperate Wet Loamy Pine Savanna communities.

Rare species:
Vascular plants – *Asclepias pedicellata, Carex emmonsii, Cyperus lecontei, Dichanthelium strigosum* var. *glabrescens, Eurybia spectabilis, Hypoxis juncea, Lechea torreyi* var. *congesta, Lythrum lanceolatum,* and *Quercus minima.* Ecotones only -- *Calopogon multiflorus, Dionaea muscipula, Drosera filiformis,* and *Lysimachia asperulifolia*.

Vertebrate animals – *Ambystoma mabeei, Anaxyrus quercicus, Crotalus adamanteus, Dryobates borealis, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Agrotis carolina, Calephelis virginiensis, Exyra fax, Franclemontia interrogans, Hemaris gracilis, Lagoa pyxidifera,* and *Melanoplus nubilus*.

WET PINE FLATWOODS (SAND MYRTLE SUBTYPE)

Concept: Wet Pine Flatwoods are longleaf pine communities of seasonally wet, coarse sandy Spodosols, less wet than the Wet Sandy Pine Savanna type, and typically low in species richness. This type may possibly have more shrub cover than the various Pine Savanna communities under natural conditions, but still is naturally more dominated by grasses than by shrubs. The Sand Myrtle Subtype covers the rare longleaf pine communities of wet sandy soils in the outer Coastal Plain where *Kalmia (Leiophyllum) buxifolia* is a dominant or codominant shrub.

Distinguishing Features: Wet Pine Flatwoods are distinguished from Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill by a characteristic lack of scrub oaks and lack of obligate upland herbs (however, scrub oaks may "stray" into them, especially during long periods without fire). Wet Pine Flatwoods are distinguished from both Wet Sandy Pine Savannas and Wet Loamy Pine Savannas by the absence of plant species typical of richer or wetter sites, such as *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, *Andropogon cretaceus* (*glaucopsis*), *Osmundastrum cinnamomeum,* and carnivorous plants. They are distinguished from Mesic Pine Savannas by sandy soil lacking fine material and by a low-diversity herbaceous flora that largely lacks legumes and has some wetland species.

The Sand Myrtle Subtype is readily distinguished from all other longleaf pine communities by the presence of significant numbers of *Kalmia buxifolia*. All of the shrub species of Wet Pine Flatwoods (Typic Subtype) may also be present. *Kalmia buxifolia* may occasionally spread into drier sandhill communities within its range; these may be distinguished by a significant component of shrub oaks and an absence of other wetland species.

Crosswalks: *Pinus palustris / Leiophyllum buxifolium / Aristida stricta* Woodland (CEGL003649).
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Wet Pine Flatwoods (*Leiophyllum* Variant) (3rd Approximation).
Wet Sandy Pine Savanna (earlier 4th approximation guide drafts).

Sites: The Sand Myrtle Subtype occurs on upland flats or terraces, on low rises or shallow depressions in relict dune fields or relict beach ridge systems, and on lower parts of Carolina bay rims, within the Coastal Plain range of *Kalmia buxifolia*.

Soils: Soils are sandy Spodosols. The coarse sandy soils are low in nutrient holding capacity. The majority of examples are mapped as the Leon series (Aeric Alaquod), a unit that can support several different communities.

Hydrology: Soils are saturated at or near the surface during wet seasons; the coarse sand has little water holding capacity, but it is unclear if drought stress is significant when water tables drop in drier seasons. Hydrology is palustrine, but these sites may not be recognized as wetlands because the sandy soils do not show many of the redoximorphic features used to recognize wetland soils.

Vegetation: Vegetation structure is similar to most longleaf pine communities, with an open woodland to savanna canopy dominated by *Pinus palustris*, a dense grassy herb layer, and a shrub layer that varies with fire history. There generally is little midstory and few canopy hardwoods. *Pinus serotina* often is present in the canopy as a minority species. The shrub layer is fairly diverse, whether cover is high or low, and this probably is natural. The most abundant shrub layer species in CVS plot data (Palmquist et al. in prep. d) are *Kalmia buxifolia, Gaylussacia dumosa*, and *Ilex glabra*. Other constant or frequent shrubs include *Gaylussacia frondosa, Hypericum tenuifolium, Persea palustris, Vaccinium tenellum, Magnolia virginiana, Ilex coriacea, Aronia arbutifolia*, and *Arundinaria tecta*. *Vaccinium crassifolium* sometimes dominates large patches of ground cover. The herb layer is strongly dominated by *Aristida stricta* when the community is in good condition, but *Pteridium pseudocaudatum* or *Vaccinium crassifolium* may reduce its density. Other frequent herbs in plot data include *Schizachyrium scoparium, Iris verna, Pyxidanthera barbulata, Pityopsis graminifolia, Carphephorus bellidifolius, Carphephorus tomentosus,* and *Trilisa paniculata*. In wetter microsites and ecotones, species of Wet Sandy Pine Savanna may be present, including, frequently, Xyris *caroliniana, Rhynchospora plumosa, Andropogon cretaceus*, and *Lachnocaulon anceps*.

Range and Abundance: Ranked G1. It is endemic to North Carolina, where it is limited primarily to Brunswick County, with small disjunct occurrences in Carteret and Hoke counties. Its distribution follows the Coastal Plain range of *Kalmia buxifolia*.

Associations and Patterns: The Sand Myrtle Subtype occurs in mosaics with the Typic Subtype, as well as with Wet Sandy Pine Savanna (Rush Featherling Subtype), Xeric Sandhill Scrub (Coastal Fringe Subtype), Pine/Scrub Oak Sandhill (Coastal Fringe Subtype), and Pond Pine Woodland.

Variation: Examples vary with the transition to adjacent communities. Drier portions may have some *Quercus geminata* and other species of the Coastal Fringe Subtype of Pine/Scrub Oak Sandhill. No variants are recognized. The two disjunct examples may be somewhat different.

Dynamics: Dynamics apparently are similar to other longleaf pine communities. Like the Typic Subtype, it may possibly support more shrubs than most longleaf pine communities under a natural regime of frequent fire (Glitzenstein et al. 2003). There may be subtle differences in the fire regime, compared to the Typic Subtype. The primary range of this subtype, southeastern Brunswick County, is known to be particularly difficult to conduct prescribed burns safely, because of the volatility of fuels and unpredictability of winds. Its location at a sharp angle on the coast subjects it to sea breeze influence from two directions.

Comments: *Kalmia buxifolia* as a species has an unusual distribution and range of ecology. It occurs in Heath Balds and high elevation rock outcrop communities in the mountains, outcrops on a few lower Piedmont monadnocks, and in this rare community subtype of the Coastal Plain.

Rare species:
Vascular plants – *Asclepias pedicellata*. Ecotones only – *Dionaea muscipula* and *Lysimachia asperulifolia*.

Vertebrate animals – *Crotalus adamanteus, Dryobates borealis, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Agrotis carolina, Calephelis virginiensis, Cyclophora* sp. 1 (*culicaria* of authors), *Exyra fax, Franclemontia interrogans, Hemaris gracilis, Lagoa pyxidifera,* and *Melanoplus nubilus*.

WET PINE FLATWOODS (DEPRESSION SUBTYPE)

Concept: Wet Pine Flatwoods are longleaf pine communities of seasonally wet, coarse sandy Spodosols, less wet than the Sandy Pine Savanna type, and typically low in species richness. The Depression Subtype covers small, marginally wet, sandy limesink depressions and swales in dry sandhills, where *Aristida stricta* and *Hypericum tenuifolium* dominate. Trees are virtually or completely absent in the few known examples, but *Pinus palustris* might potentially be present.

Distinguishing Features: Wet Pine Flatwoods are distinguished from Xeric Sandhill Scrub and Pine/Scrub Oak Sandhill by a characteristic lack of scrub oaks and lack of obligate upland herbs (however, scrub oaks may "stray" into them, especially with long periods without fire). Wet Pine Flatwoods are distinguished from both Sandy Pine Savannas and Wet Loamy Pine Savannas by the absence of plant species typical of richer or wetter sites, such as *Sporobolus pinetorum, Ctenium aromaticum, Muhlenbergia expansa*, *Andropogon cretaceus (glaucopsis)*, *Osmundastrum cinnamomeum* and carnivorous plants. They are distinguished from Mesic Pine Savanna by coarse sandy soil and by a lower-diversity herbaceous flora that largely lacks legumes and has some wetland species.

The Depression Subtype is distinguished from other Wet Pine Flatwoods subtypes by occurrence in small, closed basins, in combination with a depauperate flora and dominance of *Hypericum tenuifolium*. Local areas in the Typic Subtype may be dominated by these species, but generally trees and other shrubs will be present. The Depression Subtype is distinguished from Vernal Pools and other small depression communities by the dominance of *Aristida stricta* rather than *Andropogon* spp., *Panicum virgatum*, or species of wetter affinities, though *Andropogon* may be abundant.

Crosswalks: *Hypericum reductum* / *Aristida stricta* Wet Dwarf-shrubland (CEGL003954).
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).

Sites: The Depression Subtype occurs in small but distinct depressions or deep swales in relict sand dune areas. The depressions may be either dune swales or limesink depressions.

Soils: Soils are inclusions that are probably similar to Leon (Aeric Alaquod) or other Spodosols, but would generally be mapped as Kureb, Mandarin, or some other deep sandy Entisol.

Hydrology: Hydrology is not well known but presumably is a crucial factor in the distinctive character of this community. The few examples that have been examined showed no evidence of surface flooding, even at times of high water table and flooding of nearby depressions. Nevertheless, the exclusion of scrub oaks and pines presumably is related to wetness, albeit with a different water regime different than the wetter, but treed, Sandy Pine Savanna. The absence of the more diverse Vernal Pool flora might be due to inadequate surface flooding, or possibly to other factors such as low fertility.

Vegetation: Vegetation consists of an open shrub layer dominated by *Hypericum tenuifolium*, alone or in combination with *Lyonia mariana* or *Gaylussacia dumosa*. The herb layer is sparse to moderately dense. *Aristida stricta* or *Rhynchospora* sp. are dominant or codominant. *Andropogon* sp. may be abundant. *Vaccinium crassifolium* and a few other species may be present, but this community is extremely low in species richness. *Pinus palustris* has been observed only as a few small individuals in known examples.

Range and Abundance: Ranked G1G2Q. This community is poorly known and perhaps overlooked, but its specialized habitat appears extremely rare. It is likely to be ultimately ranked as G1. In North Carolina, it is presently known at just two sites, in Pender County and possibly New Hanover County. It may possibly also occur in northern South Carolina, though it has not been reported there and has not been attributed to it in the NVC.

Associations and Patterns: The Depression Subtype is a small patch community that is surrounded by Sand Barren or Xeric Sandhill Scrub (Coastal Fringe Subtype in all known examples). Other small depression communities, including Vernal Pool, Small Depression Drawdown Meadow, and Small Depression Pond, may occur nearby, as may Wet Pine Flatwoods (Typic Subtype) or other longleaf pine communities.

Variation: Variation is not known.

Dynamics: Dynamics are virtually unknown. Examples presumably are subject to the same fire regime as the surrounding landscape, which, if Sand Barren, may be less frequent than in most longleaf pine communities. The depression topography and sparser grass likely leads to lower fire intensity than in most longleaf pine communities.

The cause of the depauperate nature of these communities is not clear. Occasional standing water may eliminate some species, but *Aristida stricta* is not tolerant of prolonged flooding and would be absent if standing water of significant duration occurred. The coarse sandy soil may develop dry conditions when water tables are low, sufficient to exclude most wetland species typical of other Wet Pine Flatwoods. It is unclear if site conditions exclude *Pinus palustris* or if its absence in the few known examples is due to past land use or to chance. If pines could occur at the low density typical of Sand Barrens, the probability of having one in one of the small depressions would be low.

Comments: This community is one of the more problematic in the 4th Approximation, and it is uncertain if it truly warrants recognition as a subtype. It is one of the least known communities. No plot data exist. Exceptionally small patches of many communities are often floristically depauperate and not well developed. However, it appears as a distinctive entity where it occurs, the scrub oaks and most other species dropping out as you enter the depression. It was first recognized as a community by Alan Weakley, who added it to the NVC based on observations at 421 Sand Ridge, a site that has had limited scientific access in recent years. A second example has been found in a similar relict sand dune setting, in patches comparable to other small depression communities, and indicating a repeating pattern. It needs to be sought in other, similar sites, where it might not have been reported.

This community appears conceptually intermediate between Wet Pine Flatwoods and Vernal Pool, but emphasis has been given to the presence of *Aristida stricta* as a link to Wet Pine Flatwoods, despite the possible exclusion of pine.

Rare species: No rare species are known to be specifically associated with this community.

WET SANDY PINE SAVANNA (TYPIC SUBTYPE)

Concept: Wet Sandy Pine Savannas are pine/wiregrass savannas of wet sandy soils, wetter than Wet Pine Flatwoods. They are typically high in species richness but with flora consisting mostly of the more widespread savanna species. The Typic Subtype covers the examples in most parts of the Coastal Plain, where herb layers are dominated by grasses, usually *Aristida stricta*, and in which *Pleea tenuifolia* is not dominant or codominant (though it is occasionally present).

Distinguishing Features: Wet Sandy Pine Savannas are distinguished from Wet Pine Flatwoods by a more diverse herb layer that includes species indicative of greater wetness. Species in Wet Sandy Pine Savanna but scarce or absent in Wet Pine Flatwoods include *Andropogon glomeratus, Andropogon cretaceus (glaucopsis), Osmundastrum cinnamomeum, Anchistea virginica, Sarracenia flava*, *Dionaea muscipula, Calamovilfa brevipilis,* and, though infrequent, *Sporobolus pinetorum* and *Ctenium aromaticum*. All plant species of Wet Pine Flatwoods may also occur in Wet Sandy Pine Savanna. Though Wet Pine Flatwoods may naturally have more shrub cover under frequent fire, the amount of shrubs is usually artificially high in both communities and is not a good distinguishing feature. Wet Sandy Pine Savanna and Wet Pine Flatwoods can be hard to distinguish in fire-suppressed examples where indicator herbs have become sparse. It may be impossible if no herbs remain, but the presence of even small numbers of the above indicators, if not merely confined to ecotones or wet microsites, indicates this wetter community.

Wet Sandy Pine Savannas are distinguished from Wet Loamy Pine Savanna and Very Wet Loamy Pine Savanna by the soil texture and corresponding differences in vegetation. They are typically dominated by *Aristida stricta*, with *Sporobolus pinetorum*, *Ctenium aromaticum,* and *Muhlenbergia capillaris* only rarely dominant and some often scarce or absent. The flora of Wet Sandy Pine Savannas is largely a subset of that of Wet Loamy Pine Savanna, so they are best distinguished by the absence of species indicative of loamy soils. Species frequent in Wet Loamy Pine Savannas and not typically found in Wet Sandy Pine Savannas include *Coreopsis lancifolia, Marshallia graminifolia, Scleria minor, Rhexia lutea, Polygala ramosa*, *Aletris farinosa, Eupatorium rotundifolium*, *Bigelowia nudata*, *Chaptalia tomentosa*, *Cirsium virginianum*, *Helianthus heterophyllus, Helianthus angustifolius, Lysimachia loomisii, Eryngium integrifolium*, and several *Rhynchospora* species (*baldwinii, chapmanii, galeana*). Characteristic herbs such as *Andropogon* sp., *Osmundastrum cinnamomeum*, *Trilisa* spp., *Rhexia alifanus, Polygala lutea, Dionaea muscipula, Xyris caroliniana, Stenanthium (Zigadenus) densum, Sarracenia* spp., and *Drosera* spp. are generally present in both.

The Typic Subtype is distinguished from the Rush Featherling Subtype by not having *Pleea tenuifolia* dominant, though the species sometimes is present.

Crosswalks: *Pinus palustris - Pinus serotina / Ctenium aromaticum - Muhlenbergia expansa - Carphephorus odoratissima* Woodland (CEGL003658). [The NVC name likely will be changed to reflect data indicating that some of these nominal species are not reliably dominant in this community.]
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).

Pine Savanna (Wet Spodosol Variant).

Sites: Wet Sandy Pine Savannas occur on wet upland flats or terraces, on low rises or shallow depression in relict dune fields or relict beach ridge systems, and on lower parts of Carolina bay rims. They occur in areas with prolonged seasonal high water tables, which are wetter than sites of Wet Pine Flatwoods.

Soils: Soils are sandy Spodosols. The coarse sandy soils lack fine material and are low in nutrient holding capacity. The majority of examples are mapped as the Leon series (Aeric Alaquod), a few as Woodington, Foreston, or other sandy Ultisols. Wet Sandy Pine Savanna and Wet Pine Flatwoods are generally mapped as the same soils, and they often cooccur.

Hydrology: Wet Sandy Pine Savannas are saturated at or near the surface during wet seasons, but virtually never have surface flooding. These sites are generally downhill and wetter than those of Wet Pine Flatwoods.

Vegetation: Vegetation structure is similar to most longleaf pine communities, with a patchy open woodland to savanna canopy dominated by *Pinus palustris*, a dense grassy herb layer, and a shrub layer that varies with fire history. The canopy sometimes is codominated by *Pinus serotina*, though it is not certain if this is natural or is an effect of past logging and altered fire regime.

The dense herb layer is dominated by *Aristida stricta*. *Vaccinium crassifolium* can have high cover, especially when fire has been too infrequent. Other wet savanna grasses, especially *Calamovilfa brevipilis, Sporobolus pinetorum*, and *Ctenium aromaticum*, are sometimes present but rarely dominate over substantial patches. The herb layer has moderate to high species richness in examples in good condition. Data in Palmquist et al. (in prep. d) show an average of 55 vascular plant species per 1/10 hectare, compared to 83 for Wet Loamy Pine Savanna. Other herbs with high constancy and sometimes high cover include several *Andropogon* species (*cretaceus, glomeratus, virginicus*), *Osmundastrum cinnamomeum*, and *Pteridium pseudocaudatum*. Smaller herbs with high constancy in plot data include *Polygala lutea, Rhexia alifanus, Trilisa paniculata*, and *Iris verna*. Other frequent herbs include several *Rhynchospora* (*plumosa, fascicularis, ciliaris*), several *Dichanthelium* (*ensifolium, dichotomum, webberianum*), *Pityopsis graminifolia, Cleistesiopsis divaricatus, Rhexia petiolata, Trilisa odoratissima, Carphephorus tomentosus, Eupatorium pilosum, Eurybia paludosa, Dionaea muscipula, Sarracenia flava, Drosera capillaris, Eurybia paludosa, Pyxidanthera barbulata, Rhexia lutea, Stenanthium densum, Polygala brevifolia, Xyris ambigua, Carphephorus bellidifolius, Liatris* spp., *Lachnocaulon anceps, Solidago pulchra, Lobelia nuttallii, Amphicarpum amphicarpon, Gentiana autumnalis*, and *Seymeria cassioides*. Less frequent but notable species include *Carex striata, Pleea tenuifolia, Lysimachia asperulifolia, Sabatia difformis, Agalinis setacea*, *Rhynchospora pallida*, and *Balduina uniflora*.

Though shrubs are a limited component in savannas that have had frequent fire, a diversity of species may be present. Highly constant species include *Magnolia virginiana, Persea palustris, Ilex glabra, Gaylussacia frondosa, Gaylussacia dumosa, Morella pumila, Vaccinium tenellum,* and *Aronia arbutifolia*. Other frequent shrubs include *Ilex coriacea, Hypericum tenuifolium, Lyonia mariana, Lyonia ligustrina, Lyonia lucida, Morella caroliniensis, Arundinaria tecta,* *Rhododendron atlanticum, Vaccinium formosum, Vaccinium fuscatum, Clethra alnifolia, Hypericum crux-andreae*, and *Kalmia caroliniana*. *Smilax laurifolia* is also frequent.

Range and Abundance: The equivalent NVC association is ranked G3, but G2 likely is more appropriate given the high threats and dependence on continued commitment to burning. In North Carolina, this community occurs largely in the outer Coastal Plain from Carteret County southward, with a few examples on inner Coastal Plain relict sand dunes. About 25 occurrences are known. A few examples may occur in northern South Carolina. It has been questionably attributed to Georgia in the NVC but should be restricted to the range of *Aristida stricta*.

Associations and Patterns: Wet Sandy Pine Savannas usually occur on sandy landscapes in mosaics with Wet Pine Flatwoods and Pond Pine Woodland. Where they are together, Wet Pine Flatwoods are at distinctly higher elevation. In these mosaics, a few inches difference in elevation relative to the water table can separate the different communities. Where Wet Pine Flatwoods borders a Pond Pine Woodland or other pocosin community, a wet ecotone may harbor species characteristic of Sandy Pine Savanna in a narrow band. However, in other places, it appears a broad zone of Wet Sandy Pine Savanna occurred in this position but has become lost beneath the spreading shrubs of the Pond Pine Woodland.

Variation: Examples are variable and often heterogeneous within patches. Given the diversity of herbs, there can be much variation in local species composition in response to microsite differences. No variants are recognized.

Dynamics: Dynamics are similar to those generally described in the Dry Longleaf Pine Communities and Wet Pine Savannas theme descriptions, especially the crucial role of fire, the patchy tree canopy structure, the conservativeness of many of the dominant plants, and the slowness to recover after mechanical damage or fire suppression.

Frequent fire is particularly important for preventing shrub invasion in these wetter savannas, which are invaded faster than Wet Pine Flatwoods or sandhill communities. In many Pond Pine Woodland patches, including those bordered by Sandy Pine Savanna or Wet Pine Flatwoods, small numbers of *Pinus palustris*, patches of uncharacteristic shrubs (*Gaylussacia frondosa, Kalmia carolina, Rhododendron atlanticum*), or remnant individuals of savanna grasses suggest that a savanna once extended farther. Large acreage of savanna may have been lost by this encroachment of Pond Pine Woodland with past fire exclusion, even in conservation lands that are now managed with frequent fire. The absence of the shallow organic layer characteristic of Pond Pine Woodlands soils suggests this situation. Cecil Frost (personal communication) believes that it is possible for such organic layers to accumulate within historic time, suggesting that Sandy Pine Savannas may once have extended even further. Given the conservatism of most savanna herbs, and their absence in long term seed banks, it is unclear if restoration of such areas could be accomplished even with very frequent fire or chemical or mechanical removal of shrubs.

Glitzenstein et al. (2003) suggest, based on fire experiments in South Carolina and Georgia, that communities of wet Spodosols, such as our Wet Pine Flatwoods, may retain substantial shrub cover even with very frequent fire, while wetter savannas are shrubby only with less frequent fire.

It is unclear how this principle, if it can be generalized to North Carolina at all, would apply to these wetter Spodosol sites.

Comments: Wet Sandy Pine Savannas were not distinguished from Wet Loamy Pine Savannas in the 3rd Approximation, and the distinction was not generally recognized before that time, amid the high species richness and large pool of shared species. However, appreciation of the importance of soil texture as a major influence in general has been borne out by extensive observations, study of rare species, and quantitative analysis (Palmquist, et al. in prep. d). Nevertheless, distinction among the different longleaf pine savannas can be subtle and may be impossible in areas altered by absence of fire.

It has been a dilemma what to call this community, and several different names have been used in earlier drafts of the 4th Approximation. Earlier names referred to Spodosols, but this was dropped in favor of the more familiar term "sandy" because the texture rather than a spodic horizon *per se* is the likely crucial characteristic. Nevertheless, many of the loamy soils that it is contrasted with are sandy loams, and it really is the absence of fine material in the soil that presumably is most important. The late change to a name of Wet Sandy Pine Savanna was done to address a concern that the lack of "wet" in the name implied that it is drier than Wet Pine Flatwoods when it is actually wetter. It is unclear how the wetness of Wet Sandy Pine Savanna sites compares to that of Wet Loamy Pine Savanna or Very Wet Loamy Pine Savanna sites. All have seasonal water tables near the surface, all may differ in the duration of the high water table, but how much moisture remains when the water table drops may be more important and is perhaps dictated by the differing soil texture of those types.

The NVC group placement of the equivalent association is problematic. At the time of publication, it was treated in G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group. The Palmquist, et al. (in prep. d) analysis showed that it appears to straddle the boundary between that group and G190 Wet-Mesic Longleaf Pine Open Woodland Group. It may be moved in the future. The community contains many species that are shared with the other savannas in the latter group and are not otherwise in the Spodosol group. However, it has fewer of them than most members of the wet-mesic group. Field experience brings the same impression – that it has similarities to the communities in each group. However, Wet Sandy Pine Savanna (Rush Featherling Subtype), believed to be the most closely related to the Typic Subtype, has fewer shared species and was less ambiguously placed in G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group in Palmquist, et al. (in prep. d).

Rare species:
Vascular plants – *Asclepias pedicellata, Dionaea muscipula, Helenium vernale, Hypericum* sp. 2 (*brachyphyllum*), *Hypoxis juncea, Lechea torreyi var. congesta, Lophiola aurea, Lysimachia asperulifolia, Macbridea caroliniana, Paspalum dissectum, Pinguicula lutea, Pinguicula pumila, Polygala hookeri, Rhynchospora divergens,* and *Stylisma aquatica*.

Nonvascular plants – *Sphagnum fitzgeraldii.*

Vertebrate animals – *Anaxyrus quercicus, Crotalus adamanteus, Dryobates borealis, Ophisaurus mimicus, Peucaea aestivalis, Pituophis melanoleucus melanoleucus,* and *Sistrurus miliarius miliarius*.

WET SANDY PINE SAVANNA (RUSH FEATHERLING SUBTYPE)

Concept: Wet Sandy Pine Savannas are pine/wiregrass savannas of wet sandy Spodosols, wetter than Wet Pine Flatwoods. The Rush Featherling Subtype encompasses the rare communities of the southern outer Coastal Plain where *Pleea tenuifolia* is dominant or codominant in the herb layer. Examples are known only from Brunswick and Pender counties. The *Pleea* plants form tall hummocks which give the ground greater relief than in other savannas and exclude other plants from where they occur. The strong dominance of *Pleea* often leads to lower species richness in this subtype compared to other wet savannas.

Distinguishing Features: Wet Sandy Pine Savannas are distinguished from Wet Pine Flatwoods by a more diverse herb layer that includes species indicative of greater wetness. The Rush Featherling Subtype is distinguished from all other communities by the dominance of *Pleea tenuifolia* in the herb layer. The species may be present in other Pine Savanna communities but is not dominant or codominant.

Crosswalks: *Pinus palustris - Pinus serotina / Pleea tenuifolia - Aristida stricta* Woodland (CEGL003661).
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Pine Savanna (Pleea Flat Variant) (3rd Approximation).

Sites: The Rush Featherling Subtype occurs in sites similar to the Typic Subtype, on upland flats or terraces, on low rises in relict beach ridge systems, and on lower parts of Carolina bay rims. It occurs in areas with prolonged seasonal high water tables. Where it occurs with Wet Pine Flatwoods, it is at a distinctly lower elevation. In the few places where it occurs near the Typic Subtype of Wet Sandy Pine Savanna, it appears to be slightly lower.

Soils: Soils are sandy Spodosols, almost always mapped as Leon (Aeric Alaquod). The coarse sandy soils are low in nutrient holding capacity.

Hydrology: Soils are saturated at or near the surface during wet seasons, though virtually never with surface flooding. These sites are generally visibly downhill and wetter than those of Wet Pine Flatwoods, and, though less obvious, appear to be wetter than the Typic Subtype of Sandy Pine Savanna. Hydrology is palustrine, but these sites may not be recognized as wetlands because the sandy soils do not show many of the redoximorphic features used to recognize hydric soils.

Vegetation: Vegetation structure is similar to most longleaf pine communities, with a patchy open woodland to savanna canopy dominated by *Pinus palustris*, a dense grassy herb layer, and a shrub layer that varies with fire history. *Pinus serotina* sometimes is abundant in the canopy, though it is not certain if this is natural or is an effect of past logging and altered fire regime.

The dense herb layer is dominated or codominated by *Pleea tenuifolia*, with *Aristida stricta* or *Sporobolus pinetorum* sometimes codominant. *Vaccinium crassifolium* may be extensive. Frequent herbs in CVS plot data (Palmquist et al. in prep. d) include *Xyris caroliniana, Xyris* *ambigua, Polygala lutea, Rhexia alifanus, Andropogon cretaceus* (*glaucopsis*)*, Pityopsis graminifolia, Rhynchospora plumosa, Dichanthelium webberianum, Dionaea muscipula, Iris verna, Trilisa paniculata, Eurybia paludosa, Stenanthium densum, Zigadenus glaberrimus, Lachnanthes caroliniana, Fimbristylis puberula*, and *Cleistesiopsis divaricata/oricamporum*. Relatively frequent are *Sarracenia flava, Drosera capillaris, Solidago pulchra*, and *Dichanthelium tenue*. Shrubs have low cover in examples with frequent fire and may be dense in less frequently burned examples. The most abundant species are *Ilex glabra* and *Gaylussacia dumosa*. Other frequent species include *Vaccinium tenellum, Hypericum tenuifolium, Morella pumila, Morella caroliniensis, Kalmia buxifolia, Ilex coriacea, Aronia arbutifolia, Lyonia mariana, Vaccinium formosum,* and *Lyonia lucida*.

Range and Abundance: Ranked G1. This community is found only in Brunswick and Pender counties, with most of its acreage within a few miles of the towns of Boiling Spring Lakes and Southport. It is not known to occur outside of North Carolina.

Associations and Patterns: The Rush Featherling Subtype occurs as small to large patches, associated with the Typic Subtype of Wet Sandy Pine Savanna, Wet Pine Flatwoods (Typic and Sand Myrtle Subtype), and Pond Pine Woodland (Typic Subtype). Xeric Sandhill Scrub and Coastal Plain depression communities may be present nearby.

Variation: Examples vary in the amount of *Pleea tenuifolia*. No variants are recognized.

Dynamics: Dynamics are probably similar to most longleaf pine communities but are not specifically known. *Pleea tenuifolia* apparently burns readily enough, though it is not as flammable as *Aristida stricta*. The dense hummocks created by *Pleea* may exclude other plants more effectively than *Aristida*, and the Rush Featherling Subtype tends to be lower in species richness. The cause of *Pleea* codominance in these sites is not clear. The species is present in other savannas, both sandy and loamy, in places where this subtype does not occur. Where it cooccurs with other savanna communities, this subtype appears to be wetter, but where it does not occur, other savanna communities grade directly into Pond Pine Woodland. There is no evidence that it was once present in these areas.

As in the Typic Subtype, plants of Pond Pine Woodland appear to invade these communities in the long absence of fire, and a substantial acreage of degraded area may exist adjacent to existing patches.

Comments: The Rush Featherling Subtype appears very distinctive in the field, where the dense hummocks of *Pleea* make walking difficult. However, it proved difficult to distinguish in analysis of CVS data, with other vegetation clustering with the few good examples despite an absence of the distinguishing species. There were also a couple of CVS plots dominated by *Pleea* outside of known examples, and other reports of *Pleea* dominating a mowed power line right-of-way not associated with a savanna. These areas may represent a greater extent of the community than has been recognized, but a few investigated by the author were found to be patches too small to regard as separate communities.

Rare species:
Vascular plants – *Andropogon mohrii, Dionaea muscipula, Hypoxis juncea, Lysimachia asperulifolia, Pinguicula lutea, Pinguicula pumila, Platanthera integra,* and *Polygala hookeri*.

Vertebrate animals – *Anaxyrus quercicus, Crotalus adamanteus, Dryobates borealis, Ophisaurus mimicus,* and *Sistrurus miliarius miliarius*.

Invertebrate animals – *Acronicta sinescripta, Calephelis virginiensis, Exyra fax, Exyra ridingsii, Hemipachnobia subporphyrea, Melanoplus nubilus,* and *Schinia carolinensis*.

WET LOAMY PINE SAVANNA

Concept: Wet Loamy Pine Savannas are longleaf pine or pond pine savannas that are wet but less wet than the Very Wet Loamy Pine Savanna type, on soils other than pure sands (sandy loam, loam, or soils with a clayey B horizon). These communities are typically very high in fine-scale species richness, sharing all of the species of Wet Sandy Pine Savanna and having a large additional suite of herbaceous species. Besides *Aristida stricta*, any combination of *Ctenium aromaticum, Sporobolus pinetorum, Muhlenbergia expansa*, or *Rhynchospora* spp. may dominate or codominate.

Distinguishing Features: Wet Loamy Pine Savannas are distinguished from Wet Sandy Pine Savannas by a suite of herbaceous species that occur primarily on the finer textured soils, including *Coreopsis lancifolia, Marshallia graminifolia, Scleria minor, Rhexia lutea, Polygala ramosa*, *Aletris farinosa, Eupatorium rotundifolium*, *Bigelowia nudata*, *Chaptalia tomentosa*, *Cirsium virginianum*, *Helianthus heterophyllus, Helianthus angustifolius, Lysimachia loomisii, Eryngium integrifolium*, and several *Rhynchospora* species (*baldwinii, chapmanii, galeana*). Characteristic herbs such as *Andropogon* sp., *Osmundastrum cinnamomeum*, *Trilisa* spp., *Rhexia alifanus, Polygala lutea, Dionaea muscipula, Xyris caroliniana, Sarracenia* spp., and *Drosera* spp. are generally present in both, but may be less prominent in loamy savannas.

Wet Loamy Pine Savannas are distinguished from Very Wet Loamy Pine Savannas by the lack or scarcity of a suite of herbaceous species of wetter or richer sites. These include *Rhynchospora latifolia, Sporobolus teretifolius, Eryngium yuccifolium, Stenanthium (Zigadenus) densum, Carex lutea, Thalictrum cooleyi, Scleria bellii, Coreopsis aristulata,* and *Allium* sp. 1. Additional species are likely to be present in Very Wet Loamy Pine Savanna and unlikely to be present in other savannas, including *Triantha racemosa, Asclepias longifolia, Eriocaulon decangulare, Rhynchospora oligantha,* and *Ilex myrtifolia*.

Wet Loamy Pine Savannas are distinguished from Mesic Pine Savannas by an abundant suite of wetland herbaceous plants and an almost complete lack of leguminous herbs. *Desmodium lineatum, Desmodium tenuifolium, Stylosanthes biflora*, *Tephrosia hispidula, Amorpha herbacea,* and *Amorpha georgiana* are legumes known in Wet Loamy Pine Savanna in small numbers, but most other species in that family are found only in Mesic Pine Savanna and drier communities, including *Tephrosia virginiana, Baptisia cinerea, Baptisia tinctoria, Galactia* spp., *Lespedeza capitata, Lespedeza hirta, Pediomelum canescens,* and *Phaseolus sinuatus*.

Crosswalks: *Pinus palustris - Pinus serotina / Sporobolus pinetorum - (Aristida stricta) - Eryngium integrifolium* Woodland (CEGL004501).
G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Pine Savanna (Wet Ultisol Variant) (3rd Approximation).

Sites: Wet Loamy Pine Savannas occur in the outer Coastal Plain on upland flats or terraces, in shallow swales, and on low ridges amid pocosins, all where the substrate contains some silt or clay component and is not pure sand. In the Sandhills Region, they occur in shallow swales with loamy soil.

Soils: Soils in this community are wet Ultisols of a diversity of series. Most frequently mapped are Foreston (Aquic Paleudult), Rains (Typic Paleaquult), Onslow (Spodic Paleudult), and Leon (Aeric Alaquod), though it is unclear if the Leon soils are correctly mapped. Other series mapped at moderate frequency include Woodington (Typic Paleaquult), Lynchburg (Aeric Paleaquult), and Johns (Aquic Hapludult).

Hydrology: Wet Loamy Pine Savannas are saturated at or near the surface during wet seasons, but virtually never have surface flooding.

Vegetation: Vegetation structure is similar to most longleaf pine communities, with an open woodland to savanna canopy dominated by *Pinus palustris*, a dense grassy herb layer, and a shrub layer that varies with fire history. The canopy sometimes is codominated by *Pinus serotina*, though it is not certain if this is natural or is an effect of past logging and altered fire regime.

The herb layer may be dominated by *Aristida stricta, Ctenium aromaticum, Sporobolus pinetorum, Muhlenbergia expansa,* or *Andropogon cretaceus*, varying among different savannas and in patches within sites. *Vaccinium crassifolium* or *Pteridium pseudocaudatum* may also dominate patches, especially where fire has not been frequent. Though less constant, *Calamovilfa brevipilis, Osmundastrum cinnamomeum, Anchistea virginica, Centella erecta,* and *Pleea tenuifolia* may also dominate patches. The herb layer tends to be very diverse. CVS plot data (Palmquist et al. in prep. e) show an average species richness of 83 vascular plant species per 1/10 hectare, the majority of it herbs. Additional herbs that are highly constant in CVS data and in whole-site species lists by Richard LeBlond include *Rhexia alifanus, Rhexia lutea, Rhexia petiolata, Polygala lutea, Xyris caroliniana, Aletris farinosa, Coreopsis linifolia, Dichanthelium ensifolium, Rhynchospora plumosa, Carphephorus tomentosus, Pityopsis graminifolia, Cleistesiopsis divaricata*, and *Drosera capillaris*. Other frequent herbs include several *Eupatorium* (*pilosum, rotundifolium, leucolepis*), *Helianthus heterophyllus, Helianthus angustifolius, Iris verna,* several *Rhynchospora* (*baldwinii, chapmanii, ciliaris, galeana*), *Andropogon glomeratus, Lobelia nuttallii, Sisyrinchium capillare, Erigeron vernus, Xyris ambigua, Dionaea muscipula, Sarracenia flava, Sarracenia purpurea, Calopogon pallidus, Calopogon barbatus, Calopogon tuberosus, Viola primulifolia, Symphyotrichum dumosum, Eurybia paludosa, Dichanthelium strigosum, Trilisa paniculata, Gymnopogon brevifolius, Chaptalia tomentosa, Marshallia graminifolia, Eryngium integrifolium, Scleria minor, Scleria ciliata, Desmodium tenuifolium, Tephrosia hispidula, Lycopodiella alopecuroides, Lycopodiella appressa, Cirsium virginianum, Triantha racemosa, Stenanthium densum, Zigadenus glaberrimus, Sabatia difformis, Polygala hookeri, Sericocarpus linifolius, Nabalus autumnalis, Ludwigia virgata, Desmodium lineatum*, and a number of others.

Though shrubs are a limited component in savannas that have had frequent fire, a diversity of species may be present. Highly constant species include *Ilex glabra, Gaylussacia frondosa, Aronia arbutifolia, Vaccinium tenellum, Morella caroliniana, Magnolia virginiana, Hypericum crux-andreae,* and *Arundinaria tecta*. Other frequent shrubs include *Gaylussacia dumosa, Morella pumila, Vaccinium formosum, Vaccinium fuscatum, Persea palustris, Lyonia ligustrina, Lyonia* *lucida, Rhododendron atlanticum, Ilex coriacea*, and what may be an undescribed species of *Hypericum* resembling *brachyphyllum*. *Smilax laurifolia* and *Smilax glauca* are also frequent.

Range and Abundance: The equivalent NVC association is ranked G1, but G2 is probably more appropriate. There are more than 40 occurrences known in North Carolina, but very few are in good condition. The high threat and dependence on a commitment to ongoing burning gives them higher risk than number of occurrences would suggest. Examples are scattered through the southern half of the outer Coastal Plain, with a few still remaining in the middle Coastal Plain and a few possible occurrences in the Sandhills.

Associations and Patterns: Wet Loamy Pine Savannas are best regarded as small patch communities, though large patches likely existed in the past. They sometimes occur in fine-scale mosaics with Mesic Pine Savanna in nearly flat areas, occupying the slightly lower area. Less often, they may occur with Pine/Scrub Oak Sandhill (Mesic Transition or Blackjack Subtype) or, more rarely still, Very Wet Loamy Pine Savanna. Many examples, probably most in the past, are bordered by Pond Pine Woodland in wetter swales. There may be a broad ecotonal zone in the transition, where conditions are obviously wetter. Also frequent is a broad zone that is sometimes revealed by a particularly effective fire, where sparse savanna herbs are present amid dense pocosin shrubs. This suggests that the savanna may once have been more extensive and that it was overgrown by shrubs spreading from the adjacent Pond Pine Woodland.

Variation: Vegetation is highly variable both among and within examples. It is unclear how much of this variation is due to different site history, how much to microsite differences in hydrology and soil, and how much to other factors. While more patterns may ultimately be recognized, at this time, only a single, narrowly defined variant is distinguished from the rest of known examples.

1. Typic Variant encompasses almost all examples of Wet Loamy Pine Savanna.

2. Big Savannah Variant encompasses the savanna on the unusual high-silt Inceptisols (Liddel series) in northern Pender County described by Wells (1928) and called by this name. He reported a remarkable diversity of species of *Rhynchospora* and *Dichanthelium*, dominance by *Ctenium aromaticum* over a large area, and no *Aristida*. Only heavily altered remnants exist at present, and it is unclear what alteration may have occurred before 1932. Vegetation in power line corridors and logged, fire-suppressed areas was studied by Shelingoski, et al. (2005) and Wall, et al. (2011) and compared to plot data from other savannas. Their analysis showed distinct vegetation, but it is difficult to confirm if this is a result of natural differences or of the greater alteration in the Big Savannah sites. Further consideration may lead to recognition as a subtype.

Floristic differences between the outer Coastal Plain examples and those farther inland should be sought.

Dynamics: Dynamics are similar to those generally described in the Dry Longleaf Pine Communities and Wet Pine Savannas theme descriptions, especially the crucial role of fire, the patchy tree canopy structure, the conservativeness of many of the dominant plants, and the slowness to recover after mechanical damage or fire suppression. However, some dominant species, including *Andropogon* and some *Rhynchospora*, are not as conservative as *Aristida stricta*, suggesting the possibility of different dynamics.

Wet Loamy Pine Savannas are well known for their extremely high species richness at fine scales. Walker and Peet (1983) reported record-setting values of up to 42 species per 0.25 square meter, more than 50 per square meter, and 63-84 per 625 square meters in an annually burned example. Annual fire is generally believed to be more frequent than the natural regime, though some authors such as Frost (2000) believed rates nearly this high to be possible in this community. Fire at this frequency, if sustained in the long term, would prevent regeneration of even many of the characteristic species, including *Pinus palustris*, and is believed to be particularly detrimental to characteristic insect species. Palmquist et al. (2014) demonstrated that, despite the conservatism of the vegetation in general, the high species richness could disappear quickly, at least at the finer scales, through some combination of drought and reduced (but still frequent) fire. More generally, Palmquist et al. (2015) demonstrated the complexity of the interplay among site wetness, soil texture, fire frequency, and scale of measurement in changes in species richness over time. The higher productivity of the wet communities with loamy soil leads to more rapid changes in vegetation over time, even though most of the individuals are long-lived.

Comments: The crosswalked association has sometimes been interpreted to extend into the "wiregrass gap" in South Carolina, presumably because *Aristida stricta* is parenthetical in the name and because it is sometimes replaced by other grasses. However, there is no reason to believe that the overall floristic assemblage that defines this community ranges farther southward than the other longleaf pine communities that occur in North Carolina.

Two associations were initially crosswalked to this community. The second one, *Pinus palustris - Pinus serotina / Ctenium aromaticum - Muhlenbergia expansa - Rhynchospora latifolia* Woodland (CEGL003660), appears redundant and is proposed for dropping. The analysis of CVS data by Palmquist et al. (in prep. e) indicates that only one of these associations is needed. This name has been confusing because *Rhynchospora latifolia* is not frequent in Wet Loamy Pine Savanna, but only in Very Wet Loamy Pine Savanna.

In the 3rd Approximation there was recognition of a Wet Ultisol Variant of Wet Pine Flatwoods, and this was recognized as a subtype in the earliest drafts of the 4th Approximation. However, it was concluded that shrubby low-diversity communities on Ultisols likely are overgrown or depauperate Wet Loamy Pine Savanna communities.

Rare species:
Vascular plants – *Agalinis virgata, Agrostis altissima, Amorpha confusa, Amorpha georgiana, Amphicarpum muehlenbergianum, Andropogon mohrii, Aristida condensata, Aristida simpliciflora, Arnoglossum ovatum* var. *lanceolatum, Asclepias pedicellata, Balduina atropurpurea, Calopogon multiflorus, Cirsium lecontei, Coreopsis palustris, Dichanthelium caerulescens, Dichanthelium cryptanthum, Dionaea muscipula, Helenium pinnatifidum, Helenium vernale, Helianthus floridanus, Hypericum* sp. 1 (*brachyphyllum*), *Hypoxis juncea, Isoetes microvela, Lachnocaulon minus, Lophiola aurea, Lysimachia asperulifolia, Macbridea caroliniana, Muhlenbergia torreyana, Parnassia caroliniana, Paspalum dissectum, Pinguicula lutea, Pinguicula pumila, Platanthera nivea, Polygala hookeri, Pycnanthemum setosum,*

Rhynchospora divergens, Rhynchospora galeana, Sarracenia minor var. *minor, Scleria verticillata, Solidago verna, Spiranthes floridana, Spiranthes longilabris,* and *Sporobolus teretifolius*.

Vertebrate animals – *Ambystoma mabeei, Anaxyrus quercicus, Crotalus adamanteus, Dryobates borealis, Ophisaurus mimicus,* and *Peucaea aestivalis.*

Invertebrate animals – *Atrytone arogos arogos, Calephelis virginiensis, Euphyes bimacula, Exyra ridingsii, Exyra semicrocea, Gabara sp. 1, Hemipachnobia subporphyrea, Melanoplus decorus, Melanoplus nubilus, Metarranthis lateritiaria, Neonympha areolatus, Papaipema appassionata, Schinia carolinensis,* and *Schinia jaguarina*.

VERY WET LOAMY PINE SAVANNA

Concept: Very Wet Loamy Pine Savannas are very rare longleaf pine or pond pine savannas of the wettest loamy or silty soils, often with local inclusions higher in calcium and pH than in other savannas. They are typically very high in species richness. They share most plant species of the Wet Loamy Pine Savanna but have some reduced in importance, and they have a distinctive suite of additional species. *Pinus serotina* and *Ctenium aromaticum, Sporobolus teretifolius, Muhlenbergia expansa*, *Rhynchospora* spp., or *Carex striata* typically dominate. *Aristida stricta* is fairly frequent but not extensive; it may be absent altogether. *Pinus palustris* is often scarce or appears to have difficulty regenerating after logging.

Distinguishing Features: Very Wet Loamy Pine Savannas are distinguished from all other pine savannas and flatwoods by a suite of herbs that are indicative of the higher calcium conditions, including *Rhynchospora latifolia, Sporobolus teretifolius, Eryngium yuccifolium, Stenanthium (Zigadenus) densum, Carex lutea, Thalictrum cooleyi, Scleria bellii, Coreopsis aristulata,* and *Allium* sp. 1. Additional species are likely to be present in Very Wet Loamy Pine Savanna and unlikely to be present in other savannas, including *Triantha racemosa, Asclepias longifolia, Eriocaulon decangulare, Rhynchospora oligantha,* and *Ilex myrtifolia*. A few species frequent in other savannas are scarce in Very Wet Loamy Pine Savannas, including *Aristida stricta, Vaccinium crassifolium, Pteridium pseudocaudatum, Iris verna, Gymnopogon brevifolius*, and the occasional species of drier sites such as *Pityopsis graminifolia* and *Symphyotrichum walteri*. A widely used hint of the presence of Very Wet Loamy Pine Savanna is the co-occurrence of *Liriodendron tulipifera* and *Taxodium ascendens* in or near the savanna.

Crosswalks: *Pinus palustris - Pinus serotina / Magnolia virginiana / Sporobolus teretifolius - Carex striata* Woodland (CEGL004500).
G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Pine Savanna (Very Wet Clay Variant) (3rd Approximation).

Sites: Very Wet Loamy Pine Savannas occur in the outer Coastal Plain on upland flats or terraces where limestone is near the surface (though generally with no outcrop).

Soils: Most soils are mapped as Woodington (Typic Paleaquult) or Grifton (Typic Endoaqualf). Very Wet Loamy Pine Savannas appear to be associated with distinctive soils, generally with limestone near the surface. Nevertheless, soils have, at most, only small inclusions that are high in calcium and have only a somewhat higher pH (5.5 to 7.2); the majority of their soil is similar to other pine savannas (pH 3.8-4.1).

This community was called the Very Wet Clay Variant of Pine Savanna in the 3rd approximation, but soil samples in CVS plots consisted mostly of silt. Clay content was never higher than 10 percent and was not generally higher than in other loamy savannas.

Hydrology: Very Wet Loamy Pine Savannas are saturated at or near the surface during wet seasons, but virtually never have surface flooding. They are wetter than Wet Loamy Pine Savannas, presumably with the water table staying near the surface for longer periods.

Vegetation: Vegetation is an open to very open savanna, sometimes nearly treeless, that may be dominated by either *Pinus palustris* or *Pinus serotina*, with the latter more likely to be present. While it is not clear if either the sparseness of trees or the scarcity of *Pinus palustris* is fully natural, both are more likely in this community than in other Wet Pine Savannas.

The herb layer is very dense and very diverse. CVS data (Palmquist et al. in prep. e) show an average of 85 vascular plant species per 1/10 hectare. *Ctenium aromaticum* and *Muhlenbergia expansa* are both highly constant and may be dominant in substantial patches. Also frequent and sometimes dominant are *Sporobolus pinetorum* and *Sporobolus teretifolius*. *Aristida stricta* is fairly frequent but not extensive. Though not appearing dominant in CVS data, *Rhynchospora* spp., *Andropogon cretaceus*, or *Andropogon glomeratus* may also dominate large patches. Though not usually with as high cover, *Rhynchospora latifolia* sometimes dominates the aspect. Other herbs that are highly constant in CVS data include *Rhexia alifanus, Rhexia lutea, Sarracenia flava, Sarracenia purpurea, Xyris caroliniana, Rhynchospora plumosa, Coreopsis linifolia, Dichanthelium ensifolium, Eurybia paludosus, Bigelowia nudata, Drosera capillaris, Zigadenus glaberrimus, Lycopodiella alopecuroides, Symphyotrichum dumosum, Eupatorium leucolepis, Sisyrinchium capillare, Helianthus heterophyllus, Lobelia nuttallii, Erigeron vernus,* and *Aletris farinosa*. Other herbs that are frequent include several additional *Rhynchospora* species (*chapmanii, oligantha, ciliaris, baldwinii*), *Polygala lutea, Rhexia petiolata, Dionaea muscipula, Stenanthium densum, Xyris ambigua, Xyris baldwinii, Triantha racemosa, Viola primulifolia, Asclepias longifolia, Chaptalia tomentosa, Eriocaulon decangulare, Lachnocaulon anceps, Marshallia graminifolia, Calopogon pallidus, Calopogon tuberosus, Trilisa paniculata, Carphephorus tomentosus, Helianthus angustifolius, Lachnanthes caroliniana, Polygala brevifolia, Fimbristylis puberula, Carex striata, Cleistesiopsis divaricata, Solidago virgata, Pseudolycopodiella caroliniana, Lycopodiella appressa, Eryngium integrifolium, Eryngium yuccifolium* var. *synchaetum, Polygala ramosa, Polygala hookeri, Osmundastrum cinnamomeum, Oxypolis ternata, Anchistea virginica, Seymeria cassioides, Scleria minor, Scleria ciliata, Scleria pauciflora, Pycnanthemum flexuosum, Iris tridentata, Parnassia caroliniana, Sarracenia minor, Centella erecta, Osmunda spectabilis, Ludwigia virgata, Arnoglossum ovatum, Lysimachia loomisii, Panicum virgatum, Dichanthelium acuminatum, Dichanthelium longiligulatum, Amphicarpum amphicarpon, Sabatia difformis, Eupatorium pilosum,* and *Eupatorium rotundifolium*. Less frequent but notable species also include *Thalictrum cooleyi, Carex lutea*, *Scleria bellii, Coreopsis aristulata*, and an unnamed *Allium* species, all of which appear to be endemic to this community or nearly so. Analysis of whole-site species lists by Richard LeBlond largely agrees with the CVS data, but includes a few additional species at fairly high frequency: *Agalinis aphylla, Aletris aurea, Andropogon mohrii, Anthenantia rufa, Aristida palustris, Bartonia virginica, Carex glaucescens, Cirsium virginianum, Mnesithea* (*Coelorachis*) *rugosa, Dichanthelium roanokense, Dichanthelium scabriusculum, Eupatorium mohrii, Euthamia caroliniana, Lobelia canbyi, Lobelia glandulosa, Oxypolis filiformis, Paspalum praecox, Pinguicula caerulea, Pluchea baccharis* (*rosea*)*, Polygala cruciata, Proserpinaca pectinata, Scleria muhlenbergii, Solidago gracillima, Dichanthelium scoparium, Fuirena breviseta, Hyptis alata, Juncus biflorus,* and *Solidago pulchra*.

In addition to the overall high species richness, the diversity within some large genera is also remarkable. In addition to the five species of *Rhynchospora* already named, Richard LeBlond reports *Rhynchospora caduca, careyana, cephalantha* var. *cephalantha, chalarocephala, colorata, corniculata, debilis, distans, decurrens, divergens, elliottii, fascicularis, filifolia, galeana, glomerata* var. *glomerata, gracilenta, inexpansa, inundata, macrostachya, microcephala, mixta, nitens, pallida, pinetorum, pusilla, rariflora, thornei*, and *torreyana*, with 16-27 species present in the several Pender County sites. He reports a similar high diversity in the genus *Dichanthelium*, with 13-23 taxa in several of the same sites.

While shrubs and small trees are a minor component in frequently burned examples, a great diversity of them may be present. The highly constant species are *Ilex glabra, Morella caroliniensis, Acer rubrum* (presumably var. *trilobum*), *Magnolia virginiana, Aronia arbutifolia,* and *Cyrilla racemiflora*. *Cyrilla* often becomes tall and dense where burning has been inadequate. Other frequent shrubs include *Gaylussacia dumosa, Persea palustris, Vaccinium formosum, Vaccinium fuscatum, Morella pumila, Morella cerifera, Gaylussacia frondosa, Lyonia lucida, Nyssa sylvatica, Nyssa biflora, Diospyros virginiana, Clethra alnifolia, Arundinaria tecta, Hypericum crux-andreae, Ilex coriacea, Liquidambar styraciflua, Ilex myrtifolia, Rhus copallinum*, and what may be an undescribed species of *Hypericum* resembling *brachyphyllum*. *Smilax laurifolia, Smilax glauca,* and *Toxicodendron radicans* are frequent. *Vaccinium crassifolium* may be present but is less likely to dominate patches than in other wet longleaf pine communities.

Range and Abundance: Ranked G1, possibly G2. The Grank is confused by there being several associations that could potentially be applied to this subtype. About ten examples are known in North Carolina, most in two small clusters, in northeastern Pender County and around the Waccamaw River in Brunswick and Columbus County. This community is nearly endemic to North Carolina, but a single example was recently recognized in South Carolina.

Associations and Patterns: Very Wet Loamy Pine Savannas are best regarded as small patch communities, though some examples may be more than 20 acres in size. Natural associations are not well known. Some are bordered by small stream drainages, a couple by Pond Pine Woodland, but most lack natural boundaries.

Variation: The two geographic clusters of this community have enough floristic differences to recognize as variants:

1. Maple Hill Variant occurs in Pender County.
2. Old Dock Variant occurs in Columbus and Brunswick County.

The South Carolina occurrence may represent a third variant.

Dynamics: Dynamics are generally similar to those described in the Dry Longleaf Pine Communities and Wet Pine Savannas theme descriptions, especially the crucial role of fire, the patchy tree canopy structure, the conservativeness of many of the dominant plants, and the slowness to recover after mechanical damage or fire suppression. The patterns of species richness at fine scales have not been studied as intensively as they have for Wet Loamy Pine Savannas, but likely are similar. Frequent fire appears crucial for maintaining species richness, as the high productivity of the dominant herbs as well as shrubs can quickly suppress smaller species.

The cause of the sparseness of trees in so many sites is not well known. It may not be natural, but it likely reflects something other than the past logging that is universal in pine savannas. It appears possible that wetness has made it more difficult for longleaf pine to regenerate after logging. This community may be at the margin of tolerance for longleaf pine, with reproduction possible only under rare circumstances, while its natural fire frequency is beyond the tolerance of other tree species. One planting of longleaf pine in a Very Wet Loamy Pine Savanna site known to the author, though planted on artificially raised mounds, ended with complete mortality after a hurricane led to a prolonged wet period. It is possible that competition from the dense herb layer and the high fire intensity it generates are detrimental even to longleaf pine seedlings, but it is not clear that these effects are greater than in some other pine savannas.

Comments: The distinctiveness of the Very Wet Loamy Pine Savanna community type has taken time to be fully appreciated. It has a remarkable collection of endemic species, but most have been recognized only in the last few decades. The most distinctive dominant species, *Sporobolus teretifolius*, remained confounded with *Sporobolus pinetorum* until the 1990s. Most of the sites for this community became known to the scientific and land conservation community only in the 1980s or later. Though specific published literature is scare, they have been well surveyed by many botanists, and site reports and floristic analysis by Richard LeBlond and CVS data give a good picture of the community.

In addition to the NVC association named as a crosswalk above, *Pinus palustris - Pinus serotina / Sporobolus pinetorum - Ctenium aromaticum - Eriocaulon decangulare var. decangulare* Woodland (CEGL004502) was similarly described as equivalent to some of the Very Wet Loamy Pine Savannas. Palmquist, et al. (in prep. e) found this association to be redundant and recommended that it be merged.

Rare species:
Vascular plants – *Agrostis altissima, Aletris lutea, Allium* sp. 1, *Amorpha georgiana, Amphicarpum muehlenbergianum, Andropogon mohrii, Aristida condensata, Aristida simpliciflora, Arnoglossum ovatum* var. *lanceolatum, Baccharis glomeruliflora, Calopogon multiflorus, Carex austrodeflexa, Carex lutea, Cirsium lecontei, Cirsium nuttallii, Coreopsis aristulata, Coreopsis palustris, Dichanthelium caerulescens, Dionaea muscipula, Helenium pinnatifidum, Helenium vernale, Hypericum* sp. 1 (*brachyphyllum*), *Hypoxis rigida, Linum floridanum* var. *chrysocarpum, Ludwigia linifolia, Lysimachia asperulifolia, Lythrum lanceolatum, Macbridea caroliniana, Muhlenbergia torreyana, Oenothera unguiculata, Packera crawfordii, Packera paupercula* var. p*aupercula, Panicum dichotomiflorum* var. *puritanorum, Parnassia caroliniana, Pinguicula lutea, Pinguicula pumila, Plantago sparsiflora, Platanthera nivea, Polygala hookeri, Rhynchospora decurrens, Rhynchospora divergens, Rhynchospora galeana, Rhynchospora microcarpa, Rhynchospora pinetorum, Rhynchospora thornei, Sabatia kennedyana, Sarracenia minor* var. *minor, Scirpus lineatus, Scleria baldwinii, Scleria bellii, Scleria verticillata, Spiranthes longilabris, Sporobolus teretifolius, Thalictrum cooleyi, Trillium pusillum sensu lato, Xyris floridana, Xyris scabrifolia, Xyris serotina,* and *Xyris stricta*.

Vertebrate animals – *Crotalus adamanteus, Dryobates borealis,* and *Peucaea aestivalis*.

Invertebrate animals – *Acronicta sinescripta, Arphia granulata, Calephelis virginiensis, Cycnia inopinatus, Eotettix pusillus, Exyra semicrocea, Melanoplus decorus, Melanoplus nubilus, Nematocampa baggettaria, Neonympha areolatus, Papaipema appassionata, Papaipema eryngii,* and *Stethophyma celatum.*

NORTHERN WET PINE SAVANNA

Concept: The Northern Wet Pine Savanna community type encompasses all wet longleaf pine communities north of the range of wiregrass. It covers a broader range of site conditions than the other communities of the Wet Pine Savannas because the small number of sites and heavy alteration makes determination of their natural condition nearly impossible. It probably covers equivalents to Wet Pine Flatwoods, Wet Sandy Pine Savanna, and Wet Loamy Pine Savanna.

Distinguishing Features: Northern Wet Pine Savannas are distinguished from all other Pine Savanna types by occurrence north of the natural range of *Aristida stricta*, south of the Tar River and Pamlico Sound.

Crosswalks: *Pinus palustris - (Pinus serotina) / Ilex glabra - Gaylussacia frondosa - (Kalmia carolina)* Woodland (CEGL003647).
G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland Group in 2023 NVC but expected to be changed to G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods Ecological System (CES203.265).
Wet Pine Flatwoods (Northern Variant).

Sites: Northern Wet Pine Savannas occur on flat upland terraces and low ridges surrounded by swamps or marshes.

Soils: Northern Wet Pine Savannas could potentially have occurred on a wide range of wetland Ultisols and, less commonly, Spodosols. Pure sandy soils are much less extensive in the northern part of the Coastal Plain. Soils mapped in remnant examples include Exum (Aquic Paleudult), Grantham (Typic Paleaquult), Seabrook (Aquic Udipsamment), Younges (Typic Endoaqualf), and Boling (Aquic Hapludalf).

Hydrology: Sites are seasonally saturated by a high water table.

Vegetation: Remaining Northern Wet Pine Savannas, reflecting a long history of fire suppression, have canopies containing *Pinus palustris* and usually at least some *Pinus serotina*. *Acer rubrum, Liquidambar styraciflua, Quercus nigra*, and other oaks may also be present in the canopy and are common in the understory or shrub layer in sites that are now being burned. *Persea palustris, Magnolia virginiana*, *Diospyros virginiana*, and *Nyssa sylvatica* are also frequent in the understory or shrub layer. Limited CVS data (Palmquist et al. in prep. d) and site descriptions show a great diversity of shrub species common to the remnants. *Gaylussacia frondosa, Ilex glabra, Clethra alnifolia,* and *Arundinaria tecta* dominate patches. Other constant or frequent shrubs include *Morella cerifera, Aronia arbutifolia, Rhododendron atlanticum, Rhododendron viscosum, Vaccinium fuscatum, Vaccinium formosum, Vaccinium tenellum, Gaylussacia dumosa, Morella caroliniensis, Ilex coriacea, Lyonia lucida, Rhus copallinum*, and *Symplocos tinctoria*. *Smilax glauca, Smilax rotundifolia, Smilax laurifolia*, and *Muscadinia rotundifolia* are frequent, and *Gelsemium sempervirens* may also be present. Shrub layers are generally dense at present, and the NVC association is named based on shrubs, but this community was probably no more shrubby than other longleaf pine savannas in natural condition. The herb layer in natural condition was probably dominated by *Schizachyrium scoparium* or various species of *Andropogon*, but no examples are now grass-dominated. *Pteridium pseudocaudatum* is the predominant herb in many examples. Frequent species in CVS plots for the handful of sites that have been sampled include *Osmundastrum cinnamomeum, Andropogon cretaceus, Osmunda spectabilis, Aristida virgata, Solidago virgata, Eupatorium rotundifolia*, and *Eupatorium album*. Additional species reported in a thesis by Murray (1995) on the one site with substantial remaining herb diversity (combining wet and dry environments) indicate relationships to other longleaf pine communities and hint at differences: *Aletris farinosa, Dichanthelium strigosum* var. *leucoblepharis, Eupatorium pilosum, Eutrochium purpureum, Iris verna, Lobelia nuttallii, Muhlenbergia capillaris, Panicum virgatum, Polygala mariana, Rhynchospora inexpansa, Rhynchospora debilis, Scleria triglomerata, Solidago odora, Tephrosia virginiana*, *Asclepias longifolia, Eurybia paludosa, Baptisia cinerea, Baptisia tinctoria, Bartonia virginica, Carphephorus tomentosus, Danthonia sericea, Desmodium tenuifolium, Desmodium strictum, Gentiana autumnalis, Helianthus angustifolius, Lechea racemulosa, Lespedeza* sp., *Liatris graminifolia, Platanthera* sp., *Polygala lutea, Pycnanthemum* sp., *Rhexia mariana* var. *purpurea*, *Rhynchospora harveyi, Tephrosia spicata*, and *Sabatia* sp. It is not known if some Northern Wet Pine Savannas had species richness values comparable to those farther south, but likely they did not. Many of the characteristic species reach their northern range limit in southern North Carolina and do not appear to have naturally occurred in the range of this community.

Range and Abundance: Ranked G2 but warranting G1. No high-quality examples are known to remain. About five examples remain in North Carolina. This community is also known in southern Virginia. Historical records cited by Murray (1995) demonstrate that longleaf pine was widespread even in the inner Coastal Plain in Halifax County, but it is unclear if it dominated the landscape to the extent that it did farther south. The northern Coastal Plain of North Carolina at present supports more extensive oak-hickory forests than the southern part.

Associations and Patterns: Northern Wet Pine Savannas now occur as small patch communities. They probably once occurred in large patches. Natural associates are not known. Most examples are now isolated, but a few are associated with tidal marshes.

Variation: The few remaining examples show substantial variation. This community spans a broad range of wetness and soil texture, probably equivalent to at least four community types.

Dynamics: The dynamics described for the Wet Pine Savannas and Dry Longleaf Pine Communities themes probably apply fairly well to Northern Wet Pine Savannas in their natural condition. The dominance of *Pinus palustris* implies frequent fire, but the absence of the extremely flammable *Aristida stricta,* along with a somewhat different climate, may have led to somewhat lower fire frequency and intensity. The grasses most likely to have dominated are less conservative than *Aristida stricta*, and this may also have changed community dynamics in some way.

Rare species:
Vertebrate animals – *Dryobates borealis*.

SANDHILL SEEP (TYPIC SUBTYPE)

Concept: Sandhill Seeps are sloping, seepage-fed, herbaceous or shrub-herb wetlands that share flora with the Wet Pine Savannas theme. They form in interbedded sand and clay, where a clay layer forces shallow groundwater to the surface. They are primarily in the Sandhills region but may occur in similar settings of interbedded sand and clay elsewhere in the Coastal Plain. They are generally small patches on mid to lower slopes; they may occur as isolated seeps by sandhill communities or as broad to narrow ecotonal communities between Pine/Scrub Oak Sandhill and Streamhead Pocosin communities. The amount of shrub biomass varies with fire history, but the natural state includes abundant herbs. The Typic Subtype encompasses the more widespread examples that lack the distinctive flora of the Savanna Subtype that is shared with Wet Loamy Pine Savannas.

Distinguishing Features: Sandhill Seeps are distinguished from Streamhead Pocosins by occurring on mineral soils and by having a significant persistent component of herbs. Many frequently burned examples have a shrub-dominated central portion but have substantial areas of herb or mixed dominance. However, the natural boundary may be difficult to discern if long absence of fire has allowed shrubs to invade more of the seep. In general, any persisting conservative savanna herbs, even sparse, are an indication that the location was once an herb-dominated seep. Streamhead Pocosins may have opportunistic herbs immediately after a hot fire but the persistent herb component is limited to a few wetland fern and sedge species.

The Typic Subtype is distinguished from the Savanna Subtype by having smaller numbers of species shared with Wet Loamy Pine Savannas of the outer Coastal Plain, lacking much of the diverse herbaceous flora of the Savanna Subtype. Species frequent in the Savanna Subtype and scarce or absent in the Typic Subtype include *Ctenium aromaticum, Chaptalia tomentosa, Coreopsis linifolia, Erigeron vernus, Xyris ambigua, Bigelowia nudata, Eupatorium leucolepis, Viola primulifolia, Aletris farinosa, Eryngium integrifolium, Triantha racemosa, Stenanthium densum, Gymnopogon brevifolia, Marshallia graminifolia, Nabalus autumnalis, Scleria ciliaris, Centella erecta, Ludwigia virgata, Solidago speciosa, Solidago virgata, Ludwigia hirtella, Polygala cruciata,* and *Xyris curtisii/difformis*. Few species are more confined to the Typic Subtype, but *Sarracenia rubra, Scleria nitida, Pteridium pseudocaudatum, Rhododendron atlanticum, Fothergilla gardenii, Amelanchier obovalis*, *Arundinaria tecta*, and *Quercus marilandica* appear to be.

Crosswalks: *Gaylussacia frondosa - Clethra alnifolia - Arundinaria tecta / Aristida stricta - Pteridium aquilinum* var. *pseudocaudatum* Herbaceous Vegetation (CEGL004468).
G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Atlantic Coastal Plain Sandhill Seep Ecological System (CES203.253).

Sites: Sandhill Seeps occur on gentle to steep slopes on substrates where clay underlies permeable sands and where a clay layer intersects the ground surface. All or most are on side slopes in the dissected Sandhills region. Rare examples may occur elsewhere in the Coastal Plain on upland slopes along stream valleys or on relict coastal scarps. Some seeps are isolated on mid slopes, with the seepage water sinking beneath sand below them, while others are on the edges of streamhead drainages that are themselves kept saturated by seepage. Some seeps are associated with a slope break, a local steepening of the slope presumably caused by the greater coherence of the clay layer. Some seeps occur in a distinctive amphitheater-shaped indentation in the slope, likely created by sapping by the groundwater discharge. Because some clay layers are extensive while others are not, seeps may occur in bands or in multiple patches along a given drainage, while others are isolated. Even where clay layers are continuous, patterns of slope erosion or of downslope movement of sand may make seeps discontinuous.

Soils: Sandhill Seep soils consist of sand underlain by shallow clay or by dense clay at the surface. Plinthite may be common. The thickness of the sand above the clay often varies across a given seep, creating gradients in wetness and soil texture and leading to zonation in the vegetation. Seeps are inclusions in other soil map units. Most are mapped as Blaney (Arenic Hapludult), Vaucluse (Fragic Kanhapludult), or Gilead (Aquic Hapludult); fewer as Johnston (Cumulic Humaquept) or Fuquay (Plinthic Kandiudult); and rarely as various other series.

Hydrology: Sandhill Seeps are seasonally to semipermanently saturated at or near the surface. Rainwater readily percolates downward through the coarse sand uphill, but the impermeable clay layers stop downward movement and cause lateral flow that emerges as seepage where the clay layer approaches the surface. The most vigorous seeps may have their discharge collecting into a flowing rivulet in the center. In mid slope seeps, there is often a sand layer below the clay, and water flowing downhill from the seep may sink deeply enough into the sand that the rooting zone again is dry enough to support sandhill communities downhill from the seep.

Vegetation: Sandhill Seep vegetation is unusually heterogeneous and is often visibly zoned in response to variation or gradients in wetness and soil conditions. Variable depth of fire penetration also creates zonation. While seeps with little recent fire may be covered with shrubs throughout, even frequently burned seeps often have a central zone with tall woody vegetation that resembles Streamhead Pocosin. *Lyonia lucida, Ilex coriacea, Ilex glabra,* or *Cyrilla racemiflora* typically dominate this zone, while *Toxicodendron vernix, Morella caroliniensis, Aronia arbutifolia, Vaccinium fuscatum,* sometimes even *Eubotrys racemosus* or *Alnus serrulata* may be present. There may be an open canopy containing *Pinus serotina, Liriodendron tulipifera, Acer rubrum, Persea palustris*, or *Magnolia virginiana. Smilax laurifolia* may form dense tangles. These species may be present in other zones of the seep but generally at low density, though, if fire has only recently penetrated the seep, they may exist as dense beds of sprouts. Outer zones that are shrubby are more likely to be dominated by *Clethra alnifolia, Gaylussacia frondosa*, *Ilex glabra,* or *Arundinaria tecta*, and may contain *Fothergilla gardenii, Amelanchier obovalis, Rhus copallinum*, *Lyonia mariana*, *Vaccinium tenellum, Gaylussacia dumosa*, *Nyssa sylvatica*, *Sassafras albidum,* and even a few stems of *Quercus marilandica* or *Pinus palustris*. Outer zones may include some *Aristida stricta* and often abundant *Pteridium pseudocaudatum*. The herb layer in the intermediate and interior zones often includes patches dominated by *Osmundastrum cinnamomeum*, and may have patches dominated by *Andropogon glomeratus, Andropogon virginicus*, or *Dichanthelium ensifolium*. Beds of *Sphagnum* spp. may be present. Otherwise, where not shrubby, the herbaceous vegetation tends to be fairly diverse, heterogeneous within and among sites, and lacks strong dominants. The only highly constant species in CVS plot data (Palmquist et al. in prep. e) are *Eupatorium rotundifolium* and *Xyris caroliniana*. Other frequent species include *Eupatorium pilosum, Eupatorium leucolepis, Xyris caroliniana, Xyris platylepis, Polygala lutea, Rhexia petiolata, Lobelia nuttallii, Sarracenia purpurea, Sarracenia flava, Sarracenia rubra,* *Lachnocaulon anceps, Pycnanthemum flexuosum, Dichanthelium strigosum, Dichanthelium dichotomum, Ctenium aromaticum, Hexastylis sorriei, Solidago salicina,* and *Symphyotrichum dumosum*. In the wetter interior herbaceous areas, *Eriocaulon decangulare, Anchistea virginica, Lorinseria areolata*, or *Osmunda spectabilis* may be abundant. Other species that are characteristic, though less frequent in plot data, include *Sporobolus pinetorum, Calamovilfa brevipilis, Oxypolis ternata, Drosera capillaris, Drosera rotundifolia, Lilium pyrophilum, Lobelia batsonii,* and in rare examples, *Cladium mariscoides*.

Range and Abundance: The Grank is confused by there being two associations that correspond to this community, ranked G2? and G3? Based on number of occurrences, it should likely be G3, but the deterioration of many examples due to inadequate fire might warrant G2. Almost all examples are in the Sandhills region, with the majority of examples known within Fort Liberty. Rare examples attributed to this community occur in the middle or outer Coastal Plain. This community is also present in the Sandhills in South Carolina.

Associations and Patterns: Sandhill Seeps are small patch communities. They sometimes occur in complexes with multiple small patches, but never amount to a large collective acreage. Sandhill Seeps are usually bordered by Pine/Scrub Oak Sandhill (Blackjack Subtype), at least on the uphill side and often laterally and even downhill as well. Many grade downhill to Streamhead Pocosin or, probably more in the past than at present, Streamhead Canebrake. Of particular note are unusual examples that are bordered below by Coastal Plain Semipermanent Impoundments.

Variation: Sandhill Seeps encompass an extremely wide range in wetness and composition, among examples but also, because of their geologic setting, within individual seeps. See the comments below for discussion of the two former subtypes. Because of the changes caused by the universal alteration in fire regimes, it is difficult to sort out patterns in the variation. It is likely that several subtypes should be recognized, but the basis for doing so is unsettled and needs substantial additional work. Before beginning development of the 4th Approximation, several variants of Sandhill Seep were described during survey work at Fort Liberty. Though definition of them is difficult, they are retained as variants, as a starting point for future work.

1. Typic Variant best fits the description here, often encompassing strong zonation and ranging from marginally wet to moderately wet within individual examples.

2. Bog Variant encompasses lower slope and slope base examples or zones that are extremely wet and bog-like, often with more organic soil, and with vegetation that is a subset of the most saturation-tolerant herbs. This variant often is associated with Coastal Plain Semipermanent Impoundments and, though it is above the level of the impounded water, may be dependent on the effect of the impoundment on the ground water gradient. Where the impoundment is abandoned and has developed into a mire, plants of the Sandhill Seeps often extend out into the pond bed and mix with species of the mire. This is recognized as the Bog Variant of Coastal Plain Semipermanent Impoundment (Sandhills Mire Subtype).

3. Twig-rush variant is an extremely rare community occurring over a nearly flat-lying surficial clay bed and dominated by *Cladium mariscoides.*

Dynamics: As with other Wet Pine Savannas, Sandhill Seeps are extremely dependent on frequent fire to maintain their characteristic herb diversity. Without fire, shrubs quickly expand to cover the entire seep, and herbaceous plants can be largely eliminated. However, fire dynamics are more complex than in the flat savannas or even in rolling sandhills. While the outer zones likely burn every time the adjacent sandhills burn, slope breaks, rivulets, and wetter zones may limit fire spread or reduce its intensity. The Streamhead Pocosins that often lie a short distance downhill limit fire spread with some wind directions. Even if ignited, portions may be able to burn only during drier seasons. Even places with frequent prescribed fire, sufficient to maintain sandhill communities in excellent condition, may have Sandhill Seeps deteriorating because of too little burning.

Many seeps show evidence of variable fire penetration, with tall, unburned shrub zones in the middle, zones of dense shrub sprouts that are recently burned but may have once been unburned for many years, and more frequently burned outer zones. This pattern likely is largely a result of past fire suppression, but something similar probably occurred under natural conditions. Even seeps on Fort Liberty that have burned more frequently than under natural conditions sometimes have such unburned centers. Therefore, these communities may have shown more temporal variation than other savannas, with shrubs expanding and contracting over time.

More than most longleaf pine communities, Sandhill Seeps may be subject to variation in weather from year to year. The sources of ground water are local, shallow, and have limited residence time in the ground. Dry conditions may interact with the fire regime, allowing fire to penetrate farther into the seep but also allowing upland species to spread into the edge of the seep.

The seeping groundwater is low in nutrients, but it may carry enough nutrients leached from the ash and vegetation in the sandhills above to make Sandhill Seeps more fertile than adjacent communities.

Comments: Early drafts of the 4th Approximation recognized two subtypes of Sandhill Seep: Wet Subtype and Very Wet Subtype. These have now been combined in the Typic Subtype. They corresponded to two NVC associations, including *Clethra alnifolia - Toxicodendron vernix / Aristida stricta - Osmunda cinnamomea - Sarracenia* spp. Shrub Herbaceous Vegetation (CEGL004467) as well as the one crosswalked above. This division proved impractical. The vegetation they described occurs as zones in most seeps and it does not appear beneficial to conservation to track them separately. Analysis of CVS data (Palmquist, et al. in prep. e) failed to find two sets of plots corresponding to them. They recommended that CEGL004467 be retired and merged into CELG004468. The Typic Subtype is very variable and should be subdivided in a more useful way, perhaps as indicated by the variants.

Sandhill Seeps are particularly hard to study with CVS plot methodology. Their small size often is comparable to that of a single CVS plot module (10x10 meters), sometimes resulting in portions of plots containing upland vegetation. With the strong zonation, small changes in placement of the plot can lead to drastically different data. Variation in past and current fire regimes further complicates the picture. Nevertheless, Sandhill Seeps in the current broad classification are one of the most heterogeneous communities in the 4th Approximation. Further subdivision is clearly warranted if an appropriate way of organizing the variation can be clarified.

A third NVC association, *(Pinus palustris, Pinus serotina) / Ctenium aromaticum - Muhlenbergia expansa - Calamovilfa brevipilis* Woodland (CEGL003659), described as a sandhill-pocosin ecotone community, has been particularly confusing. The narrow ecotones between Pine/Scrub Oak Sandhill and Streamhead Pocosin often harbor species not found in either community, and these species are ones shared with wet pine savannas. However, these areas are usually very narrow and discontinuous, constancy and abundance of the distinctive species is low, and many of them are shared with Sandhills Seep (Typic Subtype). It was included as a separate ecotone community in early drafts of the 4th Approximation but then was dropped and implicitly treated as part of what it now called the Typic Subtype in later drafts. Palmquist, et al. (in prep. e) recommend its concept be revised to cover the rare, more extensive savanna-like areas of the eastern Sandhills, and this interpretation is the basis for the Sandhill Seep (Savanna Subtype) described below.

Rare species:
Vascular plants – *Amorpha confusa, Amphicarpum muehlenbergianum, Asclepias pedicellata, Astragalus michauxii, Balduina atropurpurea, Carex exilis, Cyperus lecontei, Danthonia epilis, Dichanthelium cryptanthum, Dionaea muscipula, Eriocaulon texense, Eupatorium resinosum, Helianthus floridanus, Lilium pyrophilum, Lindera subcoriacea, Lysimachia asperulifolia, Macbridea caroliniana, Oenothera unguiculata, Parnassia caroliniana, Rhynchospora macro, Rhynchospora oligantha, Schwalbea americana, Solidago verna, Xyris chapmanii,* and *Xyris scabrifolia*.

Vertebrate animals – *Hyla andersonii*.

Invertebrate animals – *Eotettix pusillus, Exyra semicrocea, Hesperia meskei, Melanoplus decorus, Melanoplus nubilus,* and *Schinia carolinensis*.

SANDHILL SEEP (SAVANNA SUBTYPE)

Concept: Sandhill Seeps are sloping, seepage-fed herbaceous or shrub-herb wetlands that share flora with the Wet Pine Savannas theme. They form in interbedded sand and clay, where a clay layer forces shallow groundwater to the surface. They are primarily in the Sandhills region but may occur in similar settings of interbedded sand and clay elsewhere in the Coastal Plain. The Savanna Subtype covers examples that, when frequently burned, resemble Wet Loamy Pine Savannas in their flora. Patches with this kind of vegetation exist in the frequently burned central portions of Fort Liberty. Narrow bands of what may be related vegetation exist on the ecotones between sandhill communities and Streamhead Pocosins in other areas with fairly frequent burning.

Distinguishing Features: Sandhill Seeps are distinguished from Streamhead Pocosins by occurring on mineral soils with a slope and by having a significant persistent component of herbs. However, the natural boundary may be difficult to discern if long absence of fire has allowed shrubs to spread into the seep. In general, any persisting conservative savanna herbs, even sparse, are an indication that a location was once an herb-dominated seep, though more widespread or less conservative species such as *Osmundastrum cinnamomeum* or *Rhynchospora* spp. may not be reliable indicators.

The Savanna Subtype is distinguished from the Typic Subtype by a large number of herbaceous species, most of them shared with Wet Loamy Pine Savannas. Species frequent in the Savanna Subtype and scarce or absent in the Typic Subtype include *Ctenium aromaticum, Chaptalia tomentosa, Coreopsis linifolia, Erigeron vernus, Xyris ambigua, Bigelowia nudata, Eupatorium leucolepis, Viola primulifolia, Aletris farinosa, Eryngium integrifolium, Triantha racemosa, Stenanthium densum, Gymnopogon brevifolius, Marshallia graminifolia, Nabalus autumnalis, Scleria ciliaris, Centella erecta, Ludwigia virgata, Solidago speciosa, Solidago virgata, Ludwigia hirtella, Polygala cruciata,* and *Xyris curtisii/difformis*. Few species are more confined to the Typic Subtype, but *Sarracenia rubra, Scleria nitida, Pteridium pseudocaudatum, Rhododendron atlanticum, Fothergilla gardenii, Amelanchier obovalis*, *Arundinaria tecta*, and *Quercus marilandica* appear to be.

The Savanna Subtype floristically resembles Wet Loamy Pine Savanna but may generally be distinguished by its location in the Sandhills region, occurring on at least gentle slopes, and having soil saturation resulting from seepage rather than from a high water table. Though floristically similar, there are significant floristic differences between the two communities. Some of the species frequent in the Savanna Subtype but not in Wet Loamy Pine Savanna include *Viburnum nudum, Toxicodendron vernix, Pycnanthemum flexuosum, Scleria pauciflora, Liatris spicata, Juncus acuminatus, Juncus trigonocarpus, Schwalbea americana, Angelica venenosa,* and *Lycopus virginicus*. Some of the species frequent in Wet Loamy Pine Savanna and absent or much less frequent in this community include *Dionaea muscipula, Pleea tenuifolia, Sporobolus pinetorum, Sisyrinchium capillare, Vaccinium crassifolium, Desmodium tenuifolium, Eurybia paludosa, Cleistesiopsis divaricatus, Carphephorus tomentosus, Cirsium virginianum, Lysimachia loomisii, Trilisa odoratissima, Trilisa paniculata,* and *Tephrosia hispidula*.

Crosswalks: *(Pinus palustris, Pinus serotina) / Ctenium aromaticum - Muhlenbergia expansa - Calamovilfa brevipilis* Woodland (CEGL003659).
G190 Wet-Mesic Longleaf Pine Open Woodland Group.
Atlantic Coastal Plain Sandhill Seep Ecological System (CES203.253).

Sites: Sandhill Seeps occur on gentle to steep slopes on substrates where clay underlies permeable sands and where a clay layer intersects the ground surface. All or most are on side slopes in the dissected Sandhills region. The Savanna Subtype appears to occur on less wet seeps with gentler slopes.

Soils: Sandhill Seep soils consist of sand underlain by shallow clay or by dense clay at the surface. Plinthite may be common. Details of soils for the Savanna Subtype in particular are poorly known. Examples may be expected to be mapped as the common Ultisols of the Sandhills: Blaney (Arenic Hapludult), Vaucluse (Fragic Kanhapludult), Gilead (Aquic Hapludult), Fuquay (Plinthic Kandiudult), or Byars (Umbric Paleaquult).

Hydrology: Sandhill Seeps are seasonally to semipermanently saturated at or near the surface. Rainwater readily percolates downward through the coarse sand uphill, but the impermeable clay layer stops downward movement and cause lateral flow which emerges as seepage where the clay layer approaches the surface.

Vegetation: Vegetation in the Savanna Subtype, where frequently burned, may have an open canopy of either *Pinus palustris* or *Pinus serotina*. A diverse herb layer may be dominated by *Aristida stricta* or may have patches dominated by *Ctenium aromaticum* or *Sporobolus pinetorum*, potentially also by *Calamovilfa brevipilis* or *Rhynchospora* sp. In CVS plots (Palmquist, et al. in prep. e), *Eupatorium rotundifolium, Andropogon* sp., *Dichanthelium* spp., *Scleria pauciflora*, and *Chaptalia tomentosa* sometimes have high cover. Other highly constant species in the small number of plots include *Lachnocaulon anceps, Rhexia alifanus, Symphyotrichum dumosum, Coreopsis linifolia, Drosera capillaris, Erigeron vernus, Eupatorium pilosum, Eupatorium leucolepis, Xyris ambigua, Xyris caroliniana, Osmundastrum cinnamomeum, Bigelowia nudata, Pycnanthemum flexuosum,* and *Viola primulifolia*. Additional frequent herb layer species include *Aletris farinosa, Calopogon tuberosus, Eryngium integrifolium, Helianthus angustifolius, Lespedeza capitata, Pogonia ophioglossoides, Polygala lutea, Solidago odora, Symphyotrichum walteri, Sarracenia flava, Pteridium pseudocaudatum, Hypoxis wrightii, Lycopodiella alopecuroides, Muhlenbergia expansa, Rhexia petiolata, Stylosanthes biflora, Iris verna, Stenanthium densum, Calopogon pallidus, Dichanthelium strigosum, Eupatorium mohrii/recurvans, Gymnopogon brevifolius, Ionactis linariifolia, Liatris spicata, Lespedeza virginica, Lycopodiella alopecuroides, Lycopus virginicus, Marshallia graminifolia, Nabalus autumnalis, Potentilla canadensis, Sisyrinchium capillare, Vaccinium crassifolium, Juncus acuminatus, Juncus trigonocarpus, Oxypolis ternata, Scleria ciliata, Zigadenus glaberrimus, Panicum virgatum, Aletris aurea, Centella erecta, Coreopsis verticillata, Desmodium tenuifolium, Eriocaulon decangulare, Ludwigia virgata, Orbexilum pedunculatum/psoralioides, Pinguicula caerulea, Pityopsis graminifolia, Rhexia lutea, Sarracenia purpurea, Schwalbea americana, Scleria minor, Sericocarpus linifolius, Solidago salicina, Solidago speciosa, Solidago virgata, Sophronanthe pilosa,* and several species of *Rhynchospora (chapmanii, marliniana/plumosa, grayi, rariflora*).

Shrub cover and density vary with fire history. The highly constant species in plots are *Ilex glabra, Morella carolinensis,* and *Viburnum nudum*. Other frequent species include *Clethra alnifolia, Aronia arbutifolia, Arundinaria tecta, Gaylussacia frondosa, Gaylussacia dumosa, Lyonia ligustrina, Vaccinium tenellum, Rhus copallinum, Toxicodendron vernix, Vaccinium formosum,* and *Alnus serrulata,*

Range and Abundance: Ranked G2 but see comments below about questions regarding the concept of the NVC association. The only place where broad areas with the vegetation described here are known is the central portion of Fort Liberty. This would suggest a rank of G1. Narrow ecotones with small subsets of this flora are widespread in Fort Liberty and limited in other conservation lands. If they are interpreted as the same community, most examples are very small or heavily degraded by shrub encroachment. The NVC association is also attributed to South Carolina. No plots or specific occurrences are known there, and it likely exists only as very small or degraded examples.

Associations and Patterns: The Savanna Subtype is a small patch community, at least as well-developed examples exist at present. Examples generally would be bordered by Pine/Scrub Oak Sandhill (Blackjack Subtype) uphill, and Streamhead Pocosin downhill.

Variation: Little is known of the range of variation.

Dynamics: Uncertainties in the interpretation of this community lead to different conclusions about probable dynamics. This community appears to be even more dependent on frequent fire than most wet longleaf pine communities. Well-developed examples are known only in places that are burned nearly annually by military training, more frequent than the likely natural fire regime (2-3 years).

Comments: This community was added to the 4th Approximation very late in the preparation of this document, and it is accepted provisionally, with the concept and description somewhat uncertain. The crosswalked NVC association, *(Pinus palustris, Pinus serotina) / Ctenium aromaticum - Muhlenbergia expansa - Calamovilfa brevipilis* Woodland (CEGL003659), was initially defined as the "sandhill-pocosin" ecotone, a zone between Pine/Scrub Oak Sandhill and Streamhead Pocosin in which multiple species of pine savannas are found. However, in the very frequently burned parts of central Fort Liberty, many of them in rarely accessible artillery range buffer zones, savanna-like vegetation occurs in broader expanses, running down gentle slopes to adjoin Streamhead Pocosins that are much narrower than those elsewhere. A unique opportunity to sample vegetation plots in some of these areas led to the data that were used to describe this community. Analysis of these and other CVS data (Palmquist, et al. in prep. 3) found them to be distinct from both Sandhill Seeps and Wet Loamy Pine Savannas, as described above, and recommended revising the concept of the NVC association to emphasize these areas rather than narrow ecotones. This approach has been adopted for the 4th Approximation.

As thus defined, the Savanna Subtype could be interpreted as either a version of Sandhill Seep or of Wet Loamy Pine Savanna. The decision to treat it as a Sandhill Seep is uncertain. It appears to have a setting similar to the Typic Subtype of Sandhill Seep. Its flora, based on existing plots, appears more similar to Wet Loamy Pine Savanna. However, it is unclear how much its distinctive character is a result of site differences and how much it is a result of fire history. The few species that are more abundant in plots from the Typic Subtype are mostly shrubs that generally increase with fire suppression. Most examples of the Typic Subtype occur outside of Fort Liberty, where even lands that are now burned at something approximating a natural fire frequency underwent many years with no fire. Fort Liberty was established not long after effective fire suppression came to the Sandhills region; it has been subject to frequent fire for most of the time since. It thus has a continuity with the frequently burned past that remains nowhere else. On the other hand, the near annual burning there is probably unnaturally frequent. It may have altered this community in various ways. The geology of Fort Liberty also differs in some ways from the rest of the Sandhills, so it is possible there are site differences as well. The community described here is thus an extremely rare, highly diverse community known from only a small area and distinct due to an unknown combination of subtle site differences, historical continuity of fire regimes, and an extreme present fire regime.

It is unclear if the ecotones a few meters wide, with a small subset of the species described for the Savanna Subtype, represent the same community. It is possible that they are the last remnants of savannas that once were much wider and more comparable to those in Fort Liberty. However, it is also possible that they are naturally small and depauperate, and that the Savanna Subtype can fully develop only on unusual terrain such as gentler slopes. The ecotone community was recognized for a time in early drafts of the 4th Approximation, but it was dropped, or was implicitly combined with what is now Sandhill Seep (Typic Subtype).

It also remains a question how distinct the Typic Subtype of Sandhill Seep is from the Savanna Subtype in long term character. Most remaining examples of the Typic Subtype show evidence of substantial alteration by fire suppression, suggesting they may have lost some of their herbaceous flora.

Rare species:
Vascular plants – *Amorpha confusa, Amphicarpum muehlenbergianum, Asclepias pedicellata, Astragalus michauxii, Balduina atropurpurea, Carex exilis, Cyperus lecontei, Danthonia epilis, Dichanthelium cryptanthum, Dionaea muscipula, Eriocaulon texense, Eupatorium resinosum, Helianthus floridanus, Lilium pyrophilum, Lindera subcoriacea, Lysimachia asperulifolia, Macbridea caroliniana, Oenothera unguiculata, Parnassia caroliniana, Rhynchospora macro, Rhynchospora oligantha, Schwalbea americana, Solidago verna, Xyris chapmanii,* and *Xyris scabrifolia*.

Vertebrate animals – *Hyla andersonii*.

Invertebrate animals – *Eotettix pusillus, Exyra semicrocea, Hesperia meskei, Melanoplus decorus, Melanoplus nubilus,* and *Schinia carolinensis*.

COASTAL PLAIN DEPRESSION COMMUNITIES THEME

Concept: Coastal Plain Depression Communities are wetlands of relatively small, closed basins in the Coastal Plain, which pond water at least intermittently, and which lack the characteristics of Peatland Pocosins, Natural Lake Communities, and Maritime Wetlands. They occur in Carolina bays, limesink depressions, and a variety of other depressions on geologically young surfaces. Their vegetation is extremely varied, ranging from open water and herbaceous vegetation to shrubland and forest.

Distinguishing Features: Coastal Plain Depression Communities may be distinguished from most other Coastal Plain communities by their occurrence in small, closed basins that hold standing water at least at times. Most basins are distinctive, but the subtle topography of the outer Coastal Plain and the presence of seasonally high water tables and slow runoff from high rainfall events in many flat areas can make some basins difficult to recognize. In addition, excessive soil drainage in sandy areas allows some closed basins to never hold water and not to be wetlands at all. Therefore, the distinctive vegetation of the specific communities often is crucial for recognizing Coastal Plain Depression Communities.

If permanent standing water is present, Coastal Plain Depression Communities are distinguished from Natural Lake Communities by occurring in much smaller basins and having water bodies that are much smaller, lack wave action, and generally are more vegetated. Open water is not more than a couple of acres in size, consistent with the Cowardin et al.'s (1979) definition of palustrine rather than lacustrine wetlands as being less than 20 acres/8 hectares. Maritime Wetlands, which often occur in closed basins, are distinguished by locations on barrier islands, with the concomitant influence of salt spray, geologically younger surfaces, and the dynamic coastal environment. Coastal Plain Depression Communities do not include communities that fit the characteristics of Peatland Pocosins. Where Peatland Pocosins occur in depressions, the depressions are filled with moderate-to-deep organic matter accumulations and the vegetation is indistinguishable from other peatlands. However, the distinction can be subtle in transitional communities such as Small Depression Pocosins and some Coastal Plain Depression Swamps. Coastal Plain Depression Communities are distinguished from various closed basins of active floodplains, such as Oxbow Lakes and some Cypress–Gum Swamps, by the lack of river flooding. Piedmont and Mountain Upland Pools and Depressions are similar basin communities of the inland geologic regions, sometimes sharing species with Coastal Plain Depression Communities but also having distinctive vegetation.

Within the Coastal Plain Depressions theme, the communities are distinguished by the combinations of hydrology and vegetation. Small Depression Pocosins have dense shrubby vegetation, sometimes with an open tree canopy, resembling that of Peatland Pocosins and Streamhead Pocosins, though with some additional species. Coastal Plain Depression Swamps have a substantial tree canopy, generally of *Taxodium ascendens* or *Nyssa biflora*. The Pocosin Subtype may also have a substantial shrub layer, but the Cypress Dome Subtype has deep water and little shrub layer. Cypress Savannas occur in flat basins with substantial differences in water presence from year to year. They generally have an open canopy dominated by *Taxodium ascendens*. In the few treeless examples, floristic differences distinguish them. Wetter depressions have herbaceous vegetation, but often have a ring of dense shrub and tree vegetation around their edge. This woody edge zone is recognized as the Small Depression Shrub Border community.

Herbaceous Depressions are divided into broad categories by wetness and the vegetation it promotes. Vernal Pools dry early and have facultative wetland plants, sometimes even upland species. Small Depression Drawdown Meadows have longer flooding but still a substantial dry period. They may fill a basin or occur as a broad band in zoned basins. Small Depression Ponds can hold water for much or all of the growing season. The Typic Marsh and Cutgrass Prairie subtypes are shallow enough that they are dominated by emergent large herbs, while the Open Lily Pond Subtype is dominated by floating or submersed herbs. The distinctive Floating Bog community encompasses the rare situations where a thick vegetation mat floating on water creates rooting sites for bog-like vegetation.

Sites: The most abundant sites for Coastal Plain Depression Communities are Carolina bays without peat (clay-based bays) and limesinks. Limesinks are collapsed basins in sandy or loamy sediments believed to result from solution in buried limestone. Other depressions that support these communities include swales in relict inland sand dune systems and relict fluvial features on high river terraces that no longer flood. Limesink depressions often occur in clusters, with basins that vary in depth, steepness, and size occurring close together. Other depressions may also occur in clusters or may be isolated. A given basin may hold one community or may have two or three in an irregular or concentrically zoned complex.

Soils: Most depressions are small and are treated as unnamed inclusions in soil map units. Larger depressions, such as Carolina bays, may be mapped as a variety of wet Ultisols. McColl (Typic Fragiaquult) is often mapped for clay-based Carolina bays. Soils may be an important driver of differences among depression communities or may reflect them. Kirkman, et al. (2000), working in limesink clusters in southwest Georgia, found that what they called cypress savannas were correlated with clay while what they called marshes were correlated with sand. Denser cypress-gum swamps were correlated with more organic matter in the soil as well as a longer hydroperiod.

Hydrology: Coastal Plain Depression Communities are distinguished by at least periods of standing water which cannot run off. Rain falling directly into the basin is a major source of water. Most basins have little or no surface watershed. Many basins are water table windows, with water levels rising and falling with the shallow ground water of adjacent uplands. However, many may also have perched water, with an impermeable layer preventing downward drainage when the surrounding water table falls. Some basins have outlet channels that allow drainage of excess water while retaining water to a certain depth. Water may be removed by infiltration in some cases but solely by evapotranspiration in others.

The hydroperiod – typical duration of flooding – is a crucial characteristic of depressions and is a major driver of the occurrence of the different communities. The centers of the deepest basins may remain flooded except in the most severe droughts. Most basins, however, have both flooded and drawdown periods, holding water in the winter but lacking it at least by late summer.

The variation in hydroperiod is also common and important in these communities. Water levels are sensitive to climatic cycles and to variation in weather from year to year. Some depressions may be flooded throughout some years and dry throughout others. The steepness of the slope in the depression affects the community through its effect on the hydroperiod. Flat-bottomed basins have similar water levels over large areas, and the environment can be strikingly different from year to year. More sloping basins can have greater absolute variation in water level but retain a range of environments, allowing animals and even plants to shift in response.

Vegetation: Vegetation within this theme spans a very wide range of structure and composition, reflecting the range of wetness. In communities with trees, *Taxodium ascendens* or *Nyssa biflora* usually dominate, but *Acer rubrum* var. *trilobum*, *Magnolia virginiana, Persea palustris*, or *Pinus serotina* may occur in Small Depression Pocosin and Small Depression Shrub Border communities. Shrub layers may be similar to pocosins, with *Cyrilla racemiflora, Lyonia lucida*, and *Ilex coriacea* prominent, or may contain *Vaccinium fuscatum, Vaccinium corymbosum*, or, in the case of Small Depression Shrub Border, *Litsea aestivalis*.

Herbaceous composition is even more variable. Vernal Pools often are dominated by species that may be shared with uplands, particularly *Panicum virgatum* and *Andropogon* spp. Small Depression Ponds are most often dominated by *Nymphaea odorata* in the Open Lily Pond Subtype, or by *Hymenachne* (*Panicum*) *hemitoma* or *Leersia hexandra* in the other subtypes, but a variety of other large graminoids may be abundant. Between Vernal Pool and Small Depression Pond in wetness, Small Depression Drawdown Meadows may share species with both and may contain a high diversity of rare plants and of showy herbs such as *Polygala cymosa* and *Lachnanthes caroliniana*. Cypress Savannas too can support a highly diverse herb layer with many rare species. However, more acidic subtypes of several communities have a small set of characteristic herbs shared with pocosins, such as *Anchistea virginica*, *Lorinseria areolata*, and *Sphagnum* spp.

Dynamics: Coastal Plain Depression Communities tend to have a distinctive dynamic character driven by flooding and drawdown and their variations. Intensive study of depressional wetlands at Savanna River Plant in South Carolina and Ichauway Plantation in Georgia (Mulhouse, et al. 2005, DeSteven and Toner 2004, Kirkman, et al. 2000, Kirkman 1995, Kirkman and Sharitz 1994, Kirkman and Sharitz 1993) has not been repeated in North Carolina but seems to be similar in broad outlines. However, those studies were focused on dominant species and addressed only a few of the species that can be dominant in North Carolina's communities.

Water levels fluctuate over the course of a year, generally being high in the winter and spring and drawing down with the higher temperatures and evapotranspiration in summer. The hydroperiod, the typical duration of flooding, affects the nature of the soil and is the most important driver of community types. Differences in typical water depth also are important and are at least somewhat independent of flooding duration. Some basins have relatively stable water levels while others may go from deep water to dry in many years.

There can be substantial variation from the normal hydroperiod, in response to weather. Stahle's (1988) dendrochronology work showed periods of persistent drought or high rainfall on a time scale of around 30 years. These changes for periods of several years perhaps have more effect on Coastal Plain Depression Communities than on any others. The South Carolina and Georgia studies documented some of the major changes in vegetation that are possible between wet and dry periods. During extended droughts, upland ruderal species such as *Andropogon virginicus,* *Eupatorium capillifolium*, and *Pinus taeda* can establish. Species they characterize as fugitive species, such as *Iva microcephala, Croton elliottii, Kellochloa (Panicum) verrucosa*, and *Dichanthelium wrightianum*, appear. In North Carolina, *Cyperus* spp. sometimes are prominent in dried basins. The dominant species of wetter times may remain present at reduced cover or may disappear. Species of open water, such as *Nymphaea odorata* and *Utricularia* spp., may be absent or invisible during drought, while marsh dominants such as *Hymenachne hemitoma* persist but are joined by different species. The characteristic trees species, *Taxodium ascendens* and *Nyssa biflora*, likely only establish during dry periods, presumably resulting in natural populations with several distinct cohorts. These longer-term irregular or cyclic changes are sometimes referred to as disturbances in the literature but they are quite different from other kinds of natural or human disturbances that may occur.

During dry periods, fire appears to be an important part of ecological dynamics. Different Coastal Plain Depression Communities vary, but those dominated by dense herbaceous cover, such as Vernal Pool, Small Depression Drawdown Meadow, and the marsh subtypes of Small Depression Pond can readily carry fire when dry. Even the wetter Open Lily Pond Subtype may burn if its bed becomes occupied by new grass and sedge cover during prolonged drought. The natural surrounding landscape, almost always some kind of longleaf pine community, burned frequently and would have provided ample opportunity for ignition. Thus, the loss of natural fire regimes has potentially altered the depression communities as well as the uplands. Prescribed fires conducted in the winter or confined to wetter growing seasons, when depressions are flooded, do not replace the natural fire regime. The characteristic tree species are at least somewhat tolerant of fire; nevertheless, burning must be an important mediator of their seedling establishment during dry periods.

Many published studies mention *Pinus taeda* establishing during drought, and *Liquidambar styraciflua* and *Acer rubrum* can also be observed invading depressions in North Carolina. Older trees of these species are not found in the less altered, more natural examples of these communities. It is widely believed that these trees should be eliminated when higher water levels return. This has been observed in some limesinks with the return of wetter conditions in 2017 and 2018 after a dry period. However, it appears that fire may be important in preventing the development of dense tree stands during drought. Some other sites have developed dense cover of trees that have become large enough that they may not be easily eliminated. It is often suggested that, once established, increased evapotranspiration by the trees may reduce the hydroperiod even when wet conditions return, and thus that they persist and permanently make the basin drier. This presumably would only be true of basins whose water budget is independent of the surrounding water table; basins whose water levels reflect the broader water table would be affected by transpiration throughout a large area of forested upland. The long time span of weather fluctuations makes the ultimate outcome unclear.

Other alterations besides lack of fire may also be important in the invasion of open basins by trees. The seed rain of species such as *Pinus taeda* has vastly increased with human disturbance and fire suppression in the surrounding landscape. The effects of drainage and ground water pumping in the wider landscape are also potentially crucial for basins whose hydrology is tied to the regional water table.

The changes in vegetation over time are driven both by the ecology of individual species and by interactions among them and with other factors. Mulhouse, et al. (2005) found that vegetation changed less in dense marsh vegetation such as *Hymenachne hemitoma* than in the more open *Leersia hexandra* and *Nymphaea odorata* ponds, and they suggested this was because of competitive effects of the vegetation. However, they noted that these vegetation types were associated with different hydroperiods, with more extreme fluctuation in the more open ponds, making it impossible to disentangle the effects. The ability of *Hymenachne hemitoma, Leersia hexandra*, and *Mnesithea* (*Coelorachis*) *rugosa* to persist is aided by their ability for stem elongation with rising water (Kirkman and Sharitz 1993). *Leersia* elongates the most, but it was found to have less stomatal control and so to be less tolerant of drought. *Hymenache* was found to be dependent on standing dead stems to withstand flooding; it was harmed when stands burned shortly before flooding.

Seed banking is particularly important in these depression communities. It is a beneficial strategy in an environment with such drastic changes. Kirkman and Sharitz (1994) found 72,600 seeds per square meter, with a total of 108 species and 17-19 species per plot. This was double the diversity of standing vegetation in 5x5 meter plots. Most species emerged in standard greenhouse conditions but several species, including rare ones such as *Helanthium tenellum (Echinodorus parvulus*) and *Sagittaria isoetiformis* emerged only with flooding. Perennial species that reproduce in their first year were particularly important. Despite the size of the seed bank for some species, most species had low frequency, and important dominants such as *Leersia hexandra* and *Hymenachne hemitoma* were not important. These species rely primarily on vegetative reproduction and on persistence of individuals through varying conditions. The longevity of seed banks is not well known. The rediscovery of *Lobelia boykinii*, a rare species of North Carolina depressions, in a Delaware pond after an absence of 100 years, is probably extreme but points at the possibilities.

The longer-term dynamics of depressions are necessarily less well known than those in the short term. The few pocosin-dominated, peat-filled Carolina bays that have been studied appear to have once had open vegetation that may have been akin to Coastal Plain Depression Communities. However, given the time spans involved, it is more likely that changes in climate drove the change rather than successional time. Kirkman (1995) notes that some authors have interpreted concentric zonation as representing hydrarch succession, as it is often interpreted in glacial kettle hole lakes. They note that some take the different communities in different depressions to represent successional stages, such as a progression from mineral to organic soils and from herbaceous to woody vegetation. This is possible, though it seems equally likely that they represent stable patterns in relative equilibrium with typical hydroperiods and fire regimes. However, it is possible that there are stable states that are rarely created but, once created, persist indefinitely by altering flammability or preventing reproduction of other species.

Carolina bays appear to be stable landforms at present and are probably all around the same age, but limesink depressions in a cluster may form at different times and may change as the underground solution continues. A new pond was formed in the Patsy Pond limesink complex in Croatan National Forest in 2003 and offers a chance to observe the changes first hand. Directional changes that can be expected in limesink depressions include erosion of the sides to create gentler slopes, filling of the bottom by eroded material to make them shallower, accumulation of organic matter or wind-blown clay, and development of a spodic soil horizon. The latter two processes would gradually create an impermeable layer that would perch water. Thus ponds might become more independent of water tables over time and have their hydroperiods change. The pace of such changes is not known but must be slow. The 2003 new limesink can be seen to have somewhat softened edges but remains nearly vertical-sided and with only sparse vegetation. The variation in ponds within a cluster may be related to such slow successional processes but is also related to the initial steepness, size, and depth of basins and how they interact with water tables.

Comments: Coastal Plain Depression Communities are some of the most difficult to classify for the purposes of the 4th Approximation, where enduring characteristics are emphasized. The extreme temporal variability in their environmental conditions and vegetation makes it difficult to tell what characteristics are enduring. Observation may be close to impossible in wet years and yet give false impressions if done during drought. All observations need to be interpreted in light of the relationship of current conditions to the long term variation.

Classification is also difficult because of uncertainty about the best spatial scale to use. While some depressions have homogeneous vegetation, in many the vegetation is strongly zoned. Zones may be recognized at a broad range of scales, down to just a couple meters wide. A classification of 1 meter square plots would potentially look very different from a classification of 1/10 hectare plots in the same places. At the same place, a whole-site species list might include many species that would never actually occur close to each other. The 3rd Approximation subsumed the zones, classifying a whole depression as one community based on the wettest or the most predominant portion. The 4th Approximation uses a middle ground approach, distinguishing a small number of communities that can represent broad zones within a single basin. The rationale for this change in approach is that the communities at this scale often are separated. Though a single depression could contain 3 or 4 zonal communities, most do not have that many well developed examples. The best developed, most extensive examples often are in different depressions. Conservation of their diversity is best served if they are tracked separately.

For limesink depressions and other outer Coastal Plain members of this theme, observations and synthesis by Richard LeBlond, contained in Natural Heritage Program reports and personal communications, has been a major contribution to this classification. His work is based on whole-site species lists and specific descriptions of zones and of the role of basin configuration. For Carolina bay depressions, Nifong's (1998) plot-based quantitative study contributes heavily to this classification. His analysis units are 10 meter square plots, but many are extracted from 1/10 hectare Carolina Vegetation Survey (CVS) plots. The sampling spanned a period of many years; the resulting mix of spatial and temporal variation is partially confounded; this is recognized in some places but perhaps not throughout. For these reasons, interpretation for the purpose of the Fourth Approximation is difficult and remains somewhat uncertain. More experience is needed in applying it, and further refinement of the units in this theme is likely. There is a need both for extensive study that compares depressions over a short period of time and for long-term study of the range of variation in single sites.

Coastal Plain Depression communities are better represented in the published literature in South Carolina and Georgia. Though it is difficult to match published names to our classification, much of our understanding of dynamics comes from this area.

KEY TO COASTAL PLAIN DEPRESSION COMMUNITIES

1. Community dominated by woody vegetation, with a substantial (though often open) tree canopy or shrub layer.
   2. Community a narrow band around the edge of a nonwoody depression community, adjacent to the upland on one side; vegetation of dense shrubs and often an open tree canopy; dominant species usually shrubs shared with pocosins (*Lyonia lucida, Cyrilla racemiflora, Ilex glabra, Ilex coriacea*, but potentially also *Vaccinium* spp., *Litsea aestivalis, Ilex myrtifolia*, and others)........ ....**Small Depression Shrub Border**
   2. Community filling the basin or a substantial part of it, not a narrow band on the edge; vegetation various, with or without dense shrubs shared with pocosins.
      3. Community in natural condition with a dense herb layer that often varies year to year with changing water levels; tree canopy open, dominated by *Taxodium ascendens*; occurring in a broad, flat basin, usually clay-based Carolina bays but occasionally other flat outer Coastal Plain depressions.
         4. Community with a diverse herb layer that varies substantially with water levels, often containing *Dichanthelium wrightianum, Rhexia aristosa, Scleria reticularis, Scleria muhlenbergii, Rhynchospora inundata, Rhynchospora filifolia, Eupatorium leucolepis, Eupatorium paludicola, Kellochloa (Panicum) verrucosa, Pluchea baccharis (rosea), Boltonia asteroides,* and *Eleocharis tricostata*, as well as some more widespread species such as *Hymenachne (Panicum) hemitoma* and *Kellochloa (Panicum) verrucosa*…………… ....**Cypress Savanna (Typic Subtype)**
         4. Community with a less diverse herb layer dominated by species of the most extremely acid-tolerant plants, such as *Sphagnum* spp., *Anchistea virginica, Carex striata, Carex glaucescens, Lachnanthes caroliniana*, *Hymenachne (Panicum) hemitoma*, *Kellochloa (Panicum) verrucosa*, and *Centella erecta*. .... **Cypress Savanna (Acidic Subtype)**
      3. Community in natural condition with a sparse herb layer; with a dense shrub layer or, if shrubs less dense, with a dense or only slightly open tree canopy of *Nyssa biflora, Taxodium ascendens*, or *Pinus serotina*; in various kinds of basins, including clay-based Carolina bays, limesinks, and deep swales.
         5. Canopy dominated by *Pinus serotina*, or canopy absent and shrub layer dense and pocosin-like.
            6. Community with a dense shrub layer dominated by varying combinations of *Lyonia lucida, Cyrilla racemiflora, Ilex glabra, Ilex coriacea*, *Zenobia pulverulenta*, *Vaccinium* spp., or *Ilex laevigata*; *Smilax laurifolia* often abundant... .... **Small Depression Pocosin (Typic Subtype)**
            6. Community with a dense shrub layer dominated by *Vaccinium fuscatum* or *Vaccinium formosum*, sometimes with some *Eubotrys racemosus* or *Viburnum nudum* ....**Small Depression Pocosin (Blueberry Subtype)**
         5. Canopy dominated by *Nyssa biflora* or *Taxodium ascendens*; *Pinus serotina* absent.
            7. Community with little shrub layer except on the edges; predominant shrub *Ilex myrtifolia*; canopy usually dominated by *Taxodium ascendens*; sometimes with floating-leaf aquatic plants beneath; basin with deep ponded water present most or all of most years; occurring in steep-sided limesinks.. ....**Coastal Plain Depression Swamp (Cypress Dome Subtype)**

7. Community with a well-developed shrub layer of various species; canopy dominated by either *Nyssa biflora* or *Taxodium ascendens*; water shallow, present only briefly in the growing season in most years; occurring in flat or sloping basins, including clay-based Carolina bays, limesinks, and other depressions.

8. Shrub layer dominated by varying combinations of *Lyonia lucida, Cyrilla racemiflora, Ilex glabra, Ilex coriacea*, *Zenobia pulverulenta*, *Vaccinium* spp., or *Ilex laevigata*; *Smilax laurifolia* often abundant.. **Coastal Plain Depression Swamp (Pocosin Subtype)**

8. Shrub layer dominated by other species, such as *Cephalanthus occidentalis, Morella cerifera, Eubotrys racemosus*, *Itea virginica*, *Leucothoe axillaris,* and *Arundinaria tecta.* ....**Coastal Plain Depression Swamp (Mixed Subtype)**

1. Community not dominated by woody vegetation; trees or shrubs absent or sparse, not dense enough to affect the lower strata.

9. Community with nearly permanent standing water, staying flooded throughout most years, drawing down only in drought.

10. Vegetation a dense, interwoven, free-floating mat of *Sphagnum* or vascular plants. ....**Floating Bog**

10. Vegetation dominated by floating-leaf plants such as *Nymphaea* and *Nuphar*, submersed plants, or occasionally small floating plants such as *Lemna*, or community consisting of largely unvegetated open water.......................... **Small Depression Pond (Open Lily Pond Subtype)**

9. Community with seasonal standing water, normally dry sometime in the growing season in all but the wettest years.

11. Season of standing water very short, with water absent in some years; herb layer dominated by *Andropogon, Panicum virgatum*, or species of similar water tolerance. .... **Vernal Pool**

11. Season of standing water moderate to long, though drawing down most years.

12. Season of flooding long, drawing down only late in the growing season in most years; soil somewhat mucky; vegetation marsh-like, containing more water-tolerant species, relatively stable from year to year.

13. Vegetation dominated by *Leersia hexandra* in most years, though *Kellochloa verrucosa* may dominate at times. ....**Small Depression Pond (Cutgrass Prairie Subtype)**

13. Vegetation dominated by other species, usually tall graminoids such as *Hymenachne (Panicum) hemitoma, Eleocharis equisetoides, Rhynchospora inundata*, or *Rhynchospora harperi*. .... **Small Depression Pond (Typic Marsh Subtype)**

12. Season of standing water typically medium, intermediate between that of Vernal Pool and Small Depression Pond; vegetation various but usually with many smaller herbaceous species and species less tolerant of standing water, often varying substantially from year to year; soil usually sand, without muck.

14. Community in a broad flat-bottomed basin such as a clay-based Carolina bay; vegetation usually with an open canopy of *Taxodium ascendens*, or with evidence of such a canopy in the past; if *Taxodium* canopy is absent, then the herbaceous vegetation containing species such as *Mnesithea* (*Coelorachis*) *rugosa, Eriocaulon compressum, Saccharum giganteum, Diodia virginiana*, and *Hypericum cistifolium* as well as more widespread species; most examples in clay-based Carolina bays in the inner Coastal Plain, very rare in the outer Coastal Plain.

15. Community with a diverse herb layer that varies substantially with water levels, often containing *Dichanthelium wrightianum, Rhexia aristosa, Scleria reticularis, Scleria muhlenbergii, Rhynchospora inundata, Rhynchospora filifolia, Eupatorium leucolepis, Eupatorium paludicola, Pluchea baccharis (rosea), Boltonia asteroides,* and *Eleocharis tricostata*, as well as some more widespread species such as *Hymenachne (Panicum) hemitoma* and *Kellochloa (Panicum) verrucosa*.......**Cypress Savanna (Typic Subtype)**

15. Community with a less diverse herb layer dominated by species of the most extremely acid-tolerant plants, such as *Sphagnum* spp., *Anchistea virginica, Carex striata, Carex glaucescens, Lachnanthes caroliniana*, *Hymenachne (Panicum) hemitoma*, *Kellochloa (Panicum) verrucosa*, and *Centella erecta*. .... **Cypress Savanna (Acidic Subtype)**

14. Community in a sloping basin such as a limesink depression or swale; vegetation usually with sparse or no trees (though a dense Small Depression Shrub Border often is present around the edge); herb layer lacking most of the above species, instead containing species such as *Centella erecta, Lachnanthes caroliniana, Panicum tenerum, Juncus pelocarpus (abortivus)*, and *Proserpinaca pectinata*; most examples in limesink depressions in the outer Coastal Plain.

16. Community with a diverse flora including species such as *Euthamia caroliniana, Dichanthelium erectifolium, Dichanthelium wrightianum, Eriocaulon compressum, Scleria muhlenbergii, Drosera intermedia,* and *Rhexia cubensis* as well as the above species. ....**Small Depression Drawdown Meadow (Typic Subtype)**

16. Community with a less diverse flora confined to the most acid-tolerant species such as *Anchistea virginica*, *Carex striata*, and *Sphagnum* spp... .... **Small Depression Drawdown Meadow (Boggy Pool Subtype)**

SMALL DEPRESSION POCOSIN (TYPIC SUBTYPE)

Concept: Small Depression Pocosins are shrubby wetlands of small basins that have shallow and short-lived surface flooding, with dense shrub layers of species shared with Peatland Pocosin communities. They either have no tree canopy or have an open canopy with characteristic pocosin tree species such as *Pinus serotina*, *Magnolia virginiana*, and *Persea palustris*. They are conceptually transitional between the Coastal Plain Depression Swamps and Peatland Pocosins themes. The Typic Subtype encompasses communities where the shrub layer is dominated by the most typical pocosin shrubs, generally *Cyrilla racemiflora, Lyonia lucida, Ilex coriacea, Ilex glabra*, and *Smilax laurifolia*. *Vaccinium* spp. often are present but do not dominate in this subtype.

Distinguishing Features: Small Depression Pocosins are distinguished from most other depressional wetlands by the presence of a dense shrub layer that fills all or most of the basin. Swamp trees such as *Taxodium ascendens* and *Nyssa biflora* may be present but *Pinus serotina, Magnolia virginiana*, and *Persea palustris* are dominant if there is a canopy. Small Depression Shrub Border occurrences may share many species but occur as a narrow band on the edge of a deeper depression. They are more subject to fluctuating water levels and are exposed to natural edge effects from more open vegetation on both sides. Several species are often present in Small Depression Shrub Borders but not often in Small Depression Pocosins, including *Ilex myrtifolia, Ilex cassine*, and *Litsea aestivalis*, as well as *Hymenachne hemitoma* and other species of more open pond communities.

Small Depression Pocosins are distinguished from Peatland Pocosin and Streamhead Pocosin communities by occurring in small closed basins where water is ponded at times. Small Depression Pocosins have a number of species that are scarce or absent in other communities called pocosins, including *Vaccinium* spp., *Nyssa biflora, Pinus taeda, Taxodium ascendens*, and other species more associated with ponds. There is not a defined size limit for Small Depression Pocosins, but few examples are more than 10 acres and most are much smaller.

The Typic Subtype is distinguished from the Blueberry Subtype by the dominance of characteristic pocosin species such as *Cyrilla racemiflora, Lyonia lucida, Ilex coriacea*, *Ilex glabra*, and *Smilax laurifolia*, with only a small minority presence of *Vaccinium* spp.

It can be difficult to distinguish natural Small Depression Pocosin communities from successional vegetation that can invade open depressional wetlands with drought and exclusion of fire. *Liquidambar styraciflua* is one species that is seldom, if ever, found in true Small Depression Pocosins. Dominant *Pinus taeda* or *Acer rubrum* and weedy herbaceous species also suggest artificial successional vegetation. However, they may increase in disturbed and fire-suppressed Small Depression Pocosins as readily as in open communities and do not definitively indicate a formerly open community. The context can also be an important clue; Small Depression Pocosins are likely to be similarly or less altered than the surrounding communities, rather than more altered. The presence of relict species from the open community can also be a clue. Historical accounts or photographs showing nonwoody vegetation, if not taken at a time of artificial clearing, may be crucial for confidence.

Crosswalks: *Pinus serotina / Cyrilla racemiflora - Lyonia lucida - Vaccinium fuscatum* Swamp Woodland (CEGL004434).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: Small Depression Pocosins usually occur in shallow limesink basins, less often in relict dune swales or small Carolina bays.

Soils: Soils have a shallow to deep organic surface layer. Most occurrences are smaller than the minimum map unit for soil surveys and are included in the surrounding upland soil units. A few larger ones are mapped as Murville or Lynn Haven (Typic Haplaquods) or Torhunta (Typic Humaquept).

Hydrology: Surface water is shallow and seldom persists far into the growing season. Saturation may persist for much of the year. Some Small Depression Pocosins have local deeper pools that hold water longer.

Vegetation: The vegetation is a dense shrubland with a variable density of trees. The shrub layer is a mix of species, generally without strong dominance. In CVS plot data and site descriptions, *Cyrilla racemiflora, Lyonia lucida, Persea palustris,* and *Vaccinium formosum* are usually present with high cover, while *Ilex coriacea, Arundinaria tecta*, and in the southern part of the state, *Ilex myrtifolia* can have high cover in some examples. *Magnolia virginiana, Vaccinium fuscatum,* and *Aronia arbutifolia* are frequent but with lower cover, and *Clethra alnifolia, Viburnum nudum*, and *Eubotrys racemosus* are also fairly frequent. *Litsea aestivalis* and *Zenobia pulverulenta* have been found occasionally, but they are more typical of Small Depression Shrub Border communities. *Smilax laurifolia* is frequent and may be dense. *Smilax rotundifolia, Smilax glauca*, and *Muscadinia rotundifolia* also often are present. Trees are variable in cover and species. *Pinus serotina* is highly constant, but *Nyssa biflora*, *Pinus taeda*, and *Acer rubrum* are also often found. A few examples have *Taxodium ascendens* or *Chamaecyparis thyoides*. Herbs are generally sparse, with the exception that *Sphagnum* spp. may form substantial mats and *Anchistea virginica* may have moderate cover. The outer edge of the community, where it borders longleaf pine communities, can have diverse ecotonal vegetation with species typical of wetter longleaf pine communities such as Sandy Pine Savanna. The interior of the community may have a small opening where water is the deepest, and species of Small Depression Drawdown Meadow or Depression Pond may be present in small numbers.

Range and Abundance: Ranked G2G3. The synonymized association is attributed only to North Carolina and South Carolina, though related communities must occur in much of the Coastal Plain. The abundance of this community is less certain than most. Examples are often overlooked in site surveys and plot sampling alike, and they may be lumped if larger pocosins are nearby.

Associations and Patterns: Small Depression Pocosins usually fill entire small basins, though rarely they may occupy half a basin. They often occur in complexes with other Coastal Plain Depression Communities in limesink clusters or relict dune systems and are usually set in a matrix of Wet or Dry Longleaf Pine Communities.

Variation: Three weakly marked variants are recognized to encourage further study:

1. Pocosin Variant consists largely of species typical of Pond Pine Woodland and High Pocosin, perhaps containing *Vaccinium fuscatum* or *Acer rubrum* var. *trilobum* but lacking "pond" species. This variant is most closely related to Peatland Pocosins. It is known from the middle outer Coastal Plain and inland areas.

2. Swamp Variant has a typical shrub layer but has a *Pinus taeda, Nyssa biflora*, *Acer rubrum* var. *trilobum*, or *Taxodium ascendens* rather than *Pinus serotina* as the primary tree component. It appears transitional to Small Depression Swamp forest. Occurrences are widespread in the Coastal Plain.

3. Pond Variant contains shrub species typical of wetter, more open small depressions, such as *Ilex myrtifolia, Litsea aestivalis*, and *Ilex cassine,* in addition to pocosin shrubs. It thus shows a relationship with Small Depression Drawdown Meadow. This variant is known only in the southern Outer Coastal Plain in the state.

Dynamics: Dynamics of Small Depression Pocosins are not well known. Like true pocosins, they may burn if fires occur in surrounding vegetation when they are dry. Fires may be mild surface burns that have limited effect or may be conflagrations that carry through the shrubs and top-kill all woody vegetation. Probably most often, fires will not carry but will scorch the shrubs and trees along the edges; because of the small size, this may still affect a significant part of the community.

The ecological processes that create and maintain the distinction between Small Depression Pocosins and other Coastal Plain Depression Communities are poorly known. Shrub-dominated basins are often believed to result from succession in more open wetlands, and it is sometimes believed that this has happened quickly since the advent of fire suppression. However, the common occurrence of Small Depression Pocosins in complexes with more open depressional communities, where they presumably had similar recent fire history, suggests different development due to characteristics of the basins. In general, open wetlands that are known to have become dense recently tend to be dominated by *Acer rubrum*, *Liquidambar styraciflua*, and other species not characteristic of pocosins. Nevertheless, the common presence of organic matter must suggest slow accumulation and vegetational succession sometime in the past, perhaps in the Pleistocene climate. It may result from a process of paludification similar to that believed to have formed the larger peatlands but arrested by better soil drainage or greater relief in the adjacent uplands. Once present, organic matter will favor pocosin vegetation. It will retain water, prolonging saturated conditions even when the water table drops in nearby basins.

Comments: The name and theme placement of Small Depression Pocosins indicates their marginal or intermediate character. They share dominance by the suite of woody species characteristic of all vegetation called pocosin. At the same time, they have a number of additional species shared with other communities, as well as a distinctive environment. Differences in invertebrate communities are not known but may be stronger.

The conceptual boundary between Small Depression Pocosins and Peatland Pocosins needs more investigation. Larger peat-filled Carolina bays support pocosin vegetation that is indistinguishable from domed peatlands. They do not tend to contain surface water beyond local puddles, apparently because peat has accumulated above the level where water would pond. Pond Pine Woodland occurs in shallow swales of relict dune topography. These areas too do not tend to contain standing water, and it appears that organic matter, though shallow, has accumulated to the level of the seasonal high water table. The basins where Small Depression Pocosin occurs are smaller and steeper. They do not have such deep organic deposits and are visibly lower than the surrounding land, with room for water to sit on the surface.

Rare species:
Vascular plants – Ecotones only – *Drosera filiformis, Litsea aestivalis*, and *Lysimachia asperulifolia*.

SMALL DEPRESSION POCOSIN (BLUEBERRY SUBTYPE)

Concept: Small Depression Pocosins are shrubby wetlands of small basins that have shallow and short-lived surface flooding, with dense shrub layers of species shared with Peatland Pocosin communities. The Blueberry Subtype consists of those where *Vaccinium formosum* and/or *Vaccinium fuscatum* dominate and other pocosin shrubs are less abundant. This subtype is quite rare, and it is unclear what drives its occurrence and distinction from the other subtype.

Distinguishing Features: Small Depression Pocosins are distinguished by the presence of a dense shrub layer that fills all or most of the basin. The Blueberry Subtype is distinguished by the dominance of *Vaccinium fuscatum* and *Vaccinium formosum* over more typical pocosin shrubs. Other deciduous shrubs not characteristic of pocosins, such as *Eubotrys racemosus* or *Viburnum nudum*, should be counted along with the *Vaccinium* in determining predominance.

Crosswalks: *Vaccinium formosum - Vaccinium fuscatum / Sphagnum cuspidatum* Wet Shrubland (CEGL003907).
G036 Pond-cypress Basin Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: Small Depression Pocosins usually occur in shallow limesinks, less often in relict dune swales or small Carolina bays.

Soils: Soils have a shallow to deep organic surface layer. All occurrences are smaller than the minimum map unit for soil surveys and are included in the surrounding upland soil units.

Hydrology: Surface water is shallow and seldom persists far into the growing season. Saturation may persist for much of the year. Examples may have small, deeper pools that hold water longer.

Vegetation: Blueberry Subtype vegetation is a dense shrubland with a variable density of trees. *Vaccinium formosum* and *Vaccinium fuscatum* are the most abundant species. Associated shrub species may include abundant, though not dominant, *Lyonia lucida, Cyrilla racemiflora*, *Lyonia ligustrina*, or *Zenobia pulverulenta*, as well as shrubs less typical of pocosins, such as *Eubotrys racemosus* or *Lyonia mariana*. *Smilax laurifolia* may be abundant. Trees range from an open canopy to sparse. Species may include *Pinus serotina*, *Nyssa biflora, Acer rubrum* var. *trilobum*, and *Pinus taeda*. Herbs are generally sparse, but *Sphagnum* spp. may occur in large patches. *Anchistea virginica* is the only other frequent and abundant herb, but species such as *Rhynchospora fascicularis* and *Andropogon* sp. have been noted in openings.

Range and Abundance: Ranked G3? but perhaps rarer. It is extremely rare in North Carolina, with only a handful of examples known, and is clearly rarer than the G2G3 ranked Typic Subtype in the state. Examples are in the Bladen Lakes region and the far northeastern part of the state, but others could be found elsewhere in the Coastal Plain. This community also is attributed to South Carolina.

Associations and Patterns: This community tends to fill entire small basins, with only small inclusions that are more open. The Blueberry Subtype is currently known only from relict dune fields.

Variation: Examples are too rare to define variants. Some examples are transitional to other communities, with a fairly dense tree canopy or an unusually open shrub layer.

Dynamics: Dynamics of the Blueberry Subtype are particularly poorly known. They probably are similar to the Typic Subtype, but the deciduous shrub layer is less likely to carry intense fire through the community. Questions of why this community develops in particular places are similar to those for the Typic Subtype. The occurrence in relict dunes may be important, as these areas more often have Sand Barren communities that carry fire less well than other longleaf pine communities.

Comments: Only a single CVS plot is attributed to this community, and it appears to be only marginally developed (e.g., it has a large component of *Pinus palustris*). The factors that create the Blueberry Subtype rather than the Typic Subtype are not known. The Blueberry Subtype may occur in steeper-sided basins. It probably has deeper water and possibly a longer duration of flooding, but it may also dry more and be less saturated when the water goes down.

Rare species: No rare species are known to be specifically associated with this community.

SMALL DEPRESSION SHRUB BORDER

Concept: Small Depression Shrub Border communities are narrow shrub thickets that occur as an outer zone on the rims of Small Depression Pond, Small Depression Drawdown Meadow, and Vernal Pool communities. These communities are narrow enough to be strongly subject to edge effects from both sides. They contain a mix of pocosin species, such as *Cyrilla racemiflora*, *Lyonia lucida*, and *Smilax laurifolia,* along with some characteristic pond species such as *Ilex myrtifolia*, *Ilex cassine*, *Litsea aestivalis*, and *Cephalanthus occidentalis*. Trees may be sparse or dense but have little effect on the shrubs because of open edges. They may include *Pinus serotina*, but more often will be *Nyssa biflora*, *Acer rubrum*, *Magnolia virginiana*, and *Persea palustris*. Herbaceous species of the adjacent open wetland and the adjacent upland are usually present.

Distinguishing Features: Small Depression Shrub Borders are distinguished from all other communities by the combination of shrub dominance and occurrence in a narrow zone on the edge of other, more open depressional wetlands. Small Depression Pocosins may contain some of the same species but will fill most or all of the basins they occur in and will not contain an appreciable amount of *Ilex myrtifolia, Ilex cassine, Litsea aestivalis*, or *Cephalanthus occidentalis*. Natural Lake Communities may share some species, but generally have a limited shrub layer. They occur on larger bodies of water where wave action is important.

Crosswalks: *Cyrilla racemiflora - Lyonia lucida* Wet Shrubland (CEGL003844).
G036 Pond-cypress Basin Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Small Depression Pond (3rd Approximation).

Sites: Small Depression Shrub Border communities occur primarily in limesinks but can occur in relict dune swales and around small to medium Carolina bays.

Soils: Soils are generally sandy, with only a limited organic layer. Occurrences are smaller than the minimum map unit for soil surveys and are included in the surrounding upland soil units.

Hydrology: Surface water may be present early in the growing season and in unusually wet years. These communities occur on the edges of deeper depressions. This may lead to greater soil drainage during drawdown periods.

Vegetation: The vegetation is dominated by a dense-to-moderate shrub layer. Trees usually have moderate cover but may be denser or may be absent. Both site descriptions and the limited CVS plot data have *Cyrilla racemiflora* as the most constant and usually dominant species. *Lyonia lucida* often is abundant. Other shrubs that may be present, occasionally abundant, include *Vaccinium fuscatum, Vaccinium formosum, Ilex glabra, Ilex coriacea, Ilex myrtifolia, Litsea aestivalis, Morella cerifera, Ilex cassine, Zenobia pulverulenta,* and *Symplocos tinctoria*. Vines may include *Smilax laurifolia, Smilax glauca, Smilax walteri*, and *Gelsemium sempervirens*. The tree component is highly variable. *Pinus serotina, Nyssa biflora, Pinus taeda, Persea palustris, Magnolia virginiana, Acer rubrum* var. *trilobum*, *Liquidambar styraciflua*, or other species may be abundant. The herb component is also variable, as species of the adjacent open pond community may extend into the woody border in substantial amounts and species of the adjacent upland may also be present. *Sphagnum* spp. is often present in patches. *Lachnanthes caroliniana, Centella asiatica, Rhynchospora* spp., *Hymenachne hemitoma*, *Proserpinaca pectinata, Xyris* spp., *Carex striata*, and *Drosera* spp. have been reported, and many other species may possibly occur.

Range and Abundance: Ranked G3? The synonymized association is attributed to states from North Carolina to Mississippi or Louisiana. In North Carolina, this community occurs in a wide variety of basins and is less extremely rare than many Coastal Plain Depression Communities.

Associations and Patterns: Small Depression Shrub Border is a zonal community that occurs with other Coastal Plain Depression Communities. Small Depression Drawdown Meadow and Small Depression Pond are the most frequent associates in the interior of the basin, but Cypress Savanna or Vernal Pool also are possible. On the upland side the adjacent community is usually some kind of longleaf pine community. Where Coastal Plain Depression Communities occur in clusters, Small Depression Shrub Borders are usually present around all or most of the more open communities. However, a few clusters lack them and a few have them around only some of the depressions.

Variation: Three indistinct variants parallel to those of Small Depression Pocosin may be recognized. All examples also vary with the transition to adjacent communities and in response to recent disturbances.

1. Pocosin Variant consists largely of species typical of Pond Pine Woodland and High Pocosin, though additional species such as *Vaccinium* spp. and *Morella cerifera* are usually present. *Pinus serotina* is the primary tree.

2. Swamp Variant consists of similar shrubs but with a more substantial canopy dominated by *Nyssa biflora, Pinus taeda, Liquidambar styraciflua*, or occasionally *Taxodium ascendens*. The presence of *Liquidambar styraciflua* is limited to the Sandhills region and other inland areas and may indicate a fine-textured soil version that should be a distinct variant. However, it is unclear if the *Liquidambar* is a long-term natural component or is a result of alteration.

3. Pond Variant has more shrubs not characteristic of pocosins, such as *Ilex myrtifolia, Litsea aestivalis*, and *Ilex cassine*.

Dynamics: Small Depression Shrub Border communities are potentially quite variable over time. Their natural dynamics and character are driven by a combination of seasonal but variable flooding and by intrusion of fire from the adjacent uplands, which are almost always longleaf pine communities. With fire suppression, shrub borders expand, and shrubs become taller and denser, while the return of fire narrows the shrub zone and confines it to wetter areas. Natural fires in the summer, fall, and in dry springs, would burn all the way through them and through the adjacent herbaceous wetland communities, top-killing the shrubs and possibly trees. Natural frequency of burning was presumably less than in the uplands, but more frequent than at present. Prescribed fire programs that are confined to the winter or to mild conditions may never burn through these communities, allowing them to expand both into the upland edge and into the open pond communities. Some people believe that shrub border communities are entirely an artifact of inadequate fire, but the fact that many contain plant species that do not occur in either of the adjacent communities suggests otherwise. It is possible that some have developed in places where they did not naturally occur. These can be expected to consist solely of the more mobile species, or of species present nearby. Those with characteristic pond species that are not widespread, such as *Litsea aestivalis*, almost certainly are natural, though perhaps altered in structure.

Rare species:
Vascular plants – *Litsea aestivalis*. Ecotones only – *Dionaea muscipula* and *Lysimachia asperulifolia*.

COASTAL PLAIN DEPRESSION SWAMP (MIXED SUBTYPE)

Concept: Coastal Plain Depression Swamps are depressional wetlands with a well-developed, closed or nearly closed tree canopy of Taxodium ascendens or Nyssa biflora but without a dense graminoid-dominated herb layer. They may or may not have a well-developed shrub layer. They are associated with deeper flooding than Small Depression Pocosins or Nonriverine Swamp Forests. The Mixed Subtype covers examples that do not have the characteristics of the other subtypes. They have shrub layers containing a mix of characteristic pocosin and swamp species. They are generally less deeply flooded than the Cypress Dome Subtype.

Distinguishing Features: Small Depression Swamp communities are distinguished from other Coastal Plain Depression Communities by the occurrence of a well-developed canopy of *Taxodium ascendens* or *Nyssa biflora* in a depressional wetland, without a well-developed herb layer. The shrub layer may range from dense to absent. Small Depression Pocosins can have an appreciable cover of these tree species, but they do not form a well-developed canopy and are usually associated with pines. Small Depression Swamps are distinguished from other *Taxodium*- and *Nyssa*-dominated swamps, such as Nonriverine Swamp Forest and Cypress–Gum Swamp, by occurring in Carolina bays, limesinks, or other closed depressions that are periodically ponded but lack river flooding.

The Mixed Subtype is distinguished from the Pocosin Subtype by the shrub layer having a significant component of species not characteristic of pocosins, such as *Cephalanthus occidentalis, Morella cerifera, Eubotrys racemosus*, *Itea virginica*, *Leucothoe axillaris,* and *Arundinaria tecta,* with only subordinate amounts of *Cyrilla racemiflora, Lyonia lucida, Ilex glabra, Ilex coriacea*, or *Zenobia pulverulenta*. It is distinguished from the Cypress Dome Subtype by lacking *Ilex myrtifolia* and by having other shrubs present.

Crosswalks: *Taxodium ascendens / (Nyssa biflora) / Eubotrys racemosa - Lyonia lucida - Morella cerifera* Swamp Forest (CEGL007420).
G036 Pond-cypress Basin Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Nonriverine Swamp Forest (3rd Approximation).

Sites: Coastal Plain Depression Swamps usually occur in Carolina bays, larger limesinks, or occasionally in swales in relict dune systems.

Soils: Soils may be sandy, loamy, or clayey, and generally have little or no organic surface layer. Most examples are treated as inclusions in soil mapping.

Hydrology: The range of hydrology is not well known but flooding appears to be shallow to moderate and not to typically persist long into the growing season. It is uncertain if soils dry or remain saturated after drawdown.

Vegetation: The vegetation has a closed or somewhat open tree canopy dominated by *Taxodium ascendens* or *Nyssa biflora* or both. *Acer rubrum* var. *trilobum*, *Magnolia virginiana, Persea palustris*, or occasionally *Liquidambar styraciflua* may be present in the canopy or as an understory. The shrub layer is usually moderate to fairly dense but may be denser on the drier edges. It may contain pocosin species, especially *Cyrilla racemiflora* and *Lyonia lucida*, less often *Ilex glabra* or *Lyonia ligustrina*, but they are mixed with species not typical of pocosins, such as *Vaccinium formosum, Vaccinium fuscatum, Eubotrys racemosus, Morella cerifera, Clethra alnifolia, Itea virginica*, *Decodon verticillatus*, and rarely *Litsea aestivalis*. Vines, particularly *Smilax rotundifolia* or *Smilax laurifolia*, can form dense tangles. Herbs are often sparse or nearly absent, but denser patches may be present. *Sphagnum* spp. often is present. *Saururus cernuus*, *Juncus repens, Carex striata, Anchistea virginica, Lorinseria areolata*, *Kellochloa (Panicum) verrucosa*, or other species occur in some examples, all with very low constancy. *Tillandsia usneoides* may drape the trees, and *Triadenum walteri* or *Triadenum virginianum* may occur on tree bases and cypress knees.

Range and Abundance: Ranked G3. The synonymized association ranges from North Carolina to Louisiana. It appears rare in North Carolina, though it ranges throughout the Coastal Plain and some examples may be overlooked. It may be more frequent in South Carolina, where clay-based Carolina bays are more numerous (Bennett and Nelson 1991).

Associations and Patterns: Coastal Plain Depression Swamps tend to fill entire basins. They are naturally bordered by dry or wet longleaf pine communities on their upland edges. Few of the remaining examples have intact surrounding vegetation.

Variation: Known examples are extremely variable, from ones transitional to the Pocosin Subtype to those with few pocosin shrubs. Perhaps most distinctive are those with *Decodon verticillatus* dominant in the shrub layer. Only one such example has been documented in North Carolina but several are known in South Carolina. No variants are recognized at present but they may be warranted.

Dynamics: The dynamics of the Mixed Subtype are particularly poorly known. The shrub layer is dense enough to potentially carry fire in some examples but not in others. The shrub component tends to be a mix of flammable and less flammable species. As in all Coastal Plain Depression Communities, fluctuating water levels may cause changes from year to year, but the long-lived woody vegetation is unlikely to change as much as in herbaceous communities.

Comments: This community is one of the least well understood of the Coastal Plain wetlands. With low potential for rare species, dense vegetation, and sometimes resemblance to more altered forests, site surveys often produce limited description. CVS data are limited, and the variability of vegetation makes classification of the existing plot data difficult. Nifong (1998) recognized several associations within the vegetational variation covered by this subtype, including *Nyssa biflora - Taxodium ascendens / Liquidambar styraciflua / Ilex amelanchier* (9.1.1); *Nyssa biflora - Taxodium ascendens / Decodon verticillatus / (Smilax laurifolia) / Utricularia purpurea* (8.0.3); *Taxodium ascendens / Nyssa biflora - Acer rubrum / (Leucothoe racemosa - Vaccinium* spp. *- Zenobia pulverulenta) / Sphagnum* Bog (8.0.6). Many of these were known from only a single site, often only a single plot.

The ecological factors that drive the occurrence of this community and separate it from other Coastal Plain Depression Communities are unclear. The relationships among the subtypes and the relationship of this subtype with Small Depression Pocosins, Cypress Savannas, and successional vegetation needs further investigation. Many of the scarce examples are in altered landscapes and occur without natural context; they may be altered as well. More work is needed on how to distinguish this community from successional vegetation that may grow up in more open wetlands with altered hydrology and fire exclusion. However, enough examples are known in better conditions to support belief in a natural community type.

Rare species:
Vascular plants – *Litsea aestivalis*.

COASTAL PLAIN DEPRESSION SWAMP (POCOSIN SUBTYPE)

Concept: Coastal Plain Depression Swamps are depressional wetlands with a well-developed, closed or nearly closed tree canopy of *Taxodium ascendens* or *Nyssa biflora* but without a dense graminoid-dominated herb layer. The Pocosin Subtype covers examples, generally in Carolina bays, with a dense shrub layer strongly dominated by the characteristic pocosin shrubs, mainly *Cyrilla racemiflora, Lyonia lucida, Ilex glabra,* and *Zenobia pulverulenta*, though often accompanied by *Ilex amelanchier, Vaccinium formosum*, and *Vaccinium fuscatum*. It is thus like a Small Depression Pocosin but with a well-developed swamp canopy.

Distinguishing Features: Small Depression Swamp communities are distinguished from other Coastal Plain Depression Communities by the occurrence of a well-developed canopy of *Taxodium ascendens* or *Nyssa biflora* in a depressional wetland, without a well-developed herb layer. The Pocosin Subtype is distinguished by a dense layer of characteristic shrubs of pocosins beneath a swamp canopy. *Morella cerifera, Eubotrys racemosus, Itea virginica*, and *Leucothoe axillaris*, and most other species not typical of pocosins are absent or scarce, though *Vaccinium* spp. or *Ilex Amelanchier* often are present. Small Depression Pocosins conceptually grade into this subtype; the distinction is based largely on canopy development, but the type of basin is usually different as well.

Crosswalks: *Taxodium ascendens / Cyrilla racemiflora - Zenobia pulverulenta* Swamp Woodland (CEGL003734).
G036 Pond-cypress Basin Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: The Pocosin Subtype occurs most often in Carolina bays but is also known in limesink depressions and could potentially occur in dune swales.

Soils: Sites usually have wet mineral soils, with or without a shallow organic layer. Many examples are small enough not to be distinguished in soil mapping. Soils mapped for some of the larger examples include Torhunta (Typic Humaquept), Pantego (Umbric Paleaquult), and Coxville (Typic Paleaquult). However, at least one example is mapped as an organic soil: Pamlico (Terric Medisaprist).

Hydrology: The range of hydrology is not well known but flooding appears to be shallow to moderate and typically not to persist long into the growing season. Soils probably remain saturated after drawdown but this is uncertain.

Vegetation: The vegetation has a well-developed closed or somewhat open forest canopy dominated by *Taxodium ascendens* or *Nyssa biflora*. One or both of these species may be the only trees, but *Acer rubrum* var *trilobum*, *Pinus serotina*, and *Liquidambar styraciflua* are known in some examples. The dense shrub layer may be short or tall, and is typically dominated by *Cyrilla racemiflora, Lyonia lucida*, *Zenobia pulverulenta*, or *Ilex glabra*. *Ilex amelanchier*, *Vaccinium formosum*, or *Vaccinium fuscatum* may be present, occasionally abundant, in some examples. *Smilax laurifolia* or *Smilax rotundifolia* may form dense tangles. Herbs are sparse and are largely limited to patches of *Sphagnum* spp. and *Anchistea virginica*.

Range and Abundance: Ranked G2. The handful of examples in North Carolina are scattered in the southern half of the Coastal Plain, including the outer, middle, and inner Coastal Plain and Sandhills. This community also occurs in South Carolina.

Associations and Patterns: Coastal Plain Depression Swamps tend to fill entire basins. They are naturally bordered by dry or wet longleaf pine communities on their upland edges. Few of the remaining examples have intact surrounding vegetation.

Variation: No variants are known.

Dynamics: Dynamics are poorly known. While it is possible that the shrubby vegetation developed recently and that examples once were more like Cypress Savannas, a change from one to another has not been documented. Examples sometimes occur in close proximity to Cypress Savannas, with similar landscape settings and presumably similar disturbance history.

Given the dense flammable shrub layer, fire probably naturally would be more important in the Pocosin Subtype than in other subtypes, but the frequency is not known. Almost no fires have occurred in this community in recent history. *Taxodium ascendens* is fairly tolerant of fire, *Nyssa biflora* less so, but neither would be likely to survive an intense fire burning through dense pocosin shrubs. It seems likely that trees would only regenerate after fires, when the dense cover of shrubs is reduced. Fluctuating water levels may also be important, perhaps periodically reducing shrub cover and allowing tree regeneration.

Comments: See comments for the Mixed Subtype. The Pocosin Subtype too is among the least well understood of Coastal Plain wetlands.

The Pocosin Subtype is one of two characteristic habitats for *Ilex amelanchier*. The other, banks of blackwater rivers, seems quite different. However, the species co-occurs with *Cyrilla racemiflora* in both habitats.

Nifong (1998) recognized several associations within the vegetational variation covered by this subtype: *Taxodium ascendens / Lyonia lucida / Carex striata - Woodwardia virginica / Sphagnum* Bog (8.0.1); *Nyssa biflora / Chamaedaphne calyculata / Carex striata / Sphagnum* spp. Bog (8.0.2); *Taxodium ascendens / Nyssa biflora - Acer rubrum / Zenobia pulverulenta - Lyonia lucida - Cyrilla racemiflora / Woodwardia virginica* Bog (8.0.6); *Taxodium ascendens / Lyonia lucida - Leucothoe racemosa / (Leucobryum* sp.) Bog? (8.0.8).

Rare species: No rare species are known to be specifically associated with this community.

COASTAL PLAIN DEPRESSION SWAMP (CYPRESS DOME SUBTYPE)

Concept: Coastal Plain Depression Swamps are depressional wetlands with a well-developed, closed or nearly closed tree canopy of *Taxodium ascendens* or *Nyssa biflora* but without a dense graminoid-dominated herb layer. The Cypress Dome Subtype is a deeper, more pond-like community than the other subtypes, associated with steep-sided basins. It is a more southern community that reaches its northern range limit in southeasternmost North Carolina. Farther south it occurs in a variety of settings, but in North Carolina it is largely confined to a few steep-sided limesinks.

Distinguishing Features: The Cypress Dome Subtype is distinguished from other communities by having a well-developed canopy of *Taxodium ascendens* in a depressional wetland, without a well-developed herb or shrub layer. *Ilex myrtifolia* is usually the predominant shrub. Some aquatic plants such as *Nymphaea odorata* may be present. The Mixed Subtype and Pocosin Subtype are generally dominated by *Nyssa biflora* and have well-developed shrub layers of different species. Some *Taxodium* may be present on the edge or in the interior of Small Depression Drawdown Meadow or Small Depression Pond communities, as well as in Small Depression Shrub Borders, but Coastal Plain Depression Swamp should not be recognized unless the canopy is near complete and covers a large area or fills the basin.

Crosswalks: *Taxodium ascendens / Ilex myrtifolia* Swamp Forest (CEGL007418).
G036 Pond-cypress Basin Swamp Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Small Depression Pond (3rd Approximation).

Sites: The Cypress Dome Subtype, at least in North Carolina, occurs primarily or exclusively in limesink depressions.

Soils: Soils are mineral soils with a shallow muck layer. They are generally treated as inclusions or mapped as water in soil surveys.

Hydrology: The Cypress Dome Subtype is flooded for long periods, often with water several feet deep. In the wettest parts, the bottom may only infrequently be exposed.

Vegetation: The Cypress Dome Subtype has a dense or open canopy usually dominated by *Taxodium ascendens*. *Nyssa biflora* may be present in patches. Usually, no other trees are present except on the edge. Shrubs may be fairly dense on the edge but otherwise are sparse. *Ilex myrtifolia, Cyrilla racemiflora*, and *Ilex cassine* are most frequent. The water may be permanent enough to support *Nymphaea odorata* in the deepest parts, and floating plants such as *Lemna* spp. or *Utricularia* spp. may be present. *Hymenachne hemitoma, Eleocharis tricostata, Anchistea virginica*, or other herbs may be present on the edge.

Range and Abundance: Ranked G3?. This subtype is quite rare in North Carolina, with only a handful of examples known in the southeastern corner of the state. The synonymized association ranges to Mississippi or Louisiana, and it is apparently more abundant in Florida.

Associations and Patterns: The Cypress Dome Subtype usually fills an entire basin, but in at least one example it occupies half a basin, with open water in the other half. A few examples have recognizable Small Depression Shrub Border communities around their outer edge.

Variation: No variants are known.

Dynamics: The Cypress Dome Subtype may be more stable than most other Coastal Plain Depression Communities. The wetness, limited shrub cover, and sloping basins of our examples make fire unlikely to penetrate them, even during drought. However, fire may be important on the shallower edges. Descriptions of cypress domes in Florida say that fire penetrates them at times, creating a gradient of fire frequency from the shallow edges to the center.

Water levels may fluctuate drastically over the course of a year or among years. Rare periods of low water are crucial to regeneration of the *Taxodium*, whose seedlings cannot tolerate complete submergence.

The ecological factors that distinguish the Cypress Dome Subtype from Small Depression Pond are not clear. Their hydroperiods appear to overlap. It may be that rare episodes of tree regeneration or rare tree-killing disturbances create persistent treed or treeless vegetation. However, examples of one community definitively turning into the other are not documented. It may alternatively be that subtle differences in hydroperiod or fire susceptibility created by basin slope and water table elevation determine which community occurs.

Comments: This subtype is named by analogy to the cypress dome swamps of Florida and the Gulf Coast. It does not appear, however, that our examples generally have the dome-shaped appearance of those farther south.

Rare species: No rare species are known to be specifically associated with this community.

VERNAL POOL

Concept: Vernal Pools are herb-dominated depressional wetlands with short hydroperiods, which contain wetland plants absent in surrounding communities but lack indicators of deeper water and longer hydroperiod. These communities generally completely fill shallow depressions but could be patches in complex basins.

Distinguishing Features: Vernal Pools are distinguished from other depressional wetlands by the absence of plants associated with longer hydroperiods and the presence of plants intolerant of long inundation. Typical plants include *Panicum virgatum, Erianthus giganteus, Carex glaucescens, Aristida virgata, Anchistea virginica, Aristida palustris, Schizachyrium scoparium*, and any of several *Andropogon* species. Marsh and pond species, such as *Hymenachne hemitoma, Rhynchospora tracyi, Rhynchospora inundata, Rhynchospora careyana, Leersia hexandra, Mnesithea* (*Coelorachis*) *rugosa, Diodia virginiana, Rhexia aristosa*, and *Juncus repens* are generally absent. (These species may become scarce in wetter communities during drought.) *Centella erecta, Kellochloa (Panicum) verrucosa, Lachnanthes caroliniana, Eleocharis tricostata*, and *Coleataenia rigidula* may be present in small numbers, in wet microsites, or during unusually wet periods but are not generally abundant. Vegetation resembling Vernal Pool may occur on the upper edges of some deeper ponds, but only expanses that cover a significant part of a basin or that cover a substantial area in a larger basin should be considered this type.

Crosswalks: *Panicum virgatum - Andropogon (capillipes, glaucopsis) - Aristida palustris* Marsh (CEGL004100).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Small Depression Pond (3rd Approximation - outer zone).

Sites: Vernal Pools occur in limesinks, swales in relict dune systems, and other shallow basins with short hydroperiods.

Soils: Soils are sandy, loamy, or clayey mineral soils. Examples are small enough that they are treated as inclusions in upland soil units in soil surveys.

Hydrology: Surface water is shallow to moderate, usually a few inches to a couple feet deep. Standing water seldom persists far into the growing season, and water may be absent in drier winters.

Vegetation: The vegetation is dominated by graminoids, which may be fairly sparse but usually are moderately dense. The most characteristic species, highly constant and often dominant, are *Panicum virgatum* var. *cubense* and *Andropogon* spp. The *Andropogon* are variously identified as *virginicus, cretaceus* (*glaucopsis*)*, capillipes,* or *dealbatus*. Other frequent species in CVS plots and site descriptions include *Centella erecta, Anchistea virginica, Carex glaucescens, Erianthus giganteus, Aristida virgata*, and *Lachnanthes caroliniana*. Less frequent but sometimes abundant herbs include *Juncus scirpoides, Juncus pelocarpus (abortivus), Euthamia caroliniana, Dichanthelium ravenelii, Pluchea baccharis, Drosera capillaris, Aristida palustris, Eupatorium leucolepis, Eupatorium mohrii, Dichanthelium wrightianum, Proserpinaca pectinata, Eleocharis* *tricostata, Kellochloa verrucosa, Muhlenbergia torreyana*, *Rhynchospora filifolia, Rhynchospora chalarocephala*, other *Rhynchospora* species, and *Sphagnum* spp. Species shared with wet longleaf pine communities, such as *Polygala lutea, Rhexia alifanus, Rhexia nashi, Eupatorium leucolepis, Lobelia nuttallii, Sorghastrum nutans, Lycopodiella alopecuroides*, and others, may be present with low constancy. A few shrubs and vines may be present, most frequently *Smilax rotundifolia, Smilax walteri, Smilax laurifolia, Ilex glabra, Lyonia mariana*, and *Ilex myrtifolia*. At least a few stems of *Nyssa biflora* often are present, and *Pinus taeda, Pinus serotina, Magnolia virginiana,* or other trees may occur.

Range and Abundance: Ranked G2? In North Carolina Vernal Pools are clustered in the Sandhills region and in limesink complexes in the southern part of the outer Coastal Plain. The synonymized association ranges from North Carolina to the Gulf Coast states. Its distribution on the Gulf Coast appears uncertain. If it is abundant there, it may be less rare than G2. Vernal Pools appear to be sometimes overlooked or not emphasized in site reports in North Carolina.

Associations and Patterns: Vernal Pools may fill entire small basins or may occur as a broad edge zone in larger depressions. A Small Depression Shrub Border community may be present as an outer zone around them. They often occur in limesink clusters or relict dune complexes with other Coastal Plain Depression Communities nearby, particularly Small Depression Drawdown Meadow and the various subtypes of Small Depression Pond. The surrounding matrix is usually Wet or Dry Longleaf Pine Communities.

Variation: Variation is not well known in this community. Two variants are provisionally recognized, based on geography and floristic differences, though in need of further clarification:

1. Sandhills Variant occurs in the Sandhills Region. Species more likely to be found in it include *Anchistea virginica, Carex glaucescens, Eleocharis tricostata, Rhynchospora torreyana, Aristida virgata*, and *Erianthus giganteus*.

2. Coastal Plain Variant occurs in the outer to middle Coastal Plain. Species more likely in it include *Centella erecta, Lachnanthes caroliniana*, and *Drosera capillaris*.

Dynamics: Vernal Pools demonstrate variation in response to changing water levels as other herbaceous Coastal Plain Depression Communities do. Because their typical hydroperiod is shorter, dry spells have less effect on them than wet periods. In dry periods, upland plants may establish there. In wet periods, at least those that are associated with wetter communities may see *Hymenachne hemitoma* and other more water-tolerant species spread into them.

Natural fire would be more frequent in Vernal Pools than in wetter depressions, since they are more likely to be dry when the surrounding areas burn.

Comments: The Fourth Approximation Guide included a Sphagnum Subtype of Vernal Pool as well as a Typic Subtype. This subtype has been dropped. It is equivalent to the NVC's *Sphagnum cuspidatum* Nonvascular Vegetation (CEGL004384) and is described as having very little vascular vegetation but is not otherwise well described. For the Fourth Approximation, it was conceived as being a drier analogue of Small Depression Drawdown Meadow (Boggy Pool Subtype). However, no examples have been identified. It appears reasonable that the greater frequency of fire in drier depressions would prevent persistence of a moss layer. All *Sphagnum*-dominated depressions that have been found have substantial presence of *Anchistea virginica, Carex striata*, or other vascular plants. They appear wetter than typical Vernal Pools and appear to fit the concept of Small Depression Drawdown Meadow (Boggy Pool Subtype). However, the possibility of finding a *Sphagnum* community that fits within the Vernal Pool concept should be remembered.

Rare species:
Vascular plants – *Lachnocaulon minus, Litsea aestivalis, Lobelia boykinii, Ludwigia linifolia, Muhlenbergia torreyana, Rhexia aristosa, Rhynchospora pleiantha, Sagittaria isoetiformis, Scleria reticularis,* and *Stylisma aquatica*.

Vertebrate animals – *Ambystoma tigrinum, Anaxyrus quercicus,* and *Rana capito*.

Invertebrate animals – *Triodopsis soelneri*.

CYPRESS SAVANNA (TYPIC SUBTYPE)

Concept: Cypress Savannas are wetlands of flat-bottomed depressions, usually with an open canopy of *Taxodium ascendens*, limited shrub cover, and a well-developed herb layer. They usually occur in clay-based Carolina bays but can occur in other kinds of depressions. Cypress Savannas are intermediate in wetness between Vernal Pools and Small Depression Pond communities. They overlap in hydroperiod with Small Depression Drawdown Meadows, but their vegetation and flora are different. Water typically stands well into the growing season but disappears from the surface in all but the wettest years. The hydroperiod is too short to support floating or emergent aquatic plants on a long-term basis, and too wet to support trees other than *Taxodium ascendens* and *Nyssa biflora* on a long-term basis under natural conditions.

The Typic Subtype covers examples with diverse herb layers of species typical of mineral soils. Boggy species such as *Anchistea virginica* and *Carex striata* may be present but are not strongly dominant. The Typic Subtype generally supports a diverse mixture of plants that emerge when water goes down and those that grow in the water, but the vegetation may vary drastically from year to year.

Distinguishing Features: Cypress Savannas are distinguished from Vernal Pools by the absence of less flood-tolerant plants such as *Panicum virgatum* and *Schizachyrium scoparium*. Other more upland species, such as *Andropogon virginicus, Andropogon capillipes, Andropogon cretaceus* (*glaucopsis*)*, Eupatorium compositifolium, Eupatorium album*, and *Pinus taeda,* may invade during droughts but are not present most of the time in the interior of the community. Cypress Savannas are distinguished from most subtypes of Small Depression Pond by lacking plants indicative of longer term inundation. They may include some of the more broadly tolerant emergent species, such as *Hymenachne (Panicum) hemitoma* and *Leersia hexandra* but will lack true aquatics and the more restricted emergents such as *Eleocharis equisetoides, Rhynchospora tracyi*, and *Rhynchospora inundata*.

Small Depression Drawdown Meadows may share some plants with Cypress Savanna communities, but overall flora differs. Plants that are characteristic of Cypress Savanna and uncommon in Small Depression Drawdown Meadow include *Mnesithea* (*Coelorachis*) *rugosa, Eriocaulon compressum, Saccharum giganteum, Diodia virginiana*, and *Hypericum cistifolium*. Plants characteristic of the Small Depression Drawdown Meadows and not of Cypress Savannas include *Lachnanthes caroliniana, Panicum tenerum, Juncus pelocarpus (abortivus)*, *Proserpinaca pectinata*, and *Centella erecta*, though the last is also abundant in the Coastal Plain Variant of Cypress Savanna. Some plant species, such as *Dichanthelium erectifolium, Dichanthelium wrightianum, Polygala cymosa, Rhexia aristosa, Pluchea baccharis (rosea), Scleria reticularis, Eupatorium leucolepis*, and *Kellochloa (Panicum) verrucosa*, may be frequent in either community. Distinguishing these communities is made more difficult by the fact that dominant plants and aspect dominants may very drastically from year to year, depending on rainfall.

The Typic Subtype is distinguished from the Acidic Subtype by a diverse and characteristic herbaceous flora that is not dominated by boggy species. In the Acidic Subtype, *Anchistea virginica, Carex striata, Sphagnum*, and a few other extremely acid-tolerant species dominate. These species may be present in the Typic Subtype but do not dominate.

Presence or absence of *Taxodium ascendens* is not a reliable characteristic for distinguishing among these communities. Natural patterns of tree abundance are believed to be confused by long-lasting effects of past logging and potentially of fire exclusion. Cypress Savannas usually have an open but substantial canopy of *Taxodium ascendens*; a few examples have sparse or no trees but are otherwise identical. Most Small Depression Drawdown Meadows have no trees or only sparse trees, which are as likely to be *Nyssa biflora* as *Taxodium*, but they may locally have a more substantial canopy. A denser canopy dominated by *Taxodium ascendens* or *Nyssa biflora* indicates Small Depression Swamp.

Crosswalks: *Taxodium ascendens / Panicum hemitomon - Polygala cymosa* Swamp Woodland (CEGL003733).
G036 Pond-cypress Basin Swamp Group.
Atlantic Coastal Plain Clay-Based Carolina Bay Wetland Ecological System (CES203.245).
Cypress Savanna (Typic and Depression Meadow variants) (3rd Approximation) (in part).
Small Depression Drawdown Meadow/Savanna (Typic Cypress Savanna Subtype) (earlier 4th approximation guide drafts).

Sites: Cypress Savannas are predominantly in clay-based Carolina bays – small to medium size, middle to inner Coastal Plain Carolina bays with mineral soils. Rare examples in the outer Coastal Plain occur in shallow, flat-bottomed limesink depressions or in swales on high river terraces.

Soils: Soils of most examples are wet Ultisols. McColl (Typic Fragiaquult) is mapped for more than half of the known examples. Pantego (Umbric Paleaquult), Coxville (Typic Paleaquult), and Rains (Typic Paleaquult) are mapped in several examples. The one river terrace example is mapped as Johns (Aquic Hapludult). The term "clay-based" has been used by ecologists for these sites for many years. It refers to the fragipan that is found in many examples, which restricts water penetration when wet. It appears that not all Cypress Savanna soils have a fragipan, and its importance to their occurrences is not well known.

Hydrology: Cypress Savannas have surface water of shallow-to-moderate depth, a few inches to a couple of feet, in times of normal rainfall. Surface water typically persists well into the growing season but is gone before the end of summer in ordinary years. However, water levels and hydroperiods vary substantially in response to weather cycles. Examples have been known to remain dry for periods of years or to stay flooded through whole years. The relatively flat bottom of the basins leads to similar water levels over large areas, in contrast to more sloping depressions where zones of a given water depth may shift but remain present somewhere in the basin.

Carolina bays generally have little local watershed, so most of the water that floods them presumably comes from rainfall. It is not well known how closely the hydrology of these depressions is linked to ground water. Because they have an impermeable clay layer, water presumably is perched when the water table is low, even if it connected to the water table at wetter times.

Vegetation: Cypress Savanna (Typic Subtype) usually has an open canopy of *Taxodium ascendens*, though trees can range from absent or sparse to fairly dense. The thin crowns of this species cast limited shade even at fairly high densities. Some *Nyssa biflora* may be present. *Pinus taeda*, generally smaller individuals, is often present in examples and is sometimes dense. It is believed to be an invader not characteristic of more natural conditions. The herb layer is dense and often diverse when water levels are down. Dominants can vary from time to time. Species that are at least fairly frequent in plots and sometimes dominant include *Dichanthelium wrightianum, Rhexia aristosa, Scleria reticularis, Scleria muhlenbergii, Rhynchospora inundata, Rhynchospora filifolia, Eupatorium leucolepis, Eupatorium paludicola, Kellochloa (Panicum) verrucosa, Pluchea baccharis (rosea), Boltonia asteroides,* and *Eleocharis tricostata*. Species fairly frequent in plots and sometimes abundant include *Sclerolepis uniflora, Rhynchospora perplexa, Eriocaulon compressum, Erianthus giganteus, Diodia virginiana*, *Euthamia caroliniana, Lachnanthes caroliniana,* and *Hymenachne hemitoma*. The latter two species, though occasionally abundant, are almost never as extensive as they often are in Small Depression Drawdown Meadow or Small Depression Pond communities. Other herbs sometimes reported to be abundant include *Centella erecta, Mnesithea* (*Coelorachis*) *rugosa, Hypericum cistifolium, Coleataenia longifolia* var. combsii *(Panicum rigidulum* var. *combsii), Proserpinaca pectinata, Rhynchospora perplexa, Dichanthelium erectifolium, Sabatia difformis*, and *Sagittaria isoetiformis*, though some of these species too are much more frequent in other communities. *Andropogon virginicus* or other *Andropogon* species, *Eupatorium capillifolium*, and other upland species may appear during drought periods. Shrubs are generally sparse and mostly limited to tree bases, cypress knees, and other raised microsites except on the edge. Species may include *Vaccinium fuscatum, Vaccinium formosum, Ilex amelanchier, Cyrilla racemiflora, Eubotrys racemosus, Ilex glabra,* and *Morella cerifera*, among others. *Smilax rotundifolia* may form dense tangle on the edge, and it or other vines such as *Muscadinia rotundifolia* may root in drier microsites throughout.

Range and Abundance: Ranked G2G3. North Carolina's examples are concentrated in the southern inner Coastal Plain outside of the Sandhills region, with most in Robeson, Hoke, and Scotland counties. They once were fairly common there, but remaining intact examples are rare. Scattered examples occur farther east. This community is more abundant in South Carolina, though intact examples are rare there too. It is questionably attributed to Georgia.

Associations and Patterns: Cypress Savannas tend to fill entire basins, though a Small Depression Shrub Border may be present on the edge. They naturally were surrounded by upland longleaf pine communities but virtually no remaining examples have natural surroundings.

Variation: The Typic Subtype appears highly variable. Two variants are tentatively recognized at this time, but more likely could be recognized.

1. Inland Variant occurs in the inner Coastal Plain, in the areas where clay-based Carolina bays are most common. It fits most of the above description and applies to most examples known.

2. Outer Coastal Plain Variant covers the few examples known in that region, which occur in depressions other than Carolina bays and have floristic differences that may represent either biography or the different environment. Species in this variant that are scarce or absent in plot data for the Inland Variant include *Andropogon cretaceus* (*glaucopsis*)*, Centella erecta, Eupatorium mohrii, Aristida palustris, Coleataenia tenera, Polygala ramosa*, and *Sagittaria subulata.*

More variants may be warranted, perhaps for the few middle Coastal Plain examples, perhaps for different portions of the Inland Variant. Temporal variation in vegetation makes it difficult to sort out enduring differences among sites. Changes caused by alteration of hydrology and exclusion of fire also have confused understanding of natural variation more than in most communities. The 3rd Approximation recognized Typic and Depression Meadow variants of Cypress Savanna, based largely on the presence or absence of a *Taxodium* canopy or evidence of one in the recent past. Nifong (1998) found only minor floristic differences between the two; he believed that those without canopy had once had trees. These variants have been dropped, though a different breakdown of variants may be warranted.

Cypress Savanna (Typic Subtype) equates primarily to the Nifong (1998) categories called subclass 9.2, Cypress-Gum Pond, 9.3, Drawdown Savanna/Meadow, and some of 9.4, Wet Savanna/Meadow. However, he noted that the deeply flooded Cypress-Gum Ponds probably were a temporal subclass of Drawdown Savanna/Meadows. He suggested that the Wet Savanna/Meadow subclass had a more stable hydroperiod and was dominated by longer-lived plants. This warrants further investigation. Nifong (1998) recognized multiple further divisions in each subclass, most of them known from only a single site and often from closely spaced plots. Understanding of the complex patterns within Cypress Savannas may await both extensive studies that compare sites under uniform weather conditions and additional site-specific studies that provide details of temporal changes.

Dynamics: Cypress Savanna vegetation, presumably fauna and ecosystem processes as well, vary drastically among years and over periods of years in response to changing hydroperiods. Because conditions are more uniform than in steeper-sided basins, the changes are more likely to appear as complete changes in dominants rather than as short-distance shifting of zones. Long-lived seed banks are extremely important in Cypress Savannas, apparently more so than in any other community in North Carolina. Species unseen for years may abruptly reappear in abundance when conditions change, and such species have at times been found in dormant seed banks (Kirkman and Sharitz 1994).

Among Coastal Plain Depression Communities, fire appears particularly important in Cypress Savannas. The invasion by *Pinus taeda* and *Liquidambar styraciflua* in dry periods and subsequent persistence is most pronounced in them, and fire was the likely natural mechanism keeping it in check. Some good examples of Cypress Savanna have seen substantial ecological alteration by this process.

The woody vegetation of Cypress Savannas is necessarily more stable than the herb layer. While *Taxodium ascendens* trees are not usually large, they may be old. Mature trees are tolerant of fire and could readily survive dry periods. Opportunities for reproduction of *Taxodium* may have been limited, leading to an age structure with only a few widely separated cohorts. Observations of older aerial photography suggest that tree density and cover often is stable over decades (Peroni 1988). Alterations in the tree component can also be stable. Examples with old stumps but no trees can be observed. Nifong (1998) and other observers have suggested that the treeless depression meadows that show no evidence of stumps nevertheless once had trees that were removed. Given the decay resistance of cypress wood, such removal presumably would have been long ago.

Comments: Despite long interest by the land conservation community, the classification of Cypress Savannas and related depressional wetlands has been among the most difficult to work out for this document. Early drafts of the 4th Approximation tried several different approaches, including treating them together with Small Depression Drawdown Meadow and tentative recognition of a separate Depression Meadow type. In the end the classification has returned to something more similar to that used in the 3rd Approximation, with the added recognition of the Acidic Subtype as distinct. Inner Coastal Plain areas called Depression Meadows are treated as Cypress Savannas, but many treeless outer Coastal Plain depressions that were called Depression Meadow fit better into the Small Depression Drawdown Meadow type.

Rare species:
Vascular plants – *Agalinis virgata, Amphicarpum muehlenbergianum, Boltonia asteroides var. glastifolia, Carex verrucosa, Dichanthelium hirstii, Dichanthelium spretum, Eleocharis atropurpurea, Eleocharis robbinsii, Eupatorium paludicola, Gratiola ramosa, Helanthium tenellum, Hypericum fasciculatum, Iva microcephala, Lindera melissifolia, Litsea aestivalis, Lobelia boykinii, Lophiola aurea, Ludwigia suffruticosa, Muhlenbergia torreyana, Oldenlandia boscii, Parnassia caroliniana, Paspalum dissectum, Persicaria hirsuta, Rhexia aristosa, Rhynchospora harperi, Rhynchospora microcarpa, Rhynchospora tracyi, Sagittaria isoetiformis, Scleria baldwinii, Scleria reticularis, Sclerolepis uniflora, Solidago leavenworthii, Spiranthes laciniata, Stylisma aquatica, Tiedemannia canbyi, Tridens ambiguus,* and *Utricularia cornuta.*

Vertebrate animals – *Ambystoma mabeei, Ambystoma tigrinum, Anaxyrus quercicus, Deirochelys reticularia reticularia, Eurycea quadridigitata, Liodytes rigida, Pseudacris nigrita, Pseudacris ornata,* and *Rana capito*.

Invertebrate animals – *Lynceus gracilicornis*.

CYPRESS SAVANNA (ACIDIC SUBTYPE)

Concept: Cypress Savannas are wetlands of flat-bottomed depressions, usually with an open canopy of *Taxodium ascendens*, limited shrub cover, and a well-developed herb layer. They usually occur in clay-based Carolina bays but can occur in other kinds of depressions. Cypress Savannas are intermediate in wetness between Vernal Pools and Small Depression Pond communities. They overlap in hydroperiod with Small Depression Drawdown Meadows, but their vegetation and flora are different.

The Acidic Subtype covers Cypress Savannas with vegetation that is dominated by acid-loving or boggy plants such as *Anchistea virginica, Carex striata*, and *Sphagnum* spp. and is generally relatively low in richness of other species.

Distinguishing Features: Cypress Savannas are distinguished from Vernal Pools by having a longer typical hydroperiod and are distinguished from Small Depression Ponds by a shorter hydroperiod. They are most similar in hydroperiod to Small Depression Drawdown Meadows but differ in basin shape and have different flora.

The Acidic Subtype is distinguished by vegetation dominated by plants tolerant of extreme acidity. *Sphagnum* spp, *Anchistea virginica*, and *Carex striata* usually are dominant or prominent. The less acid-tolerant species characteristic of the Typic Subtype may be present only in small numbers and with low diversity. An open canopy of *Taxodium ascendens* or *Nyssa biflora* is generally present but may be absent. Shrubs shared with either ponds or pocosins may be present but the shrub layer is open.

The Acidic Subtype shares species with the Small Depression Drawdown Meadow (Boggy Pool Subtype) but is distinguished by occurring in broad, flat basins, by the presence of a well-developed *Taxodium* or *Nyssa* canopy, and by greater species richness. It is distinguished from the Coastal Plain Depression Swamp (Mixed Subtype) by a more open canopy, well developed herb layer, and absence of a dense shrub layer. It is distinguished from Small Depression Pocosin by lacking a dense shrub layer.

Crosswalks: *Taxodium ascendens / Woodwardia virginica* Swamp Woodland (CEGL004441).
G036 Pond-cypress Basin Swamp Group.
Atlantic Coastal Plain Clay-Based Carolina Bay Wetland Ecological System (CES203.245).
Cypress Savanna (3rd Approximation).
Small Depression Drawdown Meadow/Savannas (Acid Cypress Savanna subtype) (earlier 4th approximation guide drafts).

Sites: The Acidic Subtype is known largely from clay-based Carolina bays but could occur in other kinds of depressions.

Soils: The few examples are mapped as a variety of different soils, mostly mineral soils with an organic layer or mineral soils similar to the Typic Subtype. Series mapped include Lynn Haven (Typic Alaquod), Pantego (Umbric Paleaquult), and McColl (Typic Fragiaquult).

Hydrology: The Acidic Subtype appears to be similar to the Typic Subtype in having surface water of shallow-to-moderate depth, a few inches to a couple of feet, in times of normal rainfall. Surface water typically persists well into the growing season but is gone before the end of summer in ordinary years. However, water levels and hydroperiods vary substantially in response to weather cycles through whole years. The relatively flat bottom of the basins leads to similar water levels over large areas, in contrast to more sloping depressions where zones of a given water depth may shift but remain present somewhere in the basin.

Vegetation: The Acidic Subtype usually has an open canopy of *Taxodium ascendens*, though trees can range from absent or sparse to fairly dense. The thin crowns of this species cast limited shade even at fairly high densities. *Nyssa biflora* is often present in patches or as an understory. *Pinus taeda*, generally smaller individuals, is often present in examples and is sometimes dense. It is believed to be an invader not characteristic of more natural conditions. The herb layer is moderate to dense. It is dominated by species tolerant of extremely acidic conditions and is low in species richness. *Anchistea virginica* is the most constant species and usually abundant. *Carex striata, Carex glaucescens,* or *Lachnanthes caroliniana* are often abundant. *Sphagnum* spp. is usually present, sometimes abundant, but does not form a large continuous cover. Other herbs that are noted with lower frequency include *Hymenachne hemitoma*, *Erianthus* spp., *Utricularia minor, Utricularia purpurea, Rhynchospora inundata, Scirpus cyperinus, Dulichium arundinaceum, Drosera intermedia*, and *Dichanthelium* sp. Other herbs characteristic of the Typic Subtype may occasionally occur in small numbers and with low frequency. Shrubs are usually present at low-to-moderate density with *Cyrilla racemiflora, Lyonia lucida*, *Vaccinium fuscatum, Vaccinium formosum*, and *Ilex amelanchier* most frequent. *Ilex myrtifolia, Itea virginica*, and other species occur occasionally. *Smilax rotundifolia* and occasionally *Smilax laurifolia* may be locally abundant.

Range and Abundance: Ranked G2?. Most examples in North Carolina are in the inner Coastal Plain concentration of clay-based Carolina bays in Robeson and adjacent counties. A few are reported farther east in the Coastal Plain. They range through South Carolina, where they are apparently more abundant.

Associations and Patterns: Cypress Savanna (Acidic Subtype) communities tend to fill entire basins, with the exception of a Small Depression Shrub Border community around the edge. They occur near other bays containing the Typic Subtype, Coastal Plain Depression Swamp, or other depression communities.

Variation: Patterns of variation have not been identified. Some examples seem more similar to the Typic Subtype than others.

Dynamics: Dynamics are believed to be similar to those in the Typic Subtype. Variation in vegetation in response to changing water levels may be less because of the small pool of species. As in the Typic Subtype, fire appears to be important in preventing establishment of *Pinus taeda* and *Liquidambar styraciflua* during drought. Many of the known examples now have these species present.

The factors that lead to this subtype rather than the Typic Subtype are not known. Often the two occur in close proximity. The acidic character of the vegetation appears to be stable and of long standing. However, this needs further investigation.

Comments: The name of the Acidic Subtype is meant to convey the bog-like extremely acidic conditions suggested by the species composition and abundance of *Sphagnum*. However, the Typic Subtype too has acidic soils. It is unclear if sites of the Acidic Subtype were initially more acidic or became so because of the vegetation.

This subtype includes the *Taxodium ascendens / Pinus taeda - Acer rubrum - Liquidambar styraciflua / Lindera / Smilax glauca / Carex glaucescens* Swamp (9.1.3); *Taxodium ascendens / (Nyssa biflora)* Swamp (9.1.4) of Nifong (1998).

Rare species:
Vascular plants – *Amphicarpum muehlenbergianum, Carex verrucosa, Hypericum fasciculatum, Lindera melissifolia, Litsea aestivalis,* and *Rhexia aristosa*.

Vertebrate animals – *Anaxyrus quercicus.*

SMALL DEPRESSION DRAWDOWN MEADOW (TYPIC SUBTYPE)

Concept: Small Depression Drawdown Meadows are herbaceous communities of seasonally flooded mineral soil depressions with fairly long hydroperiods. They may fill a basin but often occur as outer zones surrounding open water or marshy ponds. Most occur in limesink depressions, with occasional examples in inland dune swales or other natural depressions but generally not in clay-based Carolina bays. These communities have longer hydroperiods than Vernal Pools and shorter than Small Depression Pond communities. The Typic Subtype covers the more widespread examples that lack the abundant *Sphagnum* and other strongly acid-tolerant plants characteristic of the Boggy Pool Subtype. The Typic Subtype examples often have high species richness.

Distinguishing Features: Small Depression Drawdown Meadows are distinguished from Vernal Pools by having a longer hydroperiod, with standing water or saturated soil persisting well into the growing season. Flora intolerant of longer flooding, such as *Panicum virgatum, Saccharum giganteum, Carex glaucescens, Aristida virgata, Anchistea virginica, Aristida palustris, Schizachyrium scoparium*, and any of several *Andropogon* species, are absent, are confined to the shallowest edges, or invade only for short periods during drought. Species tolerant of wetter conditions, such as *Hymenachne (Panicum) hemitoma, Rhynchospora tracyi, Rhynchospora inundata, Rhynchospora careyana, Leersia hexandra, Mnesithea (Coelorachis) rugosa, Diodia virginiana, Rhexia aristosa*, *Juncus repens*, *Centella erecta, Kellochloa (Panicum) verrucosa, Lachnanthes caroliniana, Eleocharis tricostata*, *Coleataenia (Panicum) rigidula,* are generally present, though they may not be visible during drought.

Small Depression Drawdown Meadows are distinguished from Cypress Savannas by occurring in different kinds of basins and being floristically distinct. Plants that are characteristic of Cypress Savanna and uncommon in Small Depression Drawdown Meadows include *Eriocaulon compressum, Erianthus giganteus, Diodia virginiana*, and *Hypericum cistifolium*. Plants characteristic of Small Depression Drawdown Meadows and not of Cypress Savannas include *Centella erecta, Lachnanthes caroliniana, Panicum tenerum, Juncus pelocarpus (abortivus)*, and *Proserpinaca pectinata*. Some plant species, such as *Dichanthelium erectifolium, Dichanthelium wrightianum, Polygala cymosa, Rhexia aristosa, Pluchea baccharis (rosea), Scleria reticularis, Eupatorium leucolepis*, and *Kellochloa* may be frequent in either community. Cypress Savannas occur in flat-bottomed basins, while Small Depression Drawdown Meadows generally occur in more sloping basins, often in association with wetter subtypes.

Small Depression Drawdown Meadows are distinguished from Small Depression Pond communities, which they often adjoin, by a diverse flora that is not tolerant of longer flooding, and by the presence of mineral soil. The wetter pond communities tend to have a least some muck accumulation in the soil, which is visible even during dry periods. Small Depression Drawdown Meadow vegetation generally consists of small-to-medium size graminoids and abundant forbs, in contrast to the large emergent graminoids or floating aquatic plants of wetter Small Depression Pond communities. A sparse canopy of *Taxodium ascendens, Nyssa biflora*, *Acer rubrum*, or several kinds of shrubs may be present in either. During unusually wet periods, Small Depression Drawdown Meadows may remain flooded; the less flood-tolerant plants may not be visible and rhizomatous marsh graminoids may expand and become dominant. However, these communities will still lack the more flood-tolerant plants that are slower to invade and will lack a mucky soil.

It will generally help to know whether water levels are higher or lower than usual and to interpret communities in this light.

The Typic Subtype is distinguished from the Boggy Pool Subtype by having a diverse flora that is not confined to the most acid-tolerant species such as *Anchistea virginica* and *Carex striata. Sphagnum* is generally limited or absent.

Crosswalks: *Dichanthelium wrightianum - Dichanthelium erectifolium* Marsh (CEGL004105).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Small Depression Pond (3rd Approximation).
Small Depression Drawdown Meadow/Savanna (Pond Margin Subtype) (earlier 4th approximation guide drafts).

Sites: Small Depression Drawdown Meadows usually occur in limesink depressions but may occur in relict dune swales or other depressions.

Soils: Soils are sandy, loamy, or clayey mineral soils. Most examples are small enough that they are usually treated as inclusions in upland soil units in soil surveys, while others are mapped as water.

Hydrology: Surface water is shallow to moderate, usually a few inches to a couple feet deep at the most. Water persists well into the growing season but is gone before the end of summer in ordinary years. The soil may remain saturated for much or all of the rest of the year.

Vegetation: The vegetation is dominated by a dense herbaceous layer of small to medium size graminoids and forbs. The dominant species and overall flora are highly variable from place to place and sometimes from year to year. In 22 CVS plots representing this community, only a handful of species had constancy above 50%. The most constant species, also often abundant, are *Centella erecta* and *Lachnanthes caroliniana*. Other frequent and sometimes abundant species in plot data include *Euthamia caroliniana, Dichanthelium erectifolium, Dichanthelium wrightianum, Eriocaulon compressum, Scleria muhlenbergii, Drosera intermedia,* and *Rhexia cubensis*. Lower frequency species sometimes with high cover in plot data and/or in site descriptions include Mnesithea (*Coelorachis) rugosa*, *Eupatorium mohrii, Eupatorium leucolepis, Ludwigia suffruticosa, Pluchea baccharis, Polygala cymosa, Panicum tenerum, Coleataenia longifolia* var. *combsii, Proserpinaca pectinata*, *Dichanthelium erectifolium, Rhynchospora perplexa, Eriocaulon decangulare, Ludwigia linifolia, Ludwigia linearis, Ludwigia suffruticosa*, *Eleocharis melanocarpa*, *Muhlenbergia torreyana*, and several other *Eleocharis* and *Rhynchospora* species. *Hymenachne hemitoma* may be present, even moderately abundant, but not dominant. Other species of wetter zones, such as *Rhynchospora tracyi* and even *Nymphaea odorata*, may be present in small numbers. Species of Vernal Pool, such as *Panicum virgatum* and *Andropogon* spp., may be present but do not dominate under normal water conditions. The Typic Subtype often has high species richness compared to most Coastal Plain Depression Communities. The CVS plots averaged 24 species per 10x10 meter plot.

Though the herbaceous layer is the dominant vegetation, woody plants may be present at low to moderate density. *Litsea aestivalis* sometimes occurs scattered in this community, and sparse *Vaccinium fuscatum, Vaccinium formosum, Cyrilla racemiflora*, *Ilex myrtifolia* may be present. *Nyssa biflora* or *Taxodium ascendens* may be present as scattered or sparse trees or occasionally at moderate density. Small *Pinus taeda* are often present after periods of drought.

Range and Abundance: Ranked G2G3. Examples occur in the southern half of the Coastal Plain, including a few in the Sandhills, but most are concentrated in several clusters from Carteret to Brunswick County. The synonymized association ranges from North Carolina to Mississippi. The association as defined probably is less rare than G2, but it likely represents several unrecognized associations.

Associations and Patterns: Small Depression Drawdown Meadows often occur as zones in association with Small Depression Pond communities, sometimes with Vernal Pool, and often with Small Depression Shrub Border, but they can also fill an entire depression. The depressions may be isolated but often are clustered, so that multiple patches of this community and several other Coastal Plain Depression Communities occur close by. The surrounding landscape generally is some kind of longleaf pine community.

Variation: The Typic Subtype shows more variation than most communities in this document, including substantial changes among years as well as differences between basins and heterogeneity within single patches. Descriptions of individual ponds are sometimes organized around multiple zones within the area recognizable as Small Depression Drawdown Meadow, varying in wetness and dominant plants. At the same time, the boundary with adjacent communities such as Small Depression Pond (Typic Marsh Subtype) or Vernal Pool can be unclear because species of some zones are shared with them. While it appears undesirable to define more finely divided zones within a given pond as subtypes, the Typic Subtype may be split in the future into two or more subtypes that are related to basin configuration or biogeography. Richard LeBlond, in a series of Natural Heritage Program site reports and communications, suggested that steeper-sided basins, flatter basins, and basins with outlets that stabilized their water levels might be significantly different. Differences between Small Depression Drawdown Meadows of the outer Coastal Plain and those of the Sandhills also warrant investigation. From the viewpoint of fauna, there may be important consistent differences between Small Depression Drawdown Meadows associated with Small Depression Ponds and those where it is the wettest community in the basin. At present, no variants are defined.

Dynamics: Small Depression Drawdown Meadows are unusually dynamic on several different scales. The normal annual cycle of flooding and drawdown causes substantial changes in the environment, allowing different plants to become active and shifting the smaller fauna from aquatic to terrestrial. Variation in water levels from year to year and in longer climatic cycles can result in substantial changes in vegetation. As in Cypress Savanna, long term seed banking may be important, though it is less well documented. However, since Small Depression Drawdown Meadows more often occur in zones surrounded by wetter or drier communities, migration of species within a basin may be more important. The wettest climatic cycles likely are important for keeping uncharacteristic species such as *Pinus taeda* out of the community. In drier periods, fire likely burned into or through the meadows, and this too is probably important for excluding uncharacteristic species.

In limesink complexes, the most frequent habitat of Small Depression Drawdown Meadows, rarer but more permanent changes can also occur with continued underground solution. At least one sinkhole newly appeared a few years ago. New sinkholes probably follow a slow development as basin walls become less steep and sediment accumulates in the bottom.

Comments: The classification of what is now called Small Depression Drawdown Meadow has been one of the most difficult to settle. The boundaries with adjacent wetter and drier communities, the clarification of the range of variation over time in individual sites, and the possible recognition of variants or finer subtypes particularly need further investigation. The relationship with Cypress Savanna and with various sites called depression meadows needs more clarification. Both plot data and site descriptions pose problems in sorting out these communities because they can include portions of other communities.

The classification and naming of this community have varied substantially, reflecting the complexities and limited understanding. Drawdown zones were treated in the 3rd Approximation as part of a more heterogeneous Small Depression Pond community type. Earlier drafts of the 4th Approximation called it Small Depression Drawdown Meadow/Savanna, suggesting a closer relationship to Cypress Savannas. Other sources have called them Coastal Plain pond shore communities, emphasizing their relationship to communities with that name in states farther north.

Rhynchospora filifolia - Juncus abortivus Marsh (CEGL004131) is another Coastal Plain small depression association attributed to North Carolina. Its relationship to Small Depression Drawdown Meadow and to Small Depression Pond (Typic Marsh Subtype) is unclear, but it appears to overlap one or both without being a useful division of the great heterogeneity among these communities.

Rare species:
Vascular plants – *Agalinis virgata, Bacopa caroliniana, Carex verrucosa, Cirsium lecontei, Cyperus lecontei, Dichanthelium spretum, Eleocharis elongata, Eleocharis melanocarpa, Eleocharis robbinsii, Helanthium tenellum, Lindera melissifolia, Litsea aestivalis, Ludwigia alata, Ludwigia brevipes, Ludwigia lanceolata, Ludwigia linifolia, Ludwigia suffruticosa, Panicum dichotomiflorum* var. *puritanorum*, *Persicaria hirsuta, Rhexia aristosa, Rhynchospora harperi, Rhynchospora microcarpa, Rhynchospora pleiantha, Rhynchospora tracyi, Sagittaria chapmanii, Sagittaria isoetiformis, Scleria reticularis, Spiranthes laciniata, Stylisma aquatica, Symphyotrichum dumosum* var. *subulifolium, Utricularia cornuta,* and *Utricularia olivacea*.

Nonvascular plants – *Sphagnum fallax.*

Vertebrate animals – *Alligator mississippiensis, Ambystoma tigrinum, Anaxyrus quercicus, Deirochelys reticularia reticularia, Hyla andersonii, Pseudacris nigrita, Pseudacris ornata,* and *Rana capito*.

SMALL DEPRESSION DRAWDOWN MEADOW (BOGGY POOL SUBTYPE)

Concept: Small Depression Drawdown Meadows are herbaceous communities of seasonally flooded mineral soil depressions with fairly long hydroperiods. The Boggy Pool Subtype covers examples with vegetation dominated by the most acid-tolerant, boggy species, and generally having abundant *Sphagnum*. Trees and shrubs are usually absent or sparse.

Distinguishing Features: Small Depression Drawdown Meadows are distinguished from Vernal Pools by having a longer hydroperiod, with standing water or saturated soil persisting well into the growing season. They are distinguished from Small Depression Pond communities by a flora that is not tolerant of longer flooding. Dense cover of *Sphagnum* can make it difficult to distinguish surface water and presumably extends the time of soil saturation.

The Boggy Pool Subtype is distinguished from the Typic Subtype by having a low-diversity flora dominated by the most acid-tolerant species, such as *Anchistea virginica, Carex striata*, and *Sphagnum* spp. Other species characteristic of the Typic Subtype will be present only in small numbers and with low diversity. Most will be the more broadly tolerant species such as *Andropogon* spp., *Erianthus giganteus*, and *Hymenachne hemitoma*.

The Boggy Pool Subtype is similar floristically to the Acidic Subtype of Cypress Savanna. It is distinguished by occurrence in smaller, more steeply sloping basins, by the absence of trees, and usually by more extensive coverage of *Sphagnum*.

Crosswalks: *Woodwardia virginica / Sphagnum cuspidatum* Marsh (CEGL004475).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).
Small Depression Pond (3rd Approximation).

Sites: The Boggy Pool Subtype usually occurs in limesinks, less often in swales in dune systems, and occasionally in Carolina Bays.

Soils: All examples are small enough that they are usually treated as inclusions in surrounding soil units in soil surveys. The abundance of *Sphagnum* may contribute to accumulation of an organic layer on the soil surface, in contrast to the Typic Subtype, but this is not documented.

Hydrology: Surface water is shallow to moderate, usually a few inches to a couple feet deep at the most. Water persists well into the growing season but is gone before the end of summer in ordinary years. The soil may remain saturated for much or all of the rest of the year.

Vegetation: The vegetation is dominated by a moderate to dense herbaceous layer with low species richness. *Sphagnum cuspidatum* or some other *Sphagnum* species is usually abundant, often covering the ground beneath other plants or covering the water surface. *Anchistea virginica* is highly constant and often dominates. *Carex striata* is frequent and is abundant in some examples. *Dulichium arundinaceum, Xyris difformis, Hymenachne hemitoma, Lachnanthes caroliniana, Juncus repens, Proserpinaca pectinata, Erianthus* sp., *Carex bullata*, and species of *Rhynchospora* or *Dichanthelium* may be present. Shrubs or trees may be absent, sparse, or moderately abundant.

Nyssa biflora is the most frequent tree species but *Taxodium ascendens* occurs occasionally. *Vaccinium formosum, Vaccinium fuscatum, Eubotrys racemosus, Cyrilla racemiflora*, or *Litsea aestivalis* may be present. *Smilax rotundifolia* sometimes forms tangles.

Range and Abundance: Ranked G2?. The Boggy Pool Subtype is scattered throughout the outer Coastal Plain with a few occurrences in the middle Coastal Plain. Though rarer than the Typic Subtype, this subtype is more widely distributed than most Coastal Plain Depression Communities, occurring in several northern sites extending to the Virginia border. However, none are known in the Sandhills or in areas with a concentration of clay-based bays. The synonymized NVC association ranges from New Jersey to Florida.

Associations and Patterns: The Boggy Pool Subtype usually occupies all of a basin or is surrounded by a Small Depression Shrub Border rim. Examples sometimes occur in limesink or dune swale clusters with other depression communities but often occur as the only depression community in a site. Most are or were naturally surrounded by longleaf pine communities.

Variation: No patterns of variation have been identified other than those associated with the transition to adjacent communities.

Dynamics: The dynamics of the Boggy Pool Subtype are particularly unknown. The mossy, extremely acidic character is believed to be long-standing even as water levels change. The author has observed *Sphagnum* beds floating in some flooded depressions but submerged on other occasions. If the moss floats, its cover may remain high during wet periods. During drought, other herbaceous vegetation could produce enough cover to reduce the vigor of the moss but it can persist under heavy cover.

The water-holding capacity of *Sphagnum* and limited abundance of grass presumably makes this subtype unable to carry fire, even though it occurs in landscapes with frequent ignition.

The factors that lead to the formation of this subtype are not known. Many examples are distant from other depression communities and could lack seed sources for other species. Many are in northern or inland areas where fire may have been less frequent and where it has been absent longer. Nevertheless, a number of well-developed examples are in clusters with other depression communities and some are in landscapes where fire frequency has been greater. It is possible that some specific circumstance leads to proliferation of *Sphagnum* and that, once established, it is competitive enough to persist. Given the limited number of observations over time, it is possible that some don't persist. But current evidence suggests these communities are distinct and stable over long time periods.

Comments: A related community called Vernal Pool (Sphagnum Subtype) in earlier drafts of the 4th Approximation has been dropped. That community was based on an NVC association and was described as consisting almost solely of *Sphagnum cuspidatum*, with little vascular plant component. No definitive examples have been found in North Carolina. It was interpreted at that time as representing less wet conditions than the Boggy Pool Subtype. But, if a depression with dense *Sphagnum cuspidatum* were found in North Carolina, it is expected to fit within the concept of the Boggy Pool Subtype. Its NVC equivalent, *Sphagnum cuspidatum* Peat Marsh (CEGL004384), could be treated as a synonym to the Boggy Pool Subtype.

Carex striata var. *brevis* Marsh (CEGL004120) is an association described for New Jersey to Virginia and attributed to North Carolina and South Carolina. It might fit within this subtype's concept or that of the Cypress Savanna (Acidic Subtype). Given the close association of *Carex striata* with *Anchistea virginica*, it does not appear that such a distinction is warranted here. No distinct examples are known in North Carolina.

The acidic conditions apparently are believed to be unfavorable for the breeding of rare amphibians associated with other depression communities.

Rare species:
Vascular plants – *Litsea aestivalis*.

Vertebrate animals – *Anaxyrus quercicus* and *Deirochelys reticularia reticularia*.

SMALL DEPRESSION POND (TYPIC MARSH SUBTYPE)

Concept: Small Depression Ponds are permanently or near-permanently flooded communities in mainland Coastal Plain small depressions. The Typic Marsh Subtype covers those with emergent vegetation of various large grasses or sedges but without the characteristics of the Cutgrass Prairie Subtype. This concept differs somewhat from the 3rd Approximation, where the Small Depression Pond type covered all zones in basins that contained permanent or near permanent water in their center. As now defined, Small Depression Pond will often occur in association with one or two drier zonal community types such as Small Depression Drawdown Meadow, Vernal Pool, or Small Depression Shrub Border.

Distinguishing Features: Small Depression Ponds are distinguished from Small Depression Drawdown Meadows by vegetation and soils characteristic of deeper and more permanent standing water, with a hydroperiod lasting most, if not all, of the growing season. They tend to have soils with at least some muck accumulation. They tend to be dominated either by floating-leaf plants, submersed plants, or by large emergent graminoids, though smaller water-tolerant graminoids may dominate. Small Depression Drawdown Meadows tend to have smaller graminoids and abundant forbs, mostly species adapted to less permanent water. The Small Depression Pond type is distinguished from Natural Lake Shoreline by occurring in small, shallow depressions, less than 20 acres, where wave action is not significant, and where emergent or floating vegetation is generally able to occur all the way across.

Small Depression Ponds are closely related to Interdune Ponds; they are distinguished by occurring in coastal fringe or inland locations, not on barrier islands, nor in association with maritime communities and salt spray. Upland Pool communities of the Piedmont and Blue Ridge may be closely related, including containing some Coastal Plain flora, but are easily distinguished by their location in those provinces and by their distinctive vegetation.

The Typic Marsh Subtype is distinguished from the Open Lily Pond Subtype by the dominance of emergent plants. It is distinguished from the Cutgrass Prairie Subtype by the absence or scarcity of *Leersia hexandra*.

Crosswalks: *Panicum hemitomon - Eleocharis equisetoides - Rhynchospora inundata* Marsh (CEGL004127).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: Typic Marsh Subtype communities occur primarily in limesinks but could potentially be found in other kinds of Coastal Plain depressions.

Soils: Soils are sandy, loamy, or clayey mineral soils but generally have a thin layer of muck. Many examples are small enough that they are treated as inclusions in upland soil units in soil surveys, while others are mapped as water.

Hydrology: Surface water is shallow to deep, usually 1 to several feet deep. Standing water is present for most or all of the growing season in normal years. When it is not present, the soil remains saturated.

Vegetation: The Typic Marsh Subtype is generally dominated by emergent herbs, mostly grasses and sedges. *Hymenachne hemitoma* is highly constant and can be strongly dominant, sometimes almost to the exclusion of other species. *Eleocharis equisetoides, Rhynchospora inundata*, and *Rhynchospora tracyi* are also frequent and may be abundant. Other fairly frequent species include *Eleocharis elongata*, other *Eleocharis* species, *Rhynchospora harperi, Proserpinaca pectinata, Leersia hexandra*, and *Juncus repens*. Many species shared with Small Depression Drawdown Meadow (Typic Subtype) are mentioned in some site descriptions or found in plots with low cover and frequency. Some of them include *Centella erecta, Lachnanthes caroliniana, Polygala cymosa, Eriocaulon compressum, Pluchea baccharis, Rhexia cubensis, Xyris ambigua*, and *Rhynchospora pleiantha*. Species more typical of the Open Lily Pond Subtype may also be present in small numbers, including *Nymphaea odorata* and *Utricularia* spp. Woody species are absent or sparse, but some *Taxodium ascendens*, *Nyssa biflora*, *Ilex myrtifolia*, or other shrubs may be present. The plant species richness of this community generally is lower than that of nearby Small Depression Drawdown Meadows.

Range and Abundance: Ranked G3. The Typic Marsh Subtype is known from the outer and occasionally middle Coastal Plain in the southern half of the state, but examples could potentially be found farther north or in the Sandhills. Most examples are in a few clusters from Carteret to Brunswick County. The synonymized association ranges from North Carolina to Georgia and potentially to Florida and Alabama.

Associations and Patterns: Small Depression Pond (Typic Marsh Subtype) usually occurs as a zone in association with other depression communities. The Open Lily Pond Subtype may occur in deeper water in the center of a depression. Small Depression Drawdown Meadow, Vernal Pool, or Small Depression Shrub Border may occur on the shallow outer edge of the basin. The depressions may be isolated but often are clustered, so that multiple patches of this community and several other Coastal Plain Depression Communities occur close by. The surrounding landscape generally is some kind of longleaf pine community.

Variation: The fine-scale spatial heterogeneity and temporal variability in vegetation makes it difficult to distinguish appropriate natural divisions of these communities with plot studies or site descriptions. Some examples are relatively diverse while others appear to consist of little other than *Hymenachne hemitoma*. It is unclear if this is an enduring characteristic or a result of the season or year of survey. These examples often are more isolated and may represent a naturally depauperate variant. They could also possibly be a result of alteration.

Eleocharis (elongata, equisetoides) - Rhynchospora tracyi Marsh (CEGL004960) is an additional small depression pond association that has been attributed to North Carolina and appears to overlap the concept of this subtype. Nifong (1998) also recognized a depauperate *Panicum hemitomon* association, which was not recognized in NVC. These could potentially represent variants or subtypes but need further investigation of how distinct they are in North Carolina. Nifong (1998) also recognized an *Eleocharis quadrangulata - Rhynchospora inundata - Rhynchospora* sp. 1 /

Sphagnum Marsh association, which is not represented in NVC. It needs clarification of its concept and character but may warrant recognition as a distinct variant or subtype.

Dynamics: Small Depression Ponds, including the Typic Marsh Subtype, are expected to be more stable than the drier herbaceous-dominated depression communities. Vegetation may still change in response to unusually wet or dry periods, but the larger dominant plants are likely to remain. Because these communities remain wet much of the time, they rarely burn when surrounding areas are ignited. Because of wetness, they are less prone to invasion by uncharacteristic trees such as *Pinus taeda* during drought, but this could still happen.

Comments: Early 4^{th} Approximation drafts had two other subtypes of Small Depression Pond – Boggy Marsh and Maidencane. The former appears to be less wet and to be equivalent to Small Depression Drawdown Meadow (Boggy Pool Subtype). The latter appears to not be distinct enough from the Typic Marsh Subtype.

Rare species:
Vascular plants – *Eleocharis elongata, Eleocharis robbinsii, Eleocharis vivipara, Lachnocaulon minus, Ludwigia linifolia, Myriophyllum laxum, Paspalum dissectum, Rhynchospora harperi, Rhynchospora pleiantha, Rhynchospora tracyi*, *Sagittaria chapmanii, Sagittaria isoetiformis, Schoenoplectus etuberculatus, Utricularia cornuta,* and *Utricularia olivacea*.

Vertebrate animals – *Ambystoma mabeei, Deirochelys reticularia reticularia, Pseudacris nigrita, Pseudacris ornata,* and *Rana capito*.

SMALL DEPRESSION POND (CUTGRASS PRAIRIE SUBTYPE)

Concept: Small Depression Ponds are permanently or near-permanently flooded communities in mainland Coastal Plain small depressions. The Cutgrass Prairie Subtype encompasses examples typically in small, flat Carolina bays or other depressions with loamy soils and a hydroperiod slightly shorter than the Typic Marsh Subtype, in which the vegetation is dominated by or has a substantial component of *Leersia hexandra*.

Distinguishing Features: The Small Depression Pond type is distinguished from Small Depression Drawdown Meadow by vegetation and soils characteristic of deeper and more permanent standing water, with a hydroperiod lasting most, if not all, of the growing season. It tends to have soils with at least some muck accumulation. The Cutgrass Prairie Subtype is distinguished by the dominance or codominance of *Leersia hexandra* during wet periods and a continued substantial presence of it during droughts.

Crosswalks: *Leersia hexandra - (Panicum verrucosum, Scleria reticularis)* Marsh (CEGL004047).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: The Cutgrass Prairie Subtype occurs primarily in clay-based Carolina bays but may occur in other kinds of depressions.

Soils: Soils are believed to be mineral soils with a thin layer of muck. Most of the few examples are mapped in soil surveys as water.

Hydrology: Surface water is shallow to deep, usually 1 to several feet deep. Standing water is present for most or all of the growing season in normal years. When it is not present, the soil remains saturated. Studies of *Leersia*-dominated vegetation in South Carolina suggest that this community has deeper water and more variable water levels than other marshes (Kirkman and Sharitz 1994, Mulhouse, et al. 2005).

Vegetation: The Cutgrass Prairie Subtype is largely treeless, though *Pinus taeda* and hardwoods may invade it during prolonged drought. The herbaceous vegetation is dense. *Leersia hexandra* dominates in times of typical water levels, often in nearly pure stands. *Kellochloa (Panicum) verrucosa* may be abundant, even codominant, right after drawdown. *Hymenachne hemitoma* may become abundant in longer droughts. Low frequency herbs include *Scleria reticularis, Eleocharis robbinsii, Eleocharis melanocarpa, Dichanthelium wrightianum, Rhynchospora filifolia, Lachnanthes caroliniana, Rhexia aristosa*, and *Nymphoides cordata*.

Range and Abundance: Ranked G2G3. Only a few well-developed examples are known in North Carolina, but more may be overlooked. The synonymized NVC association is only attributed to North Carolina. It might be expected in South Carolina, but Nifong's (1998) extensive study of Carolina bays did not identify any there.

Associations and Patterns: The Cutgrass Prairie Subtype may fill most or all of a basin or may occur as a zone in bays with other communities. Sites are naturally surrounded by longleaf pine communities but now more often occur in heavily altered landscapes.

Variation: No enduring patterns of variation have been identified. Examples may vary drastically in response to changing water levels. Nifong (1998) classified three associations, which he indicated were short-term successional stages.

Dynamics: Dynamics in general are similar to other herb-dominated depression communities, with vegetation potentially varying dramatically in response to weather patterns. Kirkman and Sharitz (1993) demonstrated some of the biological characteristics of *Leersia hexandra*, showing that it has the ability for stem elongation when flooded and that it elongated more than the other species studied. This presumably makes it able to withstand deeper flooding than *Hymenachne hemitoma*, but how this compares to the other sometimes-dominant marsh species is not known. It grows and reproduces best in flooded conditions. At the same time, it had less stomatal control, making it more prone to drought. Mulhouse, et al. (2005) showed that areas dominated by *Leersia* in South Carolina showed more vegetation change during severe drought than did areas dominated by *Hymenachne* or *Carex striata*; they attributed this to less competitive standing vegetation but noted that *Leersia* marshes also had deeper water and more substantial seasonal water level fluctuations.

Nifong (1998) recognized three *Leersia* associations: *Leersia* Prairie (2.0.1), *Leersia/Panicum verrucosum* Prairie (2.0.2), *Pinus taeda/Panicum hemitomon/Leersia* "successional prairie" (2.0.3). He emphasized the successional relationships among the three, suggesting that they are different phases that can occur in the same site at different times in normal climatic cycles.

As in other herbaceous wetlands, fire may be important for keeping uncharacteristic woody vegetation from establishing during drought, but known examples appear to be less subject to tree invasion than Cypress Savanna.

Comments: The Cutgrass Prairie Subtype is one of the least well understood of North Carolina's communities. Only a few examples are known in site reports or in the Nifong (1998) plots. *Leersia hexandra* may be present in patches in other depression communities, making it difficult to recognize well-developed examples of this community.

Nifong (1998) called this community "intermittently flooded depression prairie." He suggested that it was intermediate between marshes and wet meadows. It appears wetter than Cypress Savanna, perhaps bearing the same relationship to it that the Typic Marsh Subtype does to Small Depression Drawdown Meadow (Typic Subtype). However, it appears to be much rarer. It is unclear if it is analogous to any of the communities called prairies farther south.

Rare species:
Vascular plants – *Agalinis virgata, Drosera filiformis, Eleocharis robbinsii, Eupatorium paludicola, Iva microcephala, Ludwigia suffruticosa, Paspalum dissectum, Persicaria hirsuta, Rhexia aristosa, Rhynchospora sulcata, Rhynchospora microcarpa, Rhynchospora tracyi, Sagittaria isoetiformis, Scleria reticularis,* and *Symphyotrichum dumosum* var. *subulifolium*.

Vertebrate animals – *Ambystoma tigrinum, Ambystoma mabeei, Anaxyrus quercicus, Dierochelys reticularia reticularia, Pseudacris nigrita, Pseudacris ornata,* and *Rana capito*.

SMALL DEPRESSION POND (OPEN LILY POND SUBTYPE)

Concept: Small Depression Ponds are permanently or near-permanently flooded communities in mainland Coastal Plain small depressions. The Open Lily Pond Subtype covers the deepest, most permanently flooded zones, where floating or submersed aquatic plants such as *Nymphaea*, *Nuphar, Lemna*, or *Utricularia* dominate. It generally occurs in zoned complexes with other depression communities.

Distinguishing Features: Small Depression Pond (Open Lily Pond Subtype) is distinguished from other Coastal Plain Depression Communities by having permanent or near-permanent standing water and lacking extensive emergent vegetation. Floating, floating-leaf, or submersed aquatic plants dominate, typically *Nymphaea odorata, Nuphar advena, Nymphoides aquatica, Lemna* spp., or *Utricularia* spp. This subtype largely lacks emergent marsh plants such as *Eleocharis equisetoides, Eleocharis elongata, Eleocharis melanocarpa, Rhynchospora tracyi, Rhynchospora inundata, Rhynchospora careyana, Hymenachne (Panicum) hemitoma, Leersia hexandra*, and *Kellochloa (Panicum) verrucosa*, though small amounts may be present on the edges. Trees and shrubs are generally absent or sparse. This subtype should not be classified unless it covers a major part of the basin or covers a large area in a larger basin.

Floating Bog communities may also have permanent standing water but have dense floating vegetation bound together by roots and covering the water.

The Open Lily Pond Subtype is distinguished from Natural Lake Shoreline Marsh by occurring in small basins, with less than 20 acres of water. It is distinguished from Coastal Plain Semipermanent Impoundment by occurring in small natural basins in uplands rather than in impoundments in floodplains, with corresponding lack of stream flooding.

Crosswalks: *Nymphaea odorata - Nuphar advena - (Nymphoides aquatica, Xyris smalliana)* Aquatic Vegetation (CEGL004326).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: Small Depression Pond (Open Lily Pond) communities occur most often in limesink depressions, but a few are known in clay-based Carolina bays or other kinds of depressions.

Soils: Soils generally have a shallow muck layer on the surface. Soil surveys treat them as inclusions in surrounding map units or map them as water.

Hydrology: Ponds are flooded most of the time, with water drawing down only at the end of drier summers or in severe drought. Water is often a meter or more deep.

Vegetation: The Open Lily Pond Subtype is dominated by aquatic plants. *Nymphaea odorata* is nearly always present and usually dominant, though it may range from low to high cover. Some species of *Utricularia* are often present; *U. purpurea* most frequently noted but *Utricularia biflora, olivacea, gibba*, and other species also occur. *Nuphar advena, Nymphoides aquatica, Brasenia schreberi, Myriophyllum laxum*, and *Lemna valdiviana* are sometimes present. Species rooted on the bottom, such as *Eleocharis vivipara* or *Juncus repens* may become evident when water levels are low. Emergent species shared with the Typic Marsh Subtype, such as *Hymenachne hemitoma, Leersia hexandra, Eleocharis equisetoides*, or *Rhynchospora inundata* may be present in the edges but are limited in cover. Other emergent species such as *Xyris* spp. or *Eriocaulon* spp. may be present on the edges. In extreme droughts, when the bottom may be exposed for longer times, ruderal species such as *Cyperus* spp. may appear. Woody species usually are absent, but scattered individuals of *Taxodium ascendens* or *Nyssa biflora* may be present.

Range and Abundance: Ranked G3?. Most North Carolina examples are in the southeastern outer Coastal Plain but some reach the inner Coastal Plain and a few occur farther north. The synonymized association ranges to South Carolina and is questionably attributed to Georgia and Florida. Open lily ponds are more common in Florida, so the question is primarily about whether they should be regarded as the same association.

Associations and Patterns: The Open Lily Pond Subtype usually occurs in zoned complexes, where it occupies the center or the portion with deepest water. Not all zones are well developed in most depressions, but surrounding communities are likely to include the Typic Marsh Subtype or Cutgrass Prairie Subtype of Small Depression Pond, Small Depression Drawdown Meadow, Vernal Pool, or Small Depression Shrub Border. All of these communities often occur in close proximity in multiple patches in limesink clusters. The surrounding uplands in natural condition are dry or wet longleaf pine communities.

Variation: Ponds vary in their mix of aquatic plant species, but patterns of variation have not been identified.

Dynamics: The Open Lily Pond Subtype is subject to water level fluctuations, but it can be more stable than most of the other herbaceous depression communities because only the more extreme dry spells lead to loss of standing water. However, in such extreme times, Mullhouse, et al. (2005) documented that *Nymphaea* and other floating aquatics could completely disappear and that the vegetation was more susceptible to the establishment of new plants than was the denser marsh vegetation. Even with the water gone, the vegetation of the Open Lily Pond Subtype is unlikely to carry fire unless the pond has been dry long enough for a dense stand of grasses or sedges to develop.

Comments: This community was called Nymphaea Pond (3.0.1) in Nifong 1998. Only a couple of examples are known in Carolina bays, the subject of Nifong's study.

Rare species:
Vascular plants – *Bacopa caroliniana, Myriophyllum laxum,* and *Utricularia olivacea*.

Vertebrate animals – *Alligator mississippiensis, Deirochelys reticularia reticularia, Pseudacris nigrita, Pseudacris ornata, Rana capito,* and *Seminatrix pygaea paludis*.

FLOATING BOG

Concept: Floating Bogs are rare communities developed on floating vegetation mats in deep water. They may occur in limesink depressions, or in natural or artificial impoundments. Vegetation usually includes a mixture of species shared with northern quaking bogs and pocosins. Characteristic species are *Rhynchospora alba, Dulichium arundinaceum, Hypericum virginicum, Eleocharis baldwinii, Sarracenia rubra, Sarracenia flava, Chamaedaphne calyculata*, and *Sphagnum cuspidatum*.

Distinguishing Features: Floating Bogs are distinguished from almost all other communities by their substrate, which consists of organic mats floating on water. The few examples known are in very different settings, including a limesink pond, a naturally blocked creek embayment, and an old mill pond impounded in a pocosin. The only similar community, Riverine Floating Mat, occurs in flowing or tidal waters and consists of species such as *Hydrocotyle ranunculoides* or *Sacciolepis striata* rather than species associated with bog environments.

Crosswalks: *Rhynchospora alba* Marsh Vegetation (CEGL004463).
G915 South Atlantic & Gulf Coastal Plain Pondshore Group.
Southern Atlantic Coastal Plain Depression Pond Ecological System (CES203.262).

Sites: Floating Mat communities are known from only a handful of sites. They may potentially occur in any standing water, including limesink depressions, long-standing natural or artificial impoundments, or stagnant creeks. The conditions that lead to their formation in the handful of sites and not in others are unknown.

Soils: The soil consists of a mat of floating organic matter formed by vegetation and bound together by live roots.

Hydrology: Floating mats occur in permanent or near-permanent water.

Vegetation: The vegetation is quite different in each of the handful of examples. It has in common a mix of species tolerant of extremely acidic wetland conditions, forming a dense floating herb mat and having small individuals of woody species. *Sphagnum cuspidatum* or some other species of *Sphagnum* seems to form the matrix or substrate of the mat in most or all examples. *Rhynchospora alba* often is present. In one example, *Dulichium arundinaceum* and *Decodon verticillatus* are abundant. In a second one nearby, *Rhynchospora inundata, Calopogon tuberosus*, and *Xyris smalliana* are the primary additional species. One has a mix of *Xyris* sp., *Drosera intermedia, Andropogon cretaceus* (*glaucopsis*)*, Sarracenia flava*, *Hymenachne hemitoma*, and *Chamaedaphne calyculata*. Another has *Eleocharis microcarpa, Hydrocotyle verticillata, Anchistea virginica, Persicaria* sp., and at least some *Vaccinium macrocarpon*. Woody species in examples include *Pinus serotina, Morella cerifera, Smilax laurifolia*, and *Smilax walteri*.

Range and Abundance: Ranked G1? but presumably unquestioned G1. This community is known from three examples in North Carolina. The NVC association has not been attributed to any other state but it should be sought in similar settings in nearby states.

Associations and Patterns: The known examples vary in their associations in accordance with their setting. One occurs in limesink depressions, where it is associated with Small Depression Pond and Small Depression Shrub Border communities. One is in an artificially impounded peat-filled Carolina bay, where it is surrounded by Coastal Plain Semipermanent Impoundment (Open Water Subtype) and by Low Pocosin. The third is along a small drowned river, where it is bordered by pocosin communities.

Variation: All known examples are extremely different from each other and could be regarded as distinct variants if not subtypes.

Dynamics: Virtually nothing is known about the dynamics of these communities. The factors that led to their formation are not known, beyond general conditions that are similar to numerous sites that do not have Floating Bogs. At least one example has developed in the last 200 years, in an impounded pocosin. The age of the others is not known. All examples may be relatively transient communities, though none have been observed to appear or disappear. The mechanism of mat development seems to include both accretion onto floating vegetation such as *Nymphaea* or *Sphagnum* and extension by vegetative spread at the edge of the mat.

Floating Mats may be long-term primary successional communities, with the mats gradually extending and thickening until their peat fills the basin. They resemble at least superficially the primary successional communities of northern glacial kettle hole bogs that are believed to undergo this process. If so, once grounded and stable, they likely will develop some kind of pocosin vegetation. Alternatively, they may represent a kind of dynamic equilibrium or cyclic succession, their spread and development checked by conditions or periodically destroyed by natural disturbances.

Comments: Floating Bog communities are among the more enigmatic communities of North Carolina. The examples are tied together by a distinctive phenomenon of mat development that is extremely rare and poorly understood.

This community type does not fit cleanly into any theme but fits Coastal Plain Depression Communities better than any other.

Rare species:
Vascular Plants – *Rhynchospora alba* and *Vaccinium macrocarpon*.

NATURAL LAKE COMMUNITIES THEME

Concept: Natural Lake Communities are vegetated wetland communities associated with the natural lakes of the Coastal Plain, influenced by their hydrology, and contrasting with the adjacent upland or wetland communities away from the lake. They range from wet forests to emergent and floating-leaf marshes.

Distinguishing Features: Natural Lake Communities are distinguished by occurring adjacent to large natural bodies of inland permanent fresh water. They are distinguished from the permanently flooded Coastal Plain Depression Communities by being much larger, large enough to have significant wave action. The definition of Cowardin et al. (1979) for the boundary between Palustrine and Lacustrine wetlands, 20 acres, is taken as the distinguishing value, but almost no water bodies are near the threshold. The boundary of the communities in this theme with the aquatic communities of the lakes is placed where emergent and floating-leaf rooted vegetation ends in open water. However, the aquatic community may have substantial interaction with the wetter shoreline communities. The boundary with non-Lacustrine communities is a place where the natural vegetation becomes indistinguishable from that of areas distant from the lake. Lake shorelines with scarped edges and higher surfaces may have no Natural Lake Community, while gently sloping shorelines may have two zones of different Natural Lake Communities before grading into other wetland or upland communities.

Within the Natural Lake Communities theme, communities are divided first into swamps, which have a substantial tree canopy, and marshes, which don't. Both are then subdivided by the dominant vegetation. Lake Waccamaw is an environmentally and biogeographically unique lake, which has its own distinct communities differing substantially in flora and vegetation.

Sites: There are 20 natural lakes in North Carolina, one in the Coastal Plain of Virginia, and none in other nearby states. They occur in three clusters: the Bladen Lakes, the peatlands of Croatan National Forest, and the peatlands of the Pamlimarle Peninsula and mainland Dare County.
North Carolina's natural lakes appear to have several origins, based on their settings. A number occur in large peatlands, and a number of others occur in Carolina bays, which are generally also at least partly filled with peat. A few may have formed by blockage of drainages and are elongate, but most are round. The largest lakes are bordered by mineral soil uplands, at least on substantial parts of their shoreline. All of North Carolina's natural lakes are shallow, and usually their beds slope very gradually, allowing development of a broad shoreline vegetation zone. Vegetated shorelines may appear as smooth concentric zones, but eroding shorelines often appear as irregular or scalloped edges, with peninsulas and islands of remnant vegetation separated by shallow bays that probably are of recent origin.

Soils: Soils are generally not characterized or distinguished and are little studied. The Natural Lake Shoreline Marsh communities may have mucky substrates or may have clean sand where waves carry organic matter away. Natural Lake Shoreline Swamps may have organic, sandy, or loamy soils, which often are not distinguished from those of the adjacent area.

Hydrology: Natural Lake Communities are associated with a permanent water body, but the hydroperiod of the communities varies as lake levels fluctuate. Some marshes are permanently flooded, some marshes and swamps draw down seasonally or irregularly, and some have high water tables tied to the lake but are only rarely deeply flooded. Several otherwise unaltered large lakes have had their hydrology controlled by the addition of dams or weirs at their outlets, making it difficult to tell what the hydroperiod of the lake was before they were built. These have the effect of stabilizing water level fluctuations and allow for some artificial management of water levels. However, lake levels drop below the structures during droughts, and water generally overflows them during very wet periods, so they may be more effective at reducing minor fluctuations than major ones.

Water in most lakes comes primarily from rainfall. Lake Waccamaw has a substantial tributary stream with a large watershed, but most other lakes have no stream input and have limited local watersheds. However, many lakes have blackwater, with tannins derived from their local watersheds or shoreline vegetation. All lakes probably interact with groundwater, with their levels normally reflecting the water table. Lake Waccamaw has calcareous water, apparently derived from groundwater discharged through limestone, though an eroding limestone cliff on one shore also contributes.

Vegetation: Vegetation within this theme spans a very wide range of structures. The Natural Lake Shoreline Swamps are dense forests or open woodlands. They usually have a single tree species that is strongly dominant: *Liquidambar styraciflua, Taxodium ascendens,* or *Nyssa biflora*. But the Rich Subtype has a diverse forest canopy that consists of eight or more species, its composition somewhat resembling a Brownwater Levee Forest. Natural Lake Shoreline Swamps often have a dense shrub layer and extensive vines, at least on the edge where light is abundant. Herb layers in them may vary from diverse to depauperate, depending on light availability and amount of wave disturbance. In Natural Lake Shoreline Marsh, herbaceous vegetation dominates. Most are dominated by relatively few species, limited to those able to withstand wave movement. *Hymenachne (Panicum) hemitoma* often dominates. On a few lakes, the marsh community in the drawdown zone is diverse and contains rare plant species. Lake Waccamaw is unique in containing an extensive shoreline community dominated by *Nuphar sagittifolia*.

Dynamics: The most important lake dynamics are water level fluctuations. They are driven by rainfall, groundwater input, evaporation, and in a few cases, by artificial control structures that alter natural patterns to an uncertain degree. Because of the size of lakes, only the more persistent variations in weather tend to affect water levels much. However, there may be substantial variation from the normal hydroperiod, in response to weather cycles. Stahle's (1988) dendrochronology work showed periods of persistent drought or high rainfall on a time scale of around 30 years. Periods of prolonged flooding or prolonged drawdown affect the vegetation of Natural Lake Communities substantially, though most such changes are temporary and should be regarded as natural. However, changes in water control structures may lead to permanent changes in hydroperiods. Where such changes happened long ago, the vegetation likely is stabilized in equilibrium with them. Because long term rainfall exceeds evaporation, all lakes have some kind of outflow. Sometimes it is a distinct outflow stream but sometimes it is a broad zone of overflow.

Another important dynamic on lake shores is wave action. Waves are not intense enough to generally produce natural unvegetated beaches, but clean sand substrate, even in peatland lakes, suggests enough action to carry away accumulating organic matter. These sandy shorelines are probably in equilibrium, but intensified waves during storms must act as a natural disturbance from which the vegetation then needs to recover. Other shorelines appear to be eroding. They have trees standing in the water on small islands or peninsulas, often with remnants of peat substrate held by their roots and supporting clumps of shrubs at their bases. While this pattern suggests active erosion of a formerly continuous peat shoreline, the number of fallen trees and shrubs at any given time is small, suggesting such erosion happened in the past or at least is very slow. This is in contrast to the shores of the sounds, where large numbers of fallen trees, relict stumps, and broad zones of small tree islands attest to rapid recent erosion.

The water in blackwater lakes is acidic and oligotrophic, limiting the productivity of aquatic and rooted vegetation. Lake Waccamaw is an exception, having calcareous water, but likely still with limited input of other nutrients. Where development has occurred on the lake, addition of nutrients can have substantial effects on water quality and lead to algal growth in the lake. It is unclear how much effect this has on the rooted vegetation of the shoreline communities.

The origin of North Carolina's lakes is not entirely clear. Original forms have probably all been substantially modified by wave action. Only a couple of smaller lakes appear to have originated by blocking of drainages. The largest, such as Lakes Waccamaw, Mattamuskeet, and Phelps, may be results of irregularities in the original deposition of marine sediments. Their occurrence in very flat outer Coastal Plain landscapes may explain why outflow did not cut a stream channel that would drain them.

The peatland lakes are particularly notable. Common in unpublished literature is a belief that they were created by deep peat burns during droughts, presumably in a formerly continuous peatland. If so, it was during a drought much more severe than any that have happened in historic times. Even when uncontrollable wildfires have occurred during drought and caused severe peat burning, results have been vastly short of forming a lake, and the most severe peat burning occurred in areas with artificial drainage.

Lakes in Carolina bays likely have a history similar to that of peatland lakes. They do not fill the entire bay, but instead are bordered by peat on at least some sides. It thus appears possible that these bays, like the more numerous bays around them, were filled with peat and that the lakes originated later.

Comments: North Carolina is the only state in the Mid-Atlantic region to have numerous natural lakes. Southward, lakes appear again only in Florida. Two natural lakes occur in Virginia, only one in the Coastal Plain. Northward, it appears that no more occur south of the glaciated region.

KEY TO NATURAL LAKE COMMUNITIES

1. Vegetation dominated by trees, a forest or open woodland.
   2. Forest strongly dominated by *Liquidambar styraciflua*.. .... **Natural Lake Shoreline Swamp (Sweetgum Subtype)**
   2. Forest not strongly dominated by *Liquidambar*, though it may be present in a mix of species.
      3. Forest dominated by *Taxodium* or *Nyssa*, generally *Taxodium ascendens* or *Nyssa biflora.*
         4. Forest on Lake Waccamaw; herb layer containing *Sclerolepis uniflorus, Cladium mariscoides, Boltonia asteroides*, and other species not found on other lakes......................... ....**Natural Lake Shoreline Swamp (Lake Waccamaw Subtype)**
         4. Forest not on Lake Waccamaw; herb layer not containing the above species; herb layer generally dominated by *Hymenachne hemitoma*, occasionally by *Juncus* or other species.….. .... **Natural Lake Shoreline Swamp (Cypress Subtype)**
      3. Forest dominated by *Liquidambar styraciflua* or *Liriodendron tulipifera*, with a diverse mix of other species including *Taxodium distichum*, *Ulmus rubra*, *Quercus laurifolia*, *Quercus michauxii, Platanus occidentalis, Carya cordiformis*, and *Celtis laevigata*................................ .... **Natural Lake Shoreline Swamp (Rich Subtype)**

1. Vegetation not dominated by trees; dominated by emergent or floating-leaf herbaceous plants; trees, if present at all, sparse.
   5. Vegetation dominated by *Nuphar sagittifolia*.. .... **Natural Lake Shoreline Marsh (Lake Waccamaw Pond–Lily Subtype)**
   5. Vegetation dominated by emergent herbaceous vegetation, sometimes with sparse trees or shrubs ....**Natural Lake Shoreline Marsh (Typic Subtype)**

NATURAL LAKE SHORELINE SWAMP (SWEETGUM SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Sweetgum Subtype encompasses those dominated by *Liquidambar styraciflua*, with an acidic flora related to peatland communities.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Swamps do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere.

The Sweetgum Subtype is distinguished by the dominance or codominance of *Liquidambar styraciflua*, or its predominance over *Taxodium* and *Nyssa*, and the lack of species indicative of the Rich Subtype. The abundant *Persea palustris* and other species characteristic of peatlands also distinguishes it from other subtypes. The Sweetgum Subtype of Nonriverine Swamp Forest potentially shares such a general combination of flora but usually has more *Nyssa*, as well as being remote from water bodies and having nonriverine hydrology.

Crosswalks: *Liquidambar styraciflua / Persea palustris* Wet Forest (CEGL004481).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: Natural Lake Shoreline Swamps occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of the water table tied to lake levels. The Sweetgum Subtype appears to be associated with areas where water overflows from the lake and tends to be on the southern or eastern shore.

Soils: The Sweetgum Subtype occurs on organic soils, generally mapped as Croatan (Terric Haplosaprist), Dare (Typic Haplosaprist), or Dorovan (Typic Haplosaprist). It is likely that the soil is richer in mineral material or nutrients than most peats because of water flow through the area.

Hydrology: The Sweetgum Subtype is permanently saturated and flooded seasonally or intermittently. Water levels may vary over periods of a few years in response to weather cycles but this subtype is generally not under water for extended periods in normal years.

Vegetation: The Sweetgum Subtype has a dense to open canopy dominated by *Liquidambar styraciflua*, often in combination with *Persea palustris, Nyssa biflora, Taxodium distichum, Acer rubrum,* or *Pinus taeda*. There may be a well-developed understory that is dominated by *Persea palustris* and may contain *Ilex opaca*, *Gordonia lasianthus*, *Magnolia virginiana*, or various canopy species. There is often a dense shrub layer of *Cyrilla racemiflora*, *Eubotrys racemosus*, or other species shared with peatlands or open wetlands. These may include *Lyonia lucida*, *Vaccinium formosum*, *Clethra alnifolia, Arundinaria tecta*, *Viburnum nudum*, *Morella* *caroliniana*, and *Ilex coriacea*. *Smilax laurifolia*, other *Smilax* spp., *Muscadinia rotundifolia*, or other vines are often present. The herb layer may be sparse to dense but generally consists of only a few species, usually *Anchistea virginica* and *Lorinseria areolata*. In areas with dense canopy and shrub layer, herbs may be virtually absent.

Range and Abundance: Ranked G1. This subtype is endemic to North Carolina. Three or four examples are known, in Craven, Jones, and Hyde counties.

Associations and Patterns: The Sweetgum Subtype is a large patch community, occupying significant portions of lake shores. It generally grades to Pond Pine Woodland or some other peatland community, but in at least one example it grades to Cypress–Gum Swamp along a swamp fed by lake drainage. Natural Lake Shoreline Marsh is often present on other parts of the shore.

Variation: Each of the handful of examples is somewhat different in composition.

Dynamics: Dynamics of the Sweetgum Subtype are similar to those described for the theme as a whole, including the potential importance of weather cycles. The Sweetgum Subtype tends to occur contiguous to peatland communities and this, along with its frequently dense shrub layer, probably makes it more subject to fire than other subtypes. Part of an occurrence of this subtype at Catfish Lake was burned intensely in a wildfire in the 1990s and its future composition is not yet clear.

The occurrence of *Liquidambar* in this community is interesting, since the species generally is completely absent in the adjacent peatlands and may be disjunct some miles from the nearest population. In the analogous case of the Sweetgum Subtype of Nonriverine Swamp Forest, the presence of additional mineral material in otherwise organic soils is believed to be important for the occurrence of the species. In the case of Natural Lake Shoreline Swamp, it may depend on the combination of stable organic soils with increased mineral availability due to water flow. The organic soils show evidence of input of new organic matter by water flow, but it is not clear if they are otherwise lake deposits or are parts of the surrounding peat deposits that may pre-date the lake.

Comments: There is almost no published material on North Carolina's lake shoreline communities. The one exception is Brown (1911). There are, however, a number of unpublished reports that describe them. There are a few plot samples.

The placement of the equivalent NVC association in a floodplain forest group is misleading. Though dominated by the same tree species, ecological dynamics and most other associated species are different.

Rare species:
Vascular plants – *Eleocharis robbinsii, Peltandra sagittifolia, Rhynchospora alba,* and *Scirpus acutus*.

Vertebrate animals – *Anhinga anhinga* and *Haliaeetus leucocephalus*.

NATURAL LAKE SHORELINE SWAMP (RICH SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Rich Subtype covers the very rare examples with a diverse canopy and a flora suggesting rich soils.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin (et al. 1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities.

The Rich Subtype is distinguished from other subtypes by a diverse flora suggestive of rich soil conditions. *Liquidambar styraciflua* may be codominant in parts, but it occurs with *Liriodendron tulipifera, Carya cordiformis, Quercus laurifolia, Quercus michauxii, Platanus occidentalis, Celtis laevigata*, and other species. Lower strata also contain species suggestive of rich soils, such as *Asimina triloba*.

Crosswalks: *Taxodium distichum - Liquidambar styraciflua - Platanus occidentalis / Asimina triloba* Swamp Forest (CEGL004424).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: Natural Lake Shorelines occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of the water table tied to lake levels. The Rich Subtype is associated with mineral substrates and occurs on the north shores of lakes.

Soils: The Rich Subtype has loamy mineral soils, though they may be organic-rich. The two known examples are mapped as Fortescue (Cumulic Humaquept) and Cape Fear (Typic Umbraquult). The vegetation suggests high base saturation and high fertility.

Hydrology: The Rich Subtype, where known, appears to have a range of hydroperiod, from permanently saturated and potentially flooded for long periods in lower parts, to probably seasonally saturated in the higher parts. Water levels may vary over periods of a few years in response to weather cycles.

Vegetation: The Rich Subtype has a dense canopy dominated by *Liquidambar styraciflua* or *Liriodendron tulipifera* in higher parts, with *Taxodium distichum* dominant closer to the lake. The two examples are fairly different. In one, a diversity of other hardwoods is present, including *Ulmus rubra*, *Quercus laurifolia*, *Quercus michauxii, Platanus occidentalis, Carya cordiformis*, *Celtis laevigata*, *Acer negundo*, and *Juglans nigra*. In the other, *Liquidambar styraciflua* dominates and *Ulmus americana, Platanus occidentalis, Nyssa biflora*, and *Taxodium distichum* are present. In both, the understory is dominated by *Asimina triloba*. In one, there is also *Carpinus caroliniana, Morus rubra, Prunus serotina,* and *Magnolia virginiana*. Shrubs are sparse except nearer the lake shore, where *Cephalanthus occidentalis, Swida* (*Cornus*) *stricta, Salix caroliniana*, and *Itea virginica* may be present. Vines are abundant, including *Smilax rotundifolia, Smilax glauca, Toxicodendron radicans, Muscadinia rotundifolia, Vitis aestivalis, Parthenocissus quinquefolius, Hydrangea (Decumaria) barbara, Campsis radicans*, and even more at present, the exotic *Lonicera japonica*. The herb layer is now heavily dominated by the exotic species *Microstegium vimineum* and *Stellaria media*. A diversity of other herbs may be present, including *Arisaema triphyllum, Athyrium asplenioides, Boehmeria cylindrica, Carex* spp., *Commelina virginica, Dichanthelium commutatum, Glyceria septentrionalis, Juncus effusus, Saururus cernuus, Stachys floridana, Sphenopholis obtusata, Amauropelta* (*Parathelypteris*) *noveboracensis,* and *Viola affinis*.

Range and Abundance: Ranked G1? but should be unquestioned G1 . This community is endemic to North Carolina. Only two examples are known.

Associations and Patterns: The Rich Subtype is a large patch community, occupying substantial portions of the lake shore. Natural Lake Shoreline Marsh borders other parts of the lake. No natural vegetation remains bordering the examples on the landward side, but it likely was Nonriverine Wet Hardwood Forest.

Variation: The two known examples appear quite different, though this may be due to the lack (or loss) of the highest zone in the second example. Additionally, the example at Pettigrew State Park has two distinct zones that could be regarded as variants. The lower is dominated by *Taxodium distichum* but has sufficient flora of rich-site species to distinguish it from the typical Cypress–Gum Subtype. The higher zone is dominated by *Liquidambar* and *Liriodendron* and has a more diverse canopy. The Pungo Lake example appears more uniform and seems intermediate between these two, with *Liquidambar* dominant but *Nyssa* and *Taxodium* mixed with it rather than less water-tolerant species.

Dynamics: Natural Dynamics of the Rich Subtype probably fit those described for the theme as a whole, including the potential importance of weather cycles. Both examples are on lakes with artificial water control at the outlet. Additionally, both are bordered by heavily drained agricultural lands. The combination of fertile soils with edge effects from cleared inland areas as well as from the lake has made both examples susceptible to heavy invasion by exotic plants. Windthrow in recent hurricanes caused further canopy opening, which exacerbated the invasion. *Lonicera japonica* covers the ground in large portion and drapes the trees. Where there is sufficient open ground, *Microstegium vimineum* and *Stellaria media* dominate the herb layer.

Comments: The Rich Subtype has interesting similarities to a Brownwater Levee Forest community.

Rare species:
Vascular plants – *Oplismenus setarius*.

Vertebrate animals – *Corynorhinus rafinesquii macrotis* and *Dendroica virens waynei*.

Invertebrate animals – *Apameine* new genus 2 sp. 3.

NATURAL LAKE SHORELINE SWAMP (CYPRESS SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Cypress Subtype covers wetter examples dominated by *Taxodium ascendens,* occasionally *Taxodium distichum* or *Nyssa biflora*, usually with an open or very open canopy.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Swamps do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere.

The Cypress Subtype is distinguished from the Lake Waccamaw Subtype and Rich Subtype, which may also contain substantial *Taxodium* or *Nyssa* canopy, by having limited species richness, with few herbs present. It usually occurs in nearly permanent standing water. The Cypress Subtype may grade into Natural Lake Shoreline Marsh or into open water by thinning of the canopy away from the shore.

Crosswalks: *Taxodium distichum - Taxodium ascendens / Panicum hemitomon* Swamp Woodland (CEGL004466).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: Natural Lake Shorelines occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of the water table tied to lake levels. The Cypress Subtype occurs in deeper water, extending into areas that are permanently flooded. Shorelines may be eroding or accreting. Many lakes are bordered by peatlands, and some shorelines are on organic substrates.

Soils: Soils for the Cypress Subtype are generally not mapped; they are shown as water or as part of the adjacent map unit. Soils may be organic or mineral. Sandy soils on wave-worked deposits are also common, even adjacent to peatlands. Organic soils are often eroded edges of surrounding peat or muck deposits. On eroding shorelines, trees may occur on islands of peat, which are stabilized by their roots but where surrounding peat was removed by wave erosion.

Hydrology: The Cypress Subtype is permanently saturated and often is permanently flooded in at least part of its extent. Water levels may vary over periods of a few years in response to weather cycles.

Vegetation: The Cypress Subtype has a dense to open canopy of water-tolerant trees, primarily *Taxodium ascendens*, but occasionally *Nyssa biflora*, *Taxodium distichum, Acer rubrum*, or *Chamaecyparis thyoides*. Shrubs are often present on tree bases, especially *Cyrilla racemiflora*, *Eubotrys racemosus*, *Vaccinium fuscatum*, *Clethra alnifolia*, and *Lyonia lucida*, sometimes with vines such as *Smilax laurifolia*, *Smilax walteri*, or *Muscadinia rotundifolia*. Occasional shorelines may have other woody species, such as *Zenobia pulverulenta*, *Chamaedaphne calyculata*, or *Decodon verticillatus*. Some emergent herbs may be present in the water between the trees, especially *Hymenachne (Panicum) hemitoma*, *Juncus* spp., or *Xyris smalliana*. Other herbs may be present on the tree bases, cypress knees, or stumps, or in the shallowest water, including *Triadenum walteri*, *Boehmeria cylindrica*, *Rhexia nashii*, and potentially any of the species of the Natural Lake Shoreline Marsh (Typic Subtype). Howell (2015), in a floristic study of lake shores, found only a handful of species with moderate frequency: *Magnolia virginiana, Gordonia lasianthus, Gelsemium sempervirens*, *Smilax laurifolia*, *Anchistea (Woodwardia) virginica*, and *Tillandsia usneoides*.

Range and Abundance: Ranked G3? but probably G2. The NVC association is attributed only to North Carolina, where only seven intact examples are known.

Associations and Patterns: Natural Lake Shoreline Swamp (Cypress Subtype) may occur in the same lakes as the Sweetgum Subtype and may be bordered by Natural Lake Shoreline Marsh (Typic Subtype).

Variation: Each lake is slightly different, but no variants are named.

Dynamics: The Cypress Subtype is wetter than most other subtypes. Since it often contains standing water and is adjacent to the open lake, waves are potentially important. Energy levels of shorelines vary, with some regularly washed by waves, others quiet. Some shorelines are undergoing erosion, causing the lake to expand and leaving a pattern of relict trees in the water, often with a scalloped edge of "headlands" and "bays" behind. In these cases, the trees may be relict, unable to reproduce in the current configuration.

Though not well documented, these communities probably undergo shifts in response to climatic cycles that affect lake levels. Persistent drought can allow a number of more upland species to establish, while high water periods may eliminate them. Even the dominant trees may not be able to reproduce other than in rare periods of low water. Some natural lakes have had their water levels stabilized by dams or weirs at their outlets, and the consequences of this for their shoreline communities are not well known.

Rare species:
Vascular plants – *Epidendrum conopseum* and *Eriocaulon aquaticum*.

Vertebrate animals – *Alligator mississippiensis, Anhinga anhinga,* and *Haliaeetus leucocephalus*.

NATURAL LAKE SHORELINE SWAMP (LAKE WACCAMAW SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Lake Waccamaw Subtype is analogous to the Cypress Subtype but covers the unique calcareous example at Lake Waccamaw.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere. The Lake Waccamaw Subtype is distinguished by the presence of numerous plant species not found in other subtypes, including *Sclerolepis uniflora*, *Cladium mariscoides*, and *Boltonia asteroides*. The presence of the endemic animals of Lake Waccamaw at seasonal high water levels also makes it distinctive.

Crosswalks: *Taxodium distichum - Taxodium ascendens / Panicum hemitomon - Sclerolepis uniflora* Swamp Woodland (CEGL004465).
G036 Pond-cypress Basin Swamp Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: The Lake Waccamaw Subtype occurs along the eastern and southern shore of Lake Waccamaw. It is generally flooded much of the time by lake waters but is exposed at low water levels. The lake water is somewhat calcareous.

Soils: Soils are sand, apparently clean, and presumably worked by wave action. The soil is not distinguished in soil mapping.

Hydrology: The Lake Waccamaw Subtype is permanently to seasonally flooded in normal years. Drawdown appears to be infrequent, at least in the lower portions of the community. However, water levels may vary over periods of a few years, in response to weather cycles. A dam partially controls the water levels of Lake Waccamaw, presumably stabilizing them in the middle range of normal fluctuations and preventing the lowest drawdowns. Water levels drop below it in drought and overflow it in wet periods. The vegetation zones do not show evidence that the typical water level has been changed.

Vegetation: The canopy of the Lake Waccamaw Subtype is an open woodland of *Taxodium ascendens*. In the outer parts, the canopy is sparse, and the community approaches the structure of a Natural Lake Shoreline Marsh. There are a few shrubs, primarily *Alnus serrulata*, *Cephalanthus occidentalis*, *and Cyrilla racemiflora*. The herb layer is patchy, with dense beds of graminoids, areas of sparse emergent or submersed plants, and a number of drawdown species that are visible only when water levels are low and the soil is exposed. The denser areas are dominated by *Hymenachne hemitoma* and *Cladium mariscoides*. Two CVS plots have been sampled in this community, but the most comprehensive information is a site survey report by Richard LeBlond from 1994, a year with low water. Dominants in smaller patches include *Eleocharis olivacea*, *Sclerolepis uniflora*, and *Centella erecta; Boltonia asteroides* and *Ludwigia sphaerocarpa* are also abundant. A great diversity of other herbaceous species is present, at least at times and at least locally, including *Andropogon tenuispatheus*, *Andropogon virginicus* var. *virginicus*, *Brasenia schreberi*, *Dichanthelium erectifolium*, *Eleocharis microcarpa*, *Erianthus giganteus*, *Erigeron vernus*, *Eupatorium mohrii*, *Eupatorium semiserratum*, *Euthamia tenuifolia*, *Fuirena pumila*, *Hydrocotyle umbellata*, *Juncus pelocarpus* (*abortivus*), *Juncus effusus*, *Lachnanthes caroliniana*, *Ludwigia brevipes*, *Lycopodiella appressa*, *Luziola fluitans*, *Lycopus angustifolius*, *Mitreola petiolata*, *Pluchea rosea*, *Pontederia cordata*, *Rhexia cubensis*, *Rhynchospora* spp., *Sacciolepis striata*, *Sagittaria graminea* var. *graminea*, *Sagittaria filiformis, Spiranthes laciniata*, *Utricularia* spp., *Xyris fimbriata*, and *Xyris smalliana*.

Range and Abundance: Ranked G1. This subtype is endemic to a single site, a portion of the shoreline of Lake Waccamaw, the only calcareous lake in this climatic zone.

Associations and Patterns: The Natural Lake Shoreline Swamp occurs along the eastern and southern shores of Lake Waccamaw, with the Natural Lake Shoreline Marsh on the more wave-influenced north shore, but swamp may also have been present on parts of the north shore before development. The adjacent uplands include sandhill and pocosin communities.

Variation: The single known example is somewhat heterogeneous.

Dynamics: The general dynamics of the Lake Waccamaw Subtype probably are similar to the Cypress Subtype but are not well known for either. Lake Waccamaw, similar to other lakes, is subject to moderate to severe disturbance by wind, storm waves, and possibly fire, but is generally stable. The shoreline where this community occurs appears to be in equilibrium, neither eroding nor accreting at a noticeable pace. Weather cycles or variation may be particularly important. Though Lake Waccamaw is regulated by a dam at its outlet, droughts can cause water levels to become very low, creating a drawdown zone similar to those in Small Depression Drawdown Meadows. A number of the plant species, including some of the rare ones, are shared with that community type of smaller basins. It is not clear that the waters of Lake Waccamaw draw down more than those of other lakes, but the shallowness and extremely gentle slope of its bed may make for a larger drawdown zone.

Lake Waccamaw is unique among North Carolina’s lakes in having calcareous waters. Probably no other lake with similar water chemistry occurs north of Florida and south of the glaciated areas of the North. The water pH is 6.78-7.1 (Stager and Calhoun 1987), despite a substantial input of tannic water from a blackwater creek. Given the variability in tannin levels observed in the 2010s, it is likely that the pH varies significantly from year to year. A small bluff of limestone is present on the north shore of the lake, but the calcium content of the water is believed to come primarily from groundwater input (Stan Riggs, personal communication). Stager and Cahoon (1987), studying sediment cores, concluded that the lake was younger than most Carolina bay lakes, perhaps as young as 15,000 years old and no more than 32,000 years, and had past periods when it was shallower than its current shallow depth. Diatom content indicated that the lake had always been calcareous and incipiently eutrophic.

Comments: Lake Waccamaw is noted for its unique aquatic fauna, which includes several species endemic to this single lake, and several others nearly endemic (also occurring in the Waccamaw River and Big Creek or shared with Lake Phelps). This seems particularly remarkable given the apparent young age of the lake. Many, perhaps most, of the endemic animals probably use the vegetated shoreline community when the water is high. While no endemic plant species have been found, the distinctive flora of the Lake Waccamaw Subtype, compared to all other natural lakes, is remarkable. Howell (2015), in his floristic study of Carolina bay lakes (swamp and marsh communities together) found over 80 species not found in any other lake. Most other lakes in the study had no species unique to them and contained only a small fraction of the number of species found at Lake Waccamaw.

Though Lake Waccamaw is generally called a Carolina bay, the argument for this is not compelling. It is roughly oriented northwest-southeast, with a sandy rim on the southeast side, but the shape and orientation different from well-formed bays nearby. Unlike typical Carolina bays, it has a substantial watershed as well as a sizeable outflow, and it has a bluff of marine sediments and limestone along its north shore.

Rare species:
Vascular plants – *Bacopa caroliniana, Boltonia asteroides* var. *glastifolia*, *Epidendrum conopseum, Eriocaulon aquaticum*, *Ludwigia brevipes, Ludwigia sphaerocarpa*, *Luziola fluitans, Lycopus angustifolius, Sagittaria filiformis*, *Sagittaria isoetiformis, Sclerolepis uniflora, Spiranthes laciniata, Utricularia cornuta,* and *Utricularia resupinata*.

Vertebrate animals – *Enneacanthus obesus, Etheostoma perlongum, Fundulus waccamensis, Menidia extensa*, and *Noturus* sp. 2.

Invertebrate animals – *Amnicola* sp. 1, *Catinella waccamawensis*, *Choroterpes basalis, Cincinnatia sp. 1, Elliptio folliculata, Elliptio waccamawensis, Leptodea ochracea*, *Lampsilis cariosa, Lampsilis fullerkati, Lampsilis radiata, Lampsilis splendida, Procambarus braswelli*, and *Toxoplasma pullus*.

NATURAL LAKE SHORELINE MARSH (TYPIC SUBTYPE)

Concept: Natural Lake Shoreline Marshes are herb-dominated wetlands influenced by lake hydrology. The Typic Subtype covers all examples other than the Lake Waccamaw Pond-Lily Subtype, dominated by emergent herbaceous vegetation rather that floating-leaf plants.

Distinguishing Features: Natural Lake Shoreline Marshes are distinguished from other herb-dominated wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Marsh is distinguished from Natural Lake Shoreline Swamp by lacking trees or having only sparse trees. However, *Hymenachne hemitoma* beds and other herbaceous vegetation are often present in openings between the cypress trees in the Cypress Subtype of Natural Lake Shoreline Swamp.

The Typic Subtype is distinguished from the Lake Waccamaw Pond-Lily Subtype by lacking the abundant *Nuphar sagittifolia* found in that subtype.

Crosswalks: *Panicum hemitomon - Juncus* spp. Coastal Plain Lakeshore Marsh (CEGL004307).
G188 South Atlantic & Gulf Coast Marsh & Wet Meadow Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: Natural Lake Shoreline Marshes occur in shallow water or drawdown zones on the edges of natural lakes larger than 20 acres.

Soils: Substrates are generally wave-worked sands but may be muck accumulations. This community is generally mapped as water in soil mapping.

Hydrology: Natural Lake Shoreline Marshes are permanently to seasonally flooded by the adjacent lake. They generally are subject to substantial wave action, at least when the water is high.

Vegetation: Natural Lake Shoreline Marshes are dominated by emergent herbs. *Hymenachne (Panicum) hemitoma* often dominates patches. In most examples, a small set of water-tolerant species may be present, including *Eleocharis baldwinii*, *Eleocharis equisetoides*, *Eleocharis vivipara*, *Juncus pelocarpus*, *Kellochloa (Panicum) verrucosa*, *Rhexia nashii*, *Rhynchospora distans, Erianthus giganteus, Sacciolepis striata*, *Scirpus cyperinus*, and *Xyris smalliana*. A different and richer set of species is present at Lake Phelps. There, patches are dominated by *Juncus militaris* as well as *Hymenachne*, and a few are dominated by *Eupatorium* sp. In addition to many of the species above, other species include *Andropogon cretaceus, Eupatorium perfoliatum, Utricularia subulata, Hydrocotyle umbellata, Eriocaulon aquaticum, Ludwigia alternifolia, Pontederia cordata, Nymphaea odorata, Sagittaria isoetiformis, Eleocharis microcarpa, Eleocharis robbinsii, Osmunda spectabilis, Luziola fluitans, Conium maculatum, Euthamia caroliniana, Triadenum tubulosum, Persicaria arifolia, Persicaria sagittifolia, Ptilimnium capillaceum, Rhexia petiolata, Typha angustifolia, Typha latifolia, Dulichium arundinaceum*, and several other species. Several shrubs are also present in this example, including *Cyrilla racemiflora, Swida amomum*, and *Clethra alnifolia*. In many examples, sparse trees, primarily *Taxodium ascendens*, are present.

Range and Abundance: Ranked G1, but this may be an underestimate of abundance. There appear to be nine intact examples in North Carolina, making this the most abundant of Natural Lake Communities. The association is considered endemic to North Carolina, though it could possibly occur along the one natural Coastal Plain lake in Virginia.

Associations and Patterns: The Typic Subtype is a large patch community, occupying significant portions of lake shores. It may be associated with Natural Lake Shoreline Swamp of the Sweetgum, Cypress, or Rich Subtype. Otherwise, it is most often bordered by peatland communities.

Variation: The occurrence at Lake Phelps appears to be very distinctive, perhaps enough to be a distinct subtype. However, further study of Lake Phelps and nearby lakes is needed. For now, it is recognized as a variant.

1. Lake Phelps Variant contains *Juncus militaris* and the other distinctive flora described above. It is unclear if it is endemic to Lake Phelps or may occur at Pungo Lake or New Lake. It may once have occurred at Lake Mattamuskeet. It is possible some of its distinctive character comes from artificial change in the lake level. However, the presence of numerous rare species, including at least one disjunct for a considerable distance, suggests a distinct character. The importance of the lake to large numbers of wintering waterfowl may have led to greater dispersal of plants than in more southern lakes of the Typic Variant.

2. Typic Variant covers other examples, generally much less floristically rich, as described above.

Dynamics: Natural dynamics of the Typic Subtype are probably similar to other Natural Lake Communities, as described for the theme. Natural Lake Shoreline Marshes are wetter than Natural Lake Shoreline Swamps and may be exposed only in the later summer or only in dry years. Because they are usually flooded and border the lake, they are subject to substantial wave action. During storms, this may lead to reworking of the substrate and significant natural disturbance. Though all the lakes where it occurs are acidic and oligotrophic, the water movement may provide more nutrients than nearby communities.

Rare species:
Vascular plants – *Bacopa caroliniana, Eleocharis cellulosa, Eleocharis robbinsii, Eriocaulon aquaticum, Juncus militaris, Ludwigia brevipes, Ludwigia sphaerocarpa, Luziola fluitans, Lycopus angustifolius, Myriophyllum tenellum, Peltandra sagittifolia, Rhynchospora alba, Sclerolepis uniflora, Spiranthes laciniata, Utricularia cornuta, Utricularia floridana,* and *Utricularia resupinata*.

Vertebrate animals – *Alligator mississippiensis, Anhinga anhinga, Fundulus waccamawensis, Haliaeetus leucocephalus,* and *Ixobrychus exilis*.

NATURAL LAKE SHORELINE MARSH (LAKE WACCAMAW POND-LILY SUBTYPE)

Concept: Natural Lake Shoreline Marshes are herb-dominated wetlands influenced by lake hydrology. The Lake Waccamaw Pond-Lily Subtype covers the unique community in Lake Waccamaw, dominated by *Nuphar sagittifolia*.

Distinguishing Features: Natural Lake Shoreline Marshes are distinguished from other herb-dominated wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and by wave action. The Lake Waccamaw Pond-Lily Subtype is distinguished by the dominance of *Nuphar sagittifolia*.

Crosswalks: *Nuphar sagittifolia* - *Eriocaulon aquaticum* Lakeshore Aquatic Vegetation (CEGL004297).
G114 Eastern North American Freshwater Aquatic Vegetation Group.
Southeastern Coastal Plain Natural Lakeshore Ecological System (CES203.044).

Sites: The Lake Waccamaw Pond-Lily Subtype occurs only on the northern shore of Lake Waccamaw.

Soils: Substrates are generally wave-worked sands.

Hydrology: Natural Lake Shoreline Marshes are permanently to seasonally flooded by the adjacent lake. They generally are subject to substantial wave action, at least when the water is high. The water in Lake Waccamaw is calcareous.

Vegetation: The vegetation of this community is not well known. The community is generally dominated by a sparse to dense floating cover of *Nuphar sagittifolia*. *Eriocaulon aquaticum* may range from sparse to codominant, and *Sagittaria graminea* is often present. A single CVS plot in this community has no other species in the community other than sparse *Taxodium distichum* and epiphytic *Tillandsia usneoides*, but epiphytic *Epidendrum conopseum* has also been reported. *Colocasia esculenta* has become established in this community and is widespread. Some of the submersed aquatic species of the deeper lake waters, such as *Najas*, also occur.

Range and Abundance: Ranked G1. This subtype is endemic to a single site, a portion of the shoreline of Lake Waccamaw, the only calcareous lake in this climatic zone.

Associations and Patterns: The Lake Waccamaw Pond Lily Subtype is a large patch community, occupying a significant portion of the lake shore. Its natural associations are not known because its habitat is generally heavily altered by housing development along the lake shore. It may have been bordered by Natural Lake Shoreline Swamp or by Nonriverine Swamp Forest.

Variation: Only a single example is known.

Dynamics: The general dynamics of this community are similar to those of other Natural Lake Communities, but details are not well known. The north shore of Lake Waccamaw, where it occurs, is subject to vigorous waves driven by sea breeze on most afternoons in the summer. Floating leaves may be better equipped than emergent stems to withstand this regular pounding.

Lake Waccamaw is unique among North Carolina's lakes in having calcareous waters. Probably no other lake with similar water chemistry occurs north of Florida and south of the glaciated areas of the North. The water pH is 6.78-7.1 (Stager and Calhoun 1987), despite a substantial input of tannic water from a blackwater creek. Given the variability in tannin levels observed in the 2010s, it may be that the pH varies significantly from year to year. A small bluff of limestone is present on the north shore of the lake, but the calcium content of the water is believed to come primarily from ground water input (Stan Riggs, personal communication).

Comments: This community is not well explored. It occurs amid private docks and bordered by houses throughout its entire range. It appears to be genuinely low in species richness, in contrast to the diverse flora of the Lake Waccamaw Subtype of Natural Lake Shoreline Marsh. This may have to do with the deeper water and more intense wave disturbance, but the community may be more diverse than is known.

Even more than in the Natural Lake Shoreline Swamp community of Lake Waccamaw, the unique fauna of Lake Waccamaw likely occurs most of the time in this community. Many, perhaps most, of the endemic animals probably occur in the vegetated shoreline community when the water is high.

Rare species:
Vascular plants – *Bacopa caroliniana, Epidendrum conopseum, Eriocaulon aquaticum, Ludwigia brevipes, Ludwigia sphaerocarpa, Luziola fluitans, Lycopus angustifolius, Panicum tenerum, Rhexia cubensis, Sagittaria filiformis*, *Sagittaria isoetiformis, Spiranthes laciniata, Utricularia cornuta,* and *Utricularia resupinata*.

Vertebrate animals – *Etheostoma perlongum, Fundulus waccamensis,* and *Menidia extensa*.

Invertebrate animals – *Elliptio waccamawensis, Lampsilis fullerkati,* and *Toxolasma pullus*.

MARITIME WETLANDS THEME

Concept: Maritime Wetlands encompass both woody and nonwoody communities on barrier islands and occasionally on shorelines of inland sounds, in places not flooded by tides but significantly influenced by wetness. They range from swamp forests to wet grasslands, isolated marshes, and ponds.

Distinguishing Features: Most Maritime Wetlands are distinguished by the combination of occurrence on barrier islands, wetland hydrology without tidal influence, and wetland vegetation. Some marginally wet areas, whose vegetation is dominated by facultative species and is not distinguishable from slightly drier vegetation, are included in Maritime Upland Forests or Maritime Grassland themes. Estuarine Fringe Pine Forests, included in the Maritime Wetlands theme, occur along inland sound shorelines in settings that lack tidal influence but are affected by occasional saltwater intrusion.

Sites: Maritime Wetlands occur in dune swales and other depressions on barrier islands, occasionally on sand flats elevated above tide levels. The Estuarine Fringe Pine Forest and Estuarine Beach communities within this theme occur along mainland sound shorelines on sites elevated above tide levels but influenced by the presence of salty estuarine waters and occasional storm surges.

Soils: Soils may be wet sandy Entisols, mucky sands, or true Histosols. Like other barrier island communities, most Maritime Wetlands are subject to at least some salt spray, which adds nutrients. This, in combination with shell material in the young sand deposits, presumably makes the soils higher in pH and more fertile than comparable sandy soils inland.

Hydrology: Maritime Wetlands can potentially span the range of nontidal palustrine hydrology, from seasonally saturated to permanently flooded. Water comes from rainfall rather than the ocean or estuaries, but wetness is driven by high water tables in the highly permeable sands; in many places it is associated with a lens of fresh groundwater that is perched atop saltier deeper groundwater. Water levels in many examples may vary substantially from year to year with varying rainfall. As in other barrier island communities, salt spray represents a stress to canopy species, though the location of wetlands in the interior of islands and in lower areas shelters them more than most other maritime communities. Some Maritime Wetlands are subject to intrusion by salt water in severe storms, while others are well sheltered by high dunes.

Vegetation: The vegetation within this theme encompasses a tremendous range of variation. Woody communities include forests dominated by wetland or facultative trees including *Nyssa biflora, Fraxinus* sp., *Taxodium distichum, Acer rubrum* var. *trilobum*, *Liquidambar styraciflua*, *Pinus taeda*, or *Pinus serotina.* Other communities may be dominated by tall shrubs: *Salix caroliniana, Swida foemina (Cornus stricta)*, or *Persea palustris*. Wet grasslands are usually dominated by *Spartina patens,* or *Juncus* spp., often associated with a high diversity of herbaceous species. The wettest communities are marshes of a variety of grasses or sedges, drawdown zones of ponds, or submersed aquatic vegetation. Estuarine Beach communities may be herbaceous or woody, with a wide variety of species shared with other Maritime Wetlands but also a number of opportunistic or weedy species.

Dynamics: The barrier islands and sound shorelines where these communities occur are extremely dynamic, more so than most other parts of North Carolina. They are subject to extreme natural disturbance by wind, heavy salt spray, saltwater intrusion during storms, and storm waves. Recovery may take several years. In addition to natural disturbance of vegetation, the environment itself may be drastically altered by natural processes of erosion and deposition, as well as by sea level rise. Even well above sea level, new wetlands can potentially develop as growing dunes or accreting land raise the freshwater lens beneath the barrier island.

Vegetation dynamics in the wetter communities can be strongly influenced by water levels, which vary with weather cycles. Drawdown zones may be exposed in some years but not others. Even places that appear permanently flooded may be exposed occasionally. Some plant species may be visible only in some years.

In wetlands that are not well surrounded by higher land, intrusion of salt water during major storms can be a catastrophic natural disturbance. The community may recover over time, but if protection from intrusion is reduced by erosion or sea level rise, it will eventually be permanently converted to a community of the Tidal Freshwater Wetlands or Estuarine Communities theme.

Comments: The Maritime Wetlands theme is circumscribed differently from Maritime Forests and Maritime Grasslands, encompassing both forest and non-forest communities as well as including some mainland communities. This is done primarily for convenience. Three themes could be warranted, but all would be very small.

The Estuarine Fringe Pine Forest and Estuarine Beach communities are particularly marginal for inclusion in this theme, but their inclusion is analogous to the inclusion of Coastal Fringe Evergreen Forest in the Maritime Upland Forests theme. Though lacking the extreme exposure to storms, unstable substrate, and salt spray of barrier islands; however, their lack of tidal influence but influence of occasional saltwater intrusion is a common feature with Maritime Wetlands, while separating them from Estuarine Communities, Freshwater Tidal Wetlands, and Coastal Plain Nonalluvial Wetlands.

KEY TO MARITIME WETLANDS

1. Community with permanent or semipermanent standing water, generally 1-2 feet deep or more, drawing down only during prolonged drought; vegetation consisting of floating or submersed aquatic plants, or vascular vegetation sparse, except on the edges....................... **Interdune Pond**

1. Community saturated, seasonally flooded, or, if semipermanently flooded, only shallowly; vegetation consisting of rooted vascular plants, usually dense.

  2. Community on the mainland, on the edges of estuaries and influenced by them; though not subject to tidal flooding, affected by infrequent saltwater intrusion during storms (consider Freshwater Tidal Communities and Estuarine Communities where regular or irregular tidal flooding may be a more important influence).

    3. Community dominated by *Pinus* in a dense or open canopy; shrub layer dominated or codominated by *Morella cerifera*; located on the inland edge of a tidal marsh or occasionally on an estuary shoreline that is not exposed to wave action and is above tidal flooding.

      4. Community dominated by *Pinus taeda;* substrate mucky mineral soil ....**Estuarine Fringe Pine Forest (Loblolly Pine Subtype)**

      4. Community dominated by *Pinus serotina*; substrate shallow to deep organic soil ....**Estuarine Fringe Pine Forest (Pond Pine Subtype)**

    3. Community not dominated by *Pinus*, though individuals may be present; located on shorelines of estuaries where wave disturbance is significant; vegetation a mix of wetland, estuarine, and disturbance-dependent species.. **Estuarine Beach**

  2. Community on a barrier island, similar coastal spit, or occasionally on exposed islands in estuaries; occurring in wet dune swales or on back-barrier flats that are low but above normal tidal flooding.

    5. Vegetation dominated by trees or shrubs, generally *Nyssa, Acer, Taxodium, Fraxinus, Swida* (*Cornus*)*, Persea*, or *Salix*.

      6. Vegetation a forest dominated by *Nyssa, Acer, Fraxinus, Taxodium*, or *Quercus;* trees at least more than 10 meters tall when not recently disturbed.

        7. Very rare forest dominated by *Taxodium distichum*.. .... **Maritime Swamp Forest (Cypress Subtype)**

        7. Forest not dominated by *Taxodium*; dominated by *Acer, Nyssa*, *Fraxinus*, or potentially other species... **Maritime Swamp Forest (Typic Subtype)**

      6. Vegetation of tall shrubs or short, shrub-like trees, dominated by *Persea, Swida*, or *Salix*; canopy no more than 10 meters tall.

        8. Community dominated by *Salix*............. **Maritime Shrub Swamp (Willow Subtype)**

        8. Community dominated by *Persea* or *Swida (Cornus)*

          9. Community dominated by *Persea palustris* with little or no *Swida*............................ ....**Maritime Shrub Swamp (Red Bay Subtype)**

          9. Community dominated by *Swida foemina (Cornus stricta),* sometimes with abundant *Persea palustris*. .... **Maritime Shrub Swamp (Dogwood Subtype)**

    5. Vegetation herbaceous, with woody plants sparse or confined to the edges.

      10. Community in a depression with standing water well into the growing season; vegetation marsh-like, dominated by large graminoids such as *Cladium, Typha, Zizania,* or *Schoenoplectus*, or by less often by small flood-tolerant graminoid such as *Leersia, Leptochloa*, or *Carex* .... **Interdune Marsh**

10. Community in a dune swale depression or back-barrier flat, with standing water shallow and primarily in winter; vegetation dominated by *Spartina patens, Juncus*, *Rhynchospora*, *Panicum*, or a diverse mix of graminoids and forbs less tolerant of prolonged standing water.

11. Community dominated or codominated by *Panicum virgatum*; occurring on Currituck Banks. .... **Maritime Wet Grassland (Switchgrass Subtype)**

11. Community not dominated by *Panicum virgatum*; dominated by *Spartina patens, Muhlenbergia filipes, Juncus, Rhynchospora, Eleocharis, Centella*, or a diverse mix of species; throughout the barrier islands…………………………………………………..
…………………………**Maritime Wet Grassland (Southern Hairgrass Subtype)**

MARITIME WET GRASSLAND (SOUTHERN HAIRGRASS SUBTYPE)

Concept: Maritime Wet Grasslands are herbaceous wetlands of interdune swales and low sand flats on barrier islands, generally in the island interior or inland side. They have seasonally to permanently saturated soils or shallow flooding but no regular saltwater flooding (though overwash may occur during severe storms). Vegetation is dominated by any of several grasses, sedges, or rushes, but not by species of the Dune Grass community. The Southern Hairgrass Subtype is the common Maritime Wet Grassland throughout the state, where *Spartina patens* or *Muhlenbergia filipes* typically dominate and *Panicum virgatum* is at most a minor component.

Distinguishing Features: Maritime Wet Grasslands are distinguished by herbaceous wetland vegetation on barrier islands in settings that are not deeply flooded for long periods and that do not receive tidal flooding or regular influence of brackish or salt water. They are distinguished from most Estuarine Communities by the presence of salt-intolerant species such as *Muhlenbergia filipes, Rhynchospora colorata, Panicum virgatum*, *Andropogon tenuispatheus, Andropogon glomeratus*, *Centella erecta*, and *Eustachys petraea* throughout the community. Brackish Marsh (Transitional Subtype) and the upland ecotone of other tidal marshes may contain some of the same species, but they contain them only locally, in a community consisting primarily of more salt-tolerant species. The same set of species distinguishes Maritime Wet Grasslands from Interdune Marshes, as does dominance by *Spartina patens*. Interdune Marshes are dominated by larger herbs such as *Cladium jamaicense* or *Zizania aquatica*, or by short-lived plants that are active only when water is low.

The Southern Hairgrass Subtype encompasses most examples in North Carolina, with the exception of northern examples that have *Panicum virgatum* as a major component.

Crosswalks: *Muhlenbergia filipes* - *Spartina patens* – *Rhynchospora colorata* Marsh (CEGL004051).
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).
Northern Atlantic Coastal Plain Dune and Swale Ecological System (CES203.264)?

Sites: Maritime Wet Grasslands occur on barrier islands, occupying dune swales and sometimes sand flats that are intermediate in elevation between those that support marshes and sites of Maritime Dry Grasslands. They are somewhat sheltered from salt spray and are above the highest normal tidal flooding, though some may be inundated by overwash or storm surge.

Soils: Maritime Wet Grasslands have wet sandy soils, generally mapped as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent) when large enough to be distinguished. As in many maritime communities, the soils are presumed to be more fertile than typical sands because of the presence of shell fragments and the input of nutrients by salt spray.

Hydrology: Maritime Wet Grasslands are seasonally to permanently saturated by a high water table or by seepage from adjacent dunes. They may have shallow standing water in wet seasons. Any flooding by salt or brackish water is only in extreme events.

Vegetation: Maritime Wet Grasslands of the Southern Hairgrass Subtype have dense vegetation dominated by grasses or, occasionally, rushes. While most maritime communities have only a small number of species, they often are more species-rich and share plants with other Coastal Plain wetlands. *Spartina patens* is highly constant and usually dominant, but *Muhlenbergia sericea* codominates in about half the sites. *Hydrocotyle bonariensis* is highly constant in CVS plot data. Other species frequent and sometimes codominant or abundant in plot data include *Fimbristylis castanea, Rhynchospora colorata,* and *Solidago mexicana* (*sempervirens*). *Rhynchospora colorata* is often the most visible and tell-tale plant in the summer, even when it is not dominant. Additional frequent species in plot data include *Juncus megacephalus, Juncus marginatus, Eustachys petraea, Andropogon glomeratus, Andropogon tenuispatheus, Eragrostis spectabilis, Sabatia stellaris, Phyla nodiflora* var. n*odiflora*, and species shared with Dune Grass and Maritime Dry Grassland, including *Oenothera humifusa, Erigeron pusillus* (*Conyza canadensis*), *Opuntia mesacantha*, and *Uniola paniculata*. Less frequent species sometimes noted as abundant in plot data or site descriptions include *Centella erecta, Juncus dichotomus, Juncus scirpoides, Setaria magna*, *Schoenoplectus* (*Scirpus*) *pungens*, and *Eleocharis* spp., including *rostellata, fallax*, and *cellulosa*. Less frequent species that show the character of the community include *Ludwigia microcarpa, Setaria parviflora, Euthamia weakleyi* (*hirtipes*)*, Hydrocotyle umbellata, Eupatorium leucolepis, Spiranthes vernalis, Rhynchospora odorata, Sisyrinchium angustifolium, Pluchea rosea, Galium tinctorium, Mikania scandens, Oenothera fruticosa, Rhexia virginica, Dichanthelium sphaerocarpon, Dichanthelium neuranthum, Dichanthelium caerulescens, Ionactis linariifolia, Erianthus* sp., and *Erigeron quercifolius*. The exotic *Eremochloa ophiuroides* sometimes occurs in them. Woody plants are often present in small numbers, more abundant in examples that are transitional or undergoing succession. *Baccharis halimifolia, Borrichia frutescens, Morella cerifera*, and *Juniperus silicicola* are the most frequent.

Range and Abundance: Ranked G2. In North Carolina, Maritime Wet Grasslands are scattered throughout the undeveloped barrier islands but are rare, with fewer than 20 occurrences known. The equivalent association ranges southward to Florida but probably is rarer in the more forested sea islands of South Carolina and Georgia.

Associations and Patterns: Maritime Wet Grasslands are small to large patch communities. Most occurrences are a few acres or less, though a few complexes can add up to larger acreage. They tend to be surrounded by Dune Grass or Maritime Dry Grassland, but they may also border tidal communities or any other maritime community. They are not a regular part of the barrier island landscape mosaic and are largely absent on many islands.

Variation: The Southern Hairgrass Subtype is one of the most variable communities in the 4^{th} Approximation. Additional subdivision is likely with further study, but no variants are recognized at present. Little is known of seasonal or year-to-year variation, which may affect perceptions of composition. Abundance of *Juncus*, presence or absence of *Rhynchospora colorata*, and connection to marshes are other characters that might be a basis for distinguishing variants or subtypes, but the ecological meaning of the species is not clear.

Dynamics: As with all maritime communities, Maritime Wet Grasslands are highly dynamic. They may undergo severe natural disturbance by saltwater intrusion or may quickly turn into other communities because of erosion, sand movement, or direct or indirect natural changes in sheltering from salt spray and overwash. However, many occur in stable dune fields where such disturbances have not occurred in decades, if not centuries.

Normal dynamics include seasonal and year-to-year changes in wetness because of water table movement, though variation is less than in Interdune Marshes or Interdune Ponds. In comparable wetlands in Europe (dune slacks), high species richness is supported by sorting among plant species by fine-scale hydrological niches (Dwyer 2021). Though this has not been studied in our Maritime Wet Grasslands, a similar process appears to occur. Local plants can be seen to vary substantially in response to small variations in elevation.

Comments: Maritime Dry Grasslands are often not distinguished from Maritime Wet Grasslands in site descriptions, and the relative abundance of these two types is not always well known. The nature of the transition between them needs further investigation. Many CVS plots resemble Maritime Dry Grassland but contain small amounts of a few wetland species. It is unclear if these are intermediate communities or are areas with small or peripheral inclusions of other communities.

While there has been less scientific interest in Maritime Wet Grasslands than Dune Grass, they were well described by Au (1974) and Godfrey and Godfrey (1976), focusing on the middle Outer Banks, and were included in Rosenfeld (2004) at Bird Island. A moderate number of CVS plots and plots collected by NatureServe for the National Park Service represent them.

Rare species:
Vascular plants – *Dichanthelium caerulescens, Dichanthelium neuranthum, Eleocharis cellulosa, Eleocharis montevidensis, Eleocharis rostellata, Elymus halophilus, Eupatorium maritimum, Euphorbia bombensis, Juncus articulatus, Juncus georgianus, Ludwigia alata, Oenothera unguiculata, Oplismenus hirtellus, Paspalum vaginatum, Rhynchospora microcarpa, Rhynchospora odorata, Scleria verticillata, Spiranthes laciniata, Trichostema nesophilum,* and *Yucca gloriosa*.

Vertebrate animals – *Hydroprogne caspia*.

MARITIME WET GRASSLAND (SWITCHGRASS SUBTYPE)

Concept: Maritime Wet Grasslands are herbaceous wetlands of interdune swales and low sand flats on barrier islands, generally in the island interior or inland side. They have seasonally to permanently saturated soils or shallow flooding but no regular saltwater flooding (though overwash may occur during severe storms). The Switchgrass Subtype is a northern community rare in North Carolina, where *Panicum virgatum* is dominant or codominant.

Distinguishing Features: Maritime Wet Grasslands are distinguished by herbaceous wetland vegetation on barrier islands in settings that are not deeply flooded for long periods and that do not receive tidal flooding or regular influence of brackish or salt water. They are distinguished from most Estuarine Communities by the presence of salt-intolerant species such as *Muhlenbergia filipes, Rhynchospora colorata, Panicum virgatum*, *Andropogon tenuispatheus, Andropogon glomeratus*, *Centella erecta*, and *Eustachys petraea* throughout the community. Brackish Marsh (Transitional Subtype) and the upland ecotone of other tidal marshes may contain some of the same species, but they contain them only locally, in a community consisting primarily of more salt-tolerant species. The same set of species distinguishes Maritime Wet Grasslands from Interdune Marshes, as does dominance by *Spartina patens*. Interdune Marshes are dominated by larger herbs such as *Cladium jamaicense* or *Zizania aquatica*, or by short-lived plants that are active only when water is low.

The Switchgrass Subtype is distinguished by the dominance or codominance of *Panicum virgatum* in sites on the Currituck Banks. *Spartina patens* may be codominant or may be only a minor component.

Crosswalks: *(Morella cerifera*) - *Panicum virgatum* - *Spartina patens* Wet Meadow (CEGL004129).
G752 North Atlantic Coastal Interdunal Wetland Group.
Northern Atlantic Coastal Plain Dune and Swale Ecological System (CES203.264).

Sites: Maritime Wet Grasslands occur on barrier islands, in dune swales and sometimes on sand flats that are intermediate in elevation between those that support marshes and Maritime Dry Grasslands. They are somewhat sheltered from salt spray and are above the highest normal tidal flooding, though some may occasionally be inundated by overwash or storm surge.

Soils: Maritime Wet Grasslands have wet sandy soils, generally mapped as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent) when large enough to be distinguished. As in many maritime communities, the soils are more fertile than typical sands because of the presence of shell fragments and the input of nutrients by salt spray.

Hydrology: Maritime Wet Grasslands are seasonally to permanently saturated by a high water table or by seepage from adjacent dunes. They may have shallow standing water in wet seasons. Any flooding by salt or brackish water is only in extreme events.

Vegetation: Where known in North Carolina, the Switchgrass Subtype is codominated by *Panicum virgatum* and *Spartina patens*, with *Centella erecta* abundant or also codominant. Other species present in the one documented example include *Chasmanthium laxum, Dichanthelium scoparium, Eupatorium mohrii, Juncus effusus, Senna marilandica, Viola primulifolia, Andropogon tenuispatheus, Eupatorium hyssopifolium, Euthamia caroliniana* (possibly *weakleyi*), *Dichanthelium villosissimum* var. *villosissimum, Galium tinctorium* var. *floridanum*, *Juncus biflorus, Juncus polycephalos, Osmunda spectabilis, Kellochloa (Panicum) verrucosa, Paspalum laeve, Persicaria punctata, Rhynchospora fascicularis, Solidago mexicana, Mikania scandens, Eupatorium capillifolium, Hydrocotyle bonariensis, Eupatorium rotundifolium*, *Rhexia virginica*, and *Anchistea virginica*. Woody species present with low cover include *Toxicodendron radicans, Muscadinia rotundifolia, Baccharis halimifolia*, and young *Pinus taeda*.

Range and Abundance: Ranked G2G4. This subtype is extremely rare in North Carolina. It is known only from the northern Currituck Banks area, where it cooccurs with communities classified as the Southern Hairgrass Subtype. The equivalent association ranges northward to New Jersey.

Associations and Patterns: The Switchgrass Subtype is a small patch community. The full extent of its North Carolina occurrence is not known but it is not a regular part of the landscape mosaic and patches are a handful of acres at most. It occurs with Dune Grass and Maritime Shrub communities.

Variation: Little is known of the variation of this community in North Carolina, other than that the known example is very heterogeneous and grades into what appears to be the Southern Hairgrass Subtype. It is unclear how well it resembles examples farther north.

Dynamics: Dynamics are probably similar to the Southern Hairgrass Subtype and to maritime communities in general.

Comments: The NVC association is a northern Mid-Atlantic community that barely ranges into North Carolina. It is unclear how well it resembles examples farther north. Despite the abundance of *Panicum virgatum*, it has flora very similar to the Southern Hairgrass Subtype. A single CVS plot is definitively recognizable as this subtype.

Rare species: No rare species are known to be specifically associated with the one example in North Carolina.

INTERDUNE MARSH

Concept: Interdune Marshes are rare barrier island dune swale communities that are dominated by emergent wetland vegetation. They may occur as extensive marshes, or as broad marsh edge zones around open water ponds. They are isolated from tidal marshes and tidal flooding but may be rarely flooded by salt or brackish water from storm surges. They are extremely variable in vegetation from site to site and in different years within a single site.

Distinguishing Features: Interdune Marshes are distinguished by the occurrence of marshy vegetation in barrier island depressions that are semipermanently flooded by freshwater and isolated from tidal flooding and from tidal marshes. They are distinguished from Maritime Wet Grasslands, which also have dense herbaceous vegetation in dune swales, by having longer hydroperiods, deeper water, and vegetation indicative of wetter conditions. Interdune Marsh communities are usually dominated by large graminoids, such as *Typha* spp., *Schoenoplectus* spp., *Fimbristylis* spp., *Cladium jamaicense*, or *Zizania aquatica*, but may be dominated by smaller graminoids, such as *Diplachne maritima (Leptochloa fascicularis, Leptochloa fusca), Carex* spp., or *Leersia* spp., which do not dominate in Maritime Wet Grasslands. The most characteristic species of Maritime Wet Grasslands, *Spartina patens* and *Muhlenbergia sericea*, are scarce or absent in Interdune Marshes. Edges of Interdune Ponds may have similar vegetation but should be recognized as Interdune Marshes only if they cover a substantial area. Brackish Marsh (Transitional Subtype) and the upland ecotone of other estuarine communities can contain some of the same species but also have more salt-tolerant species and are connected to tidal marsh communities.

Crosswalks: *Typha domingensis* - *Setaria magna* Marsh (CEGL004138).
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).
Northern Atlantic Coastal Plain Dune and Swale Ecological System (CES203.264)
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).
Interdune Pond (3^{rd} Approximation).

Sites: Interdune Marshes occur in basins in the interior of barrier islands, where standing water more than a few inches deep is present for long periods of time. Most are in dune swales, but some may be in former tidal channels that became blocked by sand movement.

Soils: Interdune Marshes are mapped as wet sandy soils such as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent), but often have substantial organic accumulations.

Hydrology: Interdune Marshes are semipermanently flooded with fresh water, sometimes one to two feet deep for long periods. However, surface water tends to disappear in drier years. They appear to reflect the elevation of the water table in the adjacent uplands. They are isolated from normal tidal flooding but may have saltwater intrusion from storm surge.

Vegetation: Interdune Marsh vegetation is extremely variable among patches. Most are dominated by tall graminoids such as *Typha domingensis, Typha latifolia, Zizania aquatica, Cladium jamaicense, Hymenachne (Panicum) hemitoma,* and *Schoenoplectus tabernaemontani*, in single-species stands or mixtures. A few examples are dominated by medium sized plants such as *Leersia virginica, Leersia hexandra*, *Coleataenia rigidula*, *Juncus roemerianus, Diplachne maritima,* or by a mix of species. No species have high frequency in site descriptions. Other species that are present in some examples include *Carex* spp. (*comosa, longyi, alata, lupulina*, *stipata* var. *maxima*), *Rhynchospora* spp. (*odorata, microcarpa, miliacea, mixta), Leersia oryzoides, Boehmeria cylindrica, Ludwigia palustris, Persicaria punctata, Persicaria hydropiperoides, Thelypteris palustris* var. *pubescens*, *Mitreola petiolata, Fuirena pumila, Proserpinaca palustris, Diodia virginiana, Sagittaria lancifolia* var. *media*, *Pluchea baccharis* (*rosea*), and *Bidens laevis*. Open patches where water is deeper may have *Eleocharis fallax* or *Potamogeton illinoensis*, while edges may have *Centella erecta*. A few woody species may be present, especially on the edges, including *Nekemias arborea* or other vines and *Swida foemina (Cornus stricta*).

Range and Abundance: The crosswalked association is ranked G2G3. Only a handful of widely scattered examples is known in North Carolina, and a few examples are likely to exist in other states. The NVC association ranges southward to Florida.

Associations and Patterns: Interdune Marshes are usually small patch communities. Patches tend to be a few acres or less, but one large complex amounting to more than 100 acres is present at Buxton Woods. Patches are usually surrounded by Maritime Evergreen Forest but might be surrounded by Maritime Dry Grassland, Maritime Wet Grassland, Dune Grass, or Maritime Shrub.

Variation: This is one of the most variable community types in the 4th Approximation. Each example is very different from the others and could be regarded as a distinct variant or even subtype. Many patches within the Buxton Woods complex are also very different from each other. Some variation is attributable to differences in water depth, successional age, or amount of past saltwater intrusion, but much has no obvious cause and may simply be the result of isolation and limited dispersal among examples. Two variants equivalent to those in Interdune Pond are recognized:

1. Open Variant occurs in more open landscapes such as sand flats or among open, sometimes discontinuous dunes. Since it tends to occur in a landscape of Dune Grass, Maritime Dry Grassland, or Maritime Shrub, this variant presumably is younger or is more subject to salt spray and occasional overwash. These marshes tend to have less diverse flora and to contain more salt-tolerant plants. Marshes surrounded by forest but open to saltwater intrusion should be treated as this variant too if they have similar vegetation.

2. Interior Swale Variant occurs in older relict dune systems with more relief, generally in a landscape of Maritime Deciduous Forest or Maritime Evergreen Forest. Salt spray is less, and overwash or saltwater intrusion is less likely. These marshes have a flora that includes less salt-tolerant species. They may be more diverse, but many patches are still strongly dominated by single species.

Dynamics: As with all maritime communities, Interdune Marshes are potentially highly dynamic. They may undergo severe natural disturbance by saltwater intrusion or may quickly give way to other communities because of erosion, sand movement, or direct or indirect natural changes in sheltering from salt spray and overwash. However, many occur in stable forested dune fields where such disturbances have not occurred for many decades, even centuries.

Water levels vary widely from year to year and over periods of years, in response to rainfall. When water levels fall, areas with dense emergent vegetation may change little, but local areas of deeper water may be colonized by short-lived opportunistic plants such as *Biden mitis*.

Swales may also undergo slower directional succession, with marshes developing from open ponds and later being supplanted by Maritime Swamp Forest. Brown's (1983) palynological study at Buxton Woods found that, at the oldest age of record, 895 years ago, *Typha* and *Nymphaea* were prominent but then decreased to nearly nothing, while *Cyperaceae* increased. Succession can potentially go in the opposite direction too, from woody vegetation to marsh to open pond, if the water table rises in response to rising sea level or changes in landforms.

Comments: Interdune Marshes were treated as part of the Interdune Pond type of the 3rd Approximation because marshy zones on the edges of ponds tie them together. However, most Interdune Marsh patches are not connected to ponds. Much of the earlier literature on Interdune Ponds did not tend to include Interdune Marshes, or at least did not explicitly distinguish them from edge zones of open ponds.

The placement of Interdune Marsh in the NVC is problematic. The crosswalked association is treated as provisional and its vegetation description is typical of only one of the many variations in vegetation, one in which there is recent or fairly frequent saltwater penetration. *Leptochloa fusca* ssp. *fascicularis - Sesuvium maritimum* Marsh (CEGL004125) is an interdune marshy pond defined on the basis of a site in the Bald Head Island complex. It has had repeated saltwater intrusion and appears to be transitioning to a tidal marsh edge community. *Fimbristylis castanea - Schoenoplectus pungens* Marsh (CEGL003790) was defined as an association at Cape Hatteras and Cape Lookout National Seashores and attributed only to North Carolina. It is not adopted in the 4th Approximation but needs further investigation into its ecological character and affinities. It appears to represent a shallower community intermediate between Interdune Marsh and Maritime Wet Grassland, but it may instead represent freshwater swales that are more frequently affected by saltwater. None of these associations appears to represent the more abundant Interdune Marshes of North Carolina, which are less affected by saltwater intrusion. The NVC thus appears to be both too finely divided and incomplete for the communities treated here as Interdune Marsh.

Rare species:
Vascular plants – *Eleocharis cellulosa, Ludwigia alata, Oplismenus hirtellus, Potamogeton illinoensis, Rhynchospora microcarpa, Rhynchospora odorata, Sabal palmetto, Scleria verticillata,* and *Utricularia macrorhiza*.

INTERDUNE POND

Concept: Interdune Ponds are open freshwater pond communities in the deepest, most permanently flooded interdune swales of barrier islands. In these ponds, long term emergent vegetation is confined to edge zones. Otherwise, open water, submersed aquatic plants, or floating aquatic plants predominate. Annual plants such as *Cyperus* spp. may establish during rare periods of drawdown. Marshy ponds, included in Interdune Ponds in the 3rd approximation, are now treated as the Interdune Marsh type.

Distinguishing Features: Interdune Ponds are distinguished by permanent or semipermanent open fresh water in a barrier island setting isolated from tidal marshes. Floating aquatic plants such as *Lemna* spp. may or may not be present, as may submersed aquatic plants such as *Potamogeton* spp. Woody plants as well as herbs may occur on the edges, including *Nyssa biflora, Cephalanthus occidentalis, Salix nigra, Decodon verticillatus*, and other species. Opportunistic plants may potentially establish in the pond bed in periods of extreme drawdown.

Crosswalks: No equivalent NVC association has been recognized.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).
Northern Atlantic Coastal Plain Dune and Swale Ecological System (CES203.264).
Southern Atlantic Coastal Plain Dune and Maritime Grassland Ecological System (CES203.273).

Sites: Interdune Marshes occur in basins in the interior of barrier islands, where standing water more than a few inches deep is present for long periods of time. Most are in dune swales, but some may be in former tidal channels that became blocked by sand movement.

Soils: Interdune Ponds generally are mapped as water in soil surveys, if big enough to be distinguished at all. Their substrate often has substantial organic accumulations in the center but may be sandy on the edge.

Hydrology: Interdune Ponds are permanently flooded over most of their area, with standing water present except during drought. Drawdown zones on the edge may be exposed seasonally.

Vegetation: Vegetation in Interdune Ponds is extremely variable, from site to site and among ponds within complexes. Stable ponds in older dune areas may have a number of floating aquatic plants in deep water, including *Lemna* spp., *Wolffia* spp., *Spirodela polyrhiza, Wolffiella gladiata, Azolla caroliniana*, *Hottonia inflata, Utricularia biflora, Utricularia inflata, Nymphaea odorata*, and *Brasenia schreberi*. Submersed aquatic plants, particularly *Potamogeton illinoensis*, may also be present. Ponds in more open areas, presumably younger and perhaps more often affected by saltwater, have lower aquatic diversity but may contain *Potamogeton illinoensis* or, in one case, *Ruppia maritima*. In shallower water and drawdown zones on the edge, *Phyla nodiflora, Bacopa monnieri, Limnobium spongia, Eleocharis fallax,* or *Eleocharis parvula* may occur. In rare drought conditions, when the pond bed is exposed, opportunistic herbs such as *Bidens laevis* or *Cyperus* spp. may appear. An edge zone may have wetland herbs such as *Saururus cernuus, Hydrocotyle umbellata, Hydrocotyle verticillata, Fuirena pumila, Sparganium americanum, Glyceria septentrionalis, Echinochloa walteri*, *Erianthus giganteus*, or marsh species such as *Typha latifolia* and *Juncus roemerianus*. Shrubs and trees, including *Decodon verticillatus, Salix caroliniana, Acer rubrum*, and *Nyssa biflora* may occur around some ponds.

Range and Abundance: There is no NVC rank, but the community as conceived here would likely be ranked G2G3, depending how broadly it ranges. About a dozen occurrences are known in North Carolina, widely scattered throughout the coast but with concentrations in the Buxton Woods/Cape Hatteras area and Nags Head Woods. Examples may potentially occur southward to Florida and possibly in Virginia.

Associations and Patterns: Interdune Ponds are small patch communities. Patches tend to be a few acres or less, but one large complex amounting to more than 100 acres is present at Buxton Woods. Patches are usually surrounded by Maritime Evergreen Forest but might be surrounded by Maritime Dry Grassland, Maritime Wet Grassland, Dune Grass, or Maritime Shrub.

Variation: Interdune Ponds are highly variable both among examples, among patches within complexes, and from year to year within examples. Of the three variants recognized in the 3rd Approximation, one has become the Interdune Marsh community type. Variants similar to the other two are retained, though they are renamed and defined slightly differently.

1. Open Pond Variant occurs in more open landscapes such as sand flats or among open, sometimes discontinuous dunes. Tending to occur in a landscape of Dune Grass, Maritime Dry Grassland, or Maritime Shrub, this variant presumably is younger or more subject to salt spray and occasional overwash. These ponds typically have less diverse flora and contain more salt-tolerant plants. Ponds surrounded by forest but open to saltwater intrusion should be treated as this variant, too.

2. Interior Pond Variant occurs in older relict dune systems with more relief, generally in a landscape of Maritime Deciduous Forest or Maritime Evergreen Forest. The ponds often tend to be steeper-sided and deeper. Salt spray is less, and overwash or saltwater intrusion is less likely. It may have a diverse aquatic flora that includes less salt-tolerant species.

Dynamics: As with all maritime communities, Interdune Ponds are potentially highly dynamic. They may undergo severe natural disturbance by saltwater intrusion or may quickly give way to other communities because of erosion, sand movement, or direct or indirect natural changes in sheltering from salt spray and overwash. However, most occur in stable forested dune fields where such disturbances have not occurred for many decades, if not centuries.

Comments: *Lemna* spp. Eastern North Americana Aquatic Vegetation (CEGL005451) is a successor to a now-dropped *Lemna* association that was crosswalked to this community in early drafts of the 4th Approximation. This association remains unduly broad, covering floating vegetation in a wide range of aquatic environments. A few Interdune Ponds have *Lemna* but most do not usually have abundant floating vegetation. That association would also potentially include backwaters on Coastal Plain Rivers and some beaver ponds, at least in certain seasons. It seems best not to link any existing association to this community.

Interdune Ponds have received substantial study over the years. A research project focused on the ponds of Nags Head Woods produced several publications on different biota (Bellis 1988, MacPherson 1988, Schwartz 1988). Interdune Ponds were also recognized in early work on Cape Lookout National Seashore (Au 1976, Snow and Godfrey 1978) and more generally (Odum and Harvey 1988).

Rare species:
Vascular plants – *Ceratophyllum australe, Cyperus dentatus, Cyperus lecontei, Diplachne maritima, Eleocharis cellulosa, Eleocharis parvula, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*), *Eupatorium maritimum, Hottonia inflata, Lilaeopsis carolinensis, Ludwigia alata, Paspalum vaginatum, Potamogeton illinoensis, Rhynchospora microcarpa, Rhynchospora odorata, Scleria verticillata,* and *Utricularia macrorhiza*.

MARITIME SWAMP FOREST (TYPIC SUBTYPE)

Concept: Maritime Swamp Forests are wetland forests of barrier islands and comparable coastal spits and back-barrier islands, dominated by tall trees of various species. The Typic Subtype includes most examples, those dominated by *Acer, Nyssa*, or *Fraxinus*, not by *Taxodium*. Canopy dominants are quite variable among the few examples.

Distinguishing Features: Maritime Swamp Forests are distinguished from other barrier island wetlands by dominance of tree species of (at least potentially) large stature. The Typic Subtype encompasses all swamps dominated by trees other than *Taxodium* or *Salix*. Known examples are combinations of *Nyssa, Fraxinus, Liquidambar, Acer*, or *Quercus nigra*. Maritime Shrub Swamps are dominated by tall shrubs or small trees, particularly *Salix*, *Persea*, or *Swida* (*Cornus*). Some portions of Maritime Evergreen Forest are marginally wet, but such areas are distinguished by the characteristic canopy dominants of that type, such as *Quercus virginiana, Quercus hemisphaerica*, or *Pinus taeda*. The lower strata also are different, with wetland species occurring in Maritime Swamp Forest; however, some species, such as *Morella cerifera,* may occur in both.

Crosswalks: *Acer rubrum - Nyssa biflora - (Liquidambar styraciflua, Fraxinus* sp.) Maritime Swamp Forest (CEGL004082).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Maritime Swamp Forests occur on barrier islands and comparable spits, in well-protected dune swales, edges of dune ridges, and on flats adjacent to freshwater sounds.

Soils: Soils are wet sands or mucky sands, most often mapped as Duckston (Typic Psammaquent) or Conaby (Histic Humaquept).

Hydrology: Most Maritime Swamp Forests have shallow seasonal standing water and nearly permanently saturated soils. Some may rarely be flooded by salt water during severe storms, but areas that are severely or repeatedly flooded do not recover to swamp forest.

Vegetation: Maritime Swamp Forests have somewhat open to closed canopies, where not recently disturbed. *Acer rubrum* (probably var. *trilobum*) and *Nyssa biflora* dominate most examples. In CVS plot data, *Pinus taeda* and *Liquidambar styraciflua* have high constancy but don't tend to dominate. *Fraxinus* dominates in one example. The understory may be dominated by *Persea palustris*, *Carpinus caroliniana*, or *Ilex opaca*, and may also include *Magnolia virginiana*. The shrub layer may be dense but more often is sparse to moderate. *Morella cerifera* is the most constant species, followed by *Vaccinium fuscatum*. Other species with fairly high constancy in plot data include *Decodon verticillatus, Lyonia lucida*, and *Vaccinium formosum*. Vines are frequent and diverse. *Parthenocissus quinquefolia, Toxicodendron radicans, Muscadinia rotundifolia, Smilax laurifolia*, and *Smilax rotundifolia* have high constancy, while *Berchemia scandens, Nekemias arborea*, *Hydrangea* (*Decumaria*) *barbara*, and other species may less reliably be present. The herb layer may be sparse to dense, and often is patchy. High constancy species are *Mitchella repens*, *Anchistea virginica*, *Saururus cernuus, Lorinseria virginica, Thelypteris palustris* var. *pubescens* and *Mikania scandens*, most of which dominate in some plots. Other fairly frequent species include *Osmundastrum cinnamomeum, Boehmeria cylindrica, Cicuta maculata, Hydrocotyle verticillata, Hydrocotyle umbellata, Peltandra virginica*, and a variety of *Carex* species. Species of adjacent Maritime Evergreen Forest or Maritime Deciduous Forest may occur in the edges of the swamps.

Range and Abundance: Ranked G2. Maritime Swamp Forests are rare and widely scattered in North Carolina. They only occur on the wider and more stable barrier islands, and not on all of them. All known examples are from the middle to northern part of the state, from Bogue Banks northward. The association ranges from Virginia to Georgia.

Associations and Patterns: Maritime Swamp Forests are small patch communities in most places, but they can have substantial aggregate acreage in a few places in extensive older dune systems. The largest examples are associated in mosaics with Maritime Deciduous Forest, but other examples are surrounded by Maritime Evergreen Forest. A few open onto Freshwater Tidal Wetlands at the back of the barrier island in places such as Currituck Banks.

Variation: Two well-marked variants exist, perhaps distinctive enough to warrant subtypes.

1. Maple-Gum Variant is dominated by *Acer rubrum* and *Nyssa biflora*. It includes most examples. Wentworth, et al. (1990), analyzing woody stem data from early CVS plots, identified separate groups dominated by *Acer* and *Nyssa*. These might warrant recognition as variants, but it is unclear how different they are ecologically. These species appear more intermixed in many examples, so that such variants would be much less distinct than the two recognized here.

2. Ash Variant is dominated by *Fraxinus*. It appears to be unique to Theodore Roosevelt State Natural Area, where it is the only variant.

Dynamics: In contrast to the extensive interest in the dynamics of Maritime Evergreen Forest and Maritime Shrub, and even Interdune Ponds, little has been written about the dynamics of Maritime Swamp Forests. They are subject to the high levels of stress and natural disturbance common to the Maritime Wetlands and Maritime Upland Forests themes, including the potential for geological processes to create or destroy suitable environments relatively quickly.

Maritime Swamp Forests generally do not show sculpting or stunting by chronic salt spray. They occur in the most sheltered parts of wide barrier islands, on the sound side or in deep dune swales where they are protected by high ridges and adjacent forests. Salt spray nevertheless presumably is an important input of nutrients into the swales. Heavy salt spray during storms, as well as high winds, can disturb forest canopies.

Intrusion by salt or brackish water during storms represents a potential severe natural disturbance in sites that are not fully surrounded by high dunes. Water can penetrate long distances along linear dune swales if one end is open to salt marsh or to the shoreline. Some examples are becoming increasingly vulnerable to this as sea level rises. Observations after recent hurricanes show some areas of complete mortality in Maritime Swamp Forests, where roots as well as tops of woody vegetation were killed. Some are recovering through a slow process of secondary succession. Others do not show any woody regeneration after several years. One possible reason may be that salt water may have penetrated during a storm surge but may have been unable to drain out. If salt is trapped in a swale, it may take years of gradual dilution by rainwater before the environment is again suitable for trees.

The Maritime Swamp Forests of the Currituck Banks occur on low sand flats that are not sheltered from the sound. The water in Currituck Sound is oligohaline rather than brackish and may not be harmful to the species in the swamp forest. If a new inlet formed and Currituck Sound became saltier, these swamps might not survive.

Rare species: No rare species are known to be specifically associated with this community.

MARITIME SWAMP FOREST (CYPRESS SUBTYPE)

Concept: Maritime Swamp Forests are wetland forests of barrier islands and comparable coastal spits and back-barrier islands. The Cypress Subtype covers the rare examples dominated or codominated by *Taxodium distichum*, occurring in North Carolina only at Southern Shores and in Kitty Hawk Woods.

Distinguishing Features: The Cypress Subtype is distinguished from all other communities by the dominance of *Taxodium* in a non-tidal, barrier island setting.

Crosswalks: *Taxodium distichum* - *Liquidambar styraciflua* / *Cephalanthus occidentalis* / *Boehmeria cylindrica* - *Ceratophyllum muricatum* Swamp Forest (CEGL004079).
G039 Mid-Atlantic & Northern Coastal Plain Swamp Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: This community occurs in well-protected dune swales.

Soils: Soils in the known examples are mapped as Conaby (Histic Humaquept).

Hydrology: The swales containing this subtype have fluctuating water levels that may be several feet deep for an entire season or may draw down and be unflooded but saturated. These swales are wetter than those supporting the Typic Subtype.

Vegetation: The forest is dominated by *Taxodium distichum*. A few other species may be codominant, especially *Acer rubrum*, probably var. *trilobum*. Other abundant trees may include *Liquidambar styraciflua, Pinus taeda*, *Nyssa biflora*, and *Fraxinus profunda*. The understory usually is not well developed. It consists of canopy species, frequently along with *Persea palustris* or *Carpinus caroliniana* on the edges. Shrub cover is generally low. Species fairly frequent in CVS plots include *Morella cerifera*, *Eubotrys racemosus, Decodon verticillatus, Cephalanthus occidentalis*, and *Rosa palustris*. Vines are frequent and occasionally extensive, with *Parthenocissus quinquefolia, Muscadinia rotundifolia, Berchemia scandens, Smilax rotundifolia*, and *Toxicodendron radicans* frequent in plots. Herbs generally have low cover, may be confined to edges, and may vary in cover with water levels. Frequent herbaceous species in the plots are *Boehmeria cylindrica, Saururus cernuus, Mikania scandens, Osmunda spectabilis,* and *Peltandra virginica*. Also fairly frequent are *Galium tinctorium, Hydrocotyle tribotrys, Triadenum virginicum, Limnobium spongia, Lorinseria areolata, Lycopus virginicus,* and *Persicaria hydropiperoides*.

Range and Abundance: Ranked G1. In North Carolina this community is known only in Kitty Hawk Woods and Southern Shores. A few more examples exist in nearby Virginia.

Associations and Patterns: The known examples are small patches surrounded by Maritime Deciduous Forest.

Variation: Examples are somewhat heterogeneous in composition and are zoned by water depth.

Dynamics: Nothing specific is known about the dynamics of this subtype. Examples occur in well sheltered areas where saltwater intrusion is unlikely under current circumstances.

Unlike most of the drier maritime communities, Maritime Swamp Forest may be susceptible to invasion by exotic plants. The dramatic invasion of a South Carolina example by nonnative invasive *Triadica sebifera* (Conner, et al. 2005) demonstrates the potential for alteration. Though this species is more widespread to the south, and only sparsely present in North Carolina, the moderate climate of the barrier islands likely is suitable for it.

Comments: While it may be reasonable to question whether this subtype is more distinct than the variants within the Typic Subtype, the Cypress Subtype was recognized as the most distinct cluster in Wentworth, et al. (1990) and in Virginia Natural Heritage Program data analysis. It is wetter than the Typic Subtype. Maritime Shrub Swamp, at least the Dogwood Subtype, appears similarly wet, and it is unclear what ecological factors separate it from the Cypress Subtype. Dispersal limitation in the remote locations may be a sufficient explanation.

Rare species: No rare species are known to be specifically associated with this community.

MARITIME SHRUB SWAMP (DOGWOOD SUBTYPE)

Concept: Maritime Shrub Swamps are barrier island wetlands persistently dominated by large shrubs or small trees. The Dogwood Subtype encompasses rare examples dominated or codominated by *Swida foemina* (*Cornus stricta*). It is known only from Buxton Woods and Salter Path.

Distinguishing Features: The Dogwood Subtype is readily distinguished from all other communities by the combination of barrier island dune swale setting with dominance or codominance by *Swida foemina* (*Cornus stricta*). *Persea palustris* may be abundant or codominant in this subtype but always with *Swida foemina*, which is largely absent from the Red Bay Subtype. *Pinus taeda* may be present as emergent trees or a supercanopy on edges of patches. An ususual shrubby wetland dominated by *Decodon verticillatus* but with abundant *Swida foemina* is tentatively included in this subtype.

Crosswalks: *Cornus foemina / Berchemia scandens* Scrub Swamp (CEGL007384).
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Maritime Shrub Swamps occur in wet dune swales. In the best known occurrence, at Buxton Woods, they occupy numerous swales in the extensive forested dune system but are not in the deepest swales.

Soils: Soils are sands with a shallow muck surface layer. They are mapped as Conaby (Histic Humaquept).

Hydrology: Swales containing this community have fluctuating water levels that may be several feet deep for an entire season or may draw down and be unflooded but saturated. The water levels represent the water table.

Vegetation: The vegetation is a closed to open tall shrubland dominated by *Swida foemina* (*Cornus stricta, Cornus foemina*), alone or codominant with *Persea palustris*. There often is a visible gradient in vegetation within the community from the edge of the swale to the center. *Pinus taeda* may be present as an open supercanopy or as sparser emergent trees in the transition to adjacent forests. *Carpinus caroliniana* is frequent and may be abundant on edges. In CVS plot data, *Morella cerifera, Ilex vomitoria*, and *Sabal minor* are frequent and may be abundant on edges, and a number of other species shared with Maritime Evergreen Forest may be present. *Smilax laurifolia, Berchemia scandens*, *Muscadinia rotundifolia, Parthenocissus quinquefolia, Smilax rotundifolia, Nekemias arborea*, *Smilax bona-nox*, and *Gelsemium sempervirens* are fairly constant and may have substantial cover, and *Hydrangea (Decumaria) barbara, Toxicodendron radicans,* and *Vitis aestivalis* are also fairly frequent. Herbs are sparse and patchy, largely confined only to edges, and no species has as much as 50% constancy in CVS plots. *Thelypteris palustris* var. *pubescens, Boehmeria cylindrica, Chasmanthium laxum, Hydrocotyle verticillata*, and *Carex* spp. are the most frequent in plots, but seldom have high cover. Other species noted as abundant locally include *Leersia virginica, Leersia oryzoides, Rhynchospora miliacea, Persicaria* sp., *Sparganium americanum, Limnobium spongia*, and *Carex lupulina*.

Range and Abundance: Ranked G1. The only well-developed example of this community is at Buxton Woods, with a marginally developed example in Salter Path. This subtype apparently is endemic to North Carolina.

Associations and Patterns: The Dogwood Subtype occurs in small but numerous patches at Buxton Woods. Patches are surrounded by Maritime Evergreen Forest, and some may be on the edges of Interdune Marsh or Interdune Pond communities in deeper swale areas.

Variation: Many patches show a distinct zonation or gradient along the sloping bottoms of the swales.

Dynamics: Little is known specifically about the dynamics of this subtype. It is subject to the same natural disturbances as the other woody Maritime Wetlands.

The author's observations in the 2000s suggest some substantial changes in the ecotonal (drier) parts of patches. Many large *Pinus taeda*, often all of the emergent or supercanopy trees, had died standing. It is unclear if they died in the same hurricane that caused catastrophic mortality of pines in the surrounding Maritime Evergreen Forest, apparently as a result of heavy salt spray, or if they died later as a result of prolonged high water levels. The large size of the trees suggests the cause was a very rare event. The lack of substantial pine regeneration and the apparent uniform size of the trees suggest that establishment of pines may also be a rare event, perhaps associated with prolonged drought. The author has observed substantially different, but long lasting, water levels in this community at different times from the 1980s through the 2010s.

Comments: The Wentworth, et al. (1990) analysis of CVS woody stem data found the Maritime Shrub Swamps to be a distinctive cluster, with Dogwood and Red Bay subtypes substantially different.

Rare species: No rare species are known to be specifically associated with this community.

MARITIME SHRUB SWAMP (RED BAY SUBTYPE)

Concept: Maritime Shrub Swamps are barrier island wetlands persistently dominated by large shrubs or small trees. The Red Bay Subtype encompasses examples dominated by *Persea palustris*, with *Swida foemina* scarce or absent.

Distinguishing Features: The Red Bay Subtype is distinguished from all other communities by the combination of barrier island setting and dominance by *Persea palustris* without *Swida foemina* (*Cornus stricta*) as a codominant. *Persea palustris* may be codominant with *Swida* in the Dogwood Subtype.

Crosswalks: *Persea palustris / Morella cerifera* Scrub Swamp (CEGL004635).
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: The Red Bay Subtype occurs on the lower flanks of dunes and on low-lying flats on the sound side of barrier islands.

Soils: The few examples are mapped as Duckston (Typic Psammaquent) and Conaby (Histic Humaquept). The Duckston examples may be on inclusions of mucky soil more like Conaby.

Hydrology: This subtype appears to have saturated soils, with the water table near the surface, but may not have the deep ponding characteristic of the Dogwood Subtype. The Nags Head Woods example may have significant seepage from the adjacent high dunes.

Vegetation: The Red Bay Subtype has a canopy of short trees, dominated by *Persea palustris*. Some examples have smaller amounts of *Acer rubrum*. A few other trees, such as *Carpinus caroliniana, Magnolia virginiana*, or *Liquidambar styraciflua*, may be present. A lower shrub layer dominated by *Morella cerifera* may be sparse to moderately dense. Vines are often abundant, particularly *Smilax laurifolia*, but also including *Smilax rotundifolia, Berchemia scandens, Toxicodendron radicans, Parthenocissus quinquefolia*, and other species. Herbs are patchy. *Lorinseria areolata, Thelypteris palustris* var. *pubescens, Boehmeria cylindrica*, and *Leersia virginica* may dominate patches. Other notable species include *Osmunda spectabilis, Rhynchospora miliacea, Osmundastrum cinnamomeum, Persicaria hydropiperoides, Cicuta maculata*, and *Peltandra virginica*. Extensive *Sphagnum* cover was noted in one site.

Range and Abundance: Ranked G1. Only three examples are known in North Carolina, widely scattered in the northern half of the coast. The association is reported to also be in South Carolina, but the identification of examples there is unclear.

Associations and Patterns: The examples of the Red Bay Subtype are small patches associated with Maritime Deciduous or Maritime Evergreen Forest on the upland side, and often with tidal marshes nearby.

Variation: Documentation of this community remains somewhat partial, and the variation is confusing. Some descriptions of the Nags Head Woods example make it sound different from the other examples. It occurs just below the sound side slope of the dunes, adjacent to marshes. It has extensive *Sphagnum* cover and a high diversity of herbs. It may receive significant seepage, but it may also be transitional to a marsh ecotone community. The other two examples, at Pine Island and Hatteras Island, are on sand flats, also on the back of barrier islands and near marshes, but without evidence of seepage. They have lower species richness and appear to be less wet.

Dynamics: The natural dynamics of this subtype are particularly poorly known. All examples are in locations exposed to potential flooding from the sound side of the islands, so they may be subject to significant natural disturbance. It is possible they represent a successional stage leading to Maritime Swamp Forest, which occurs in similar settings. However, where both communities occur together, Maritime Shrub Swamp occurs in discrete patches that appear to be slightly lower and wetter.

Comments: This community remains poorly understood. The Nags Head Woods occurrence has been known for many years and has been characterized in several reports, but older and newer descriptions appear rather different. The other occurrences are more newly discovered and are limited in extent. CVS plot data do not characterize the community well, with some plots misclassified and others ecotonal. However, the Wentworth, et al. (1990) analysis identified a distinct group of bay-dominated wetland plots. There is no other published literature on the Red Bay Subtype.

Rare species:
Vascular plants – *Liparis loeselii*.

MARITIME SHRUB SWAMP (WILLOW SUBTYPE)

Concept: Maritime Shrub Swamps are barrier island wetlands persistently dominated by large shrubs or small trees. The Willow Subtype encompasses examples dominated or codominated by *Salix caroliniana*.

Distinguishing Features: The Willow Subtype is readily distinguished from all other communities by the combination of barrier island dune swale setting and dominance by *Salix caroliniana*. *Salix* may be present in small amounts in Maritime Swamp Forest or on edges of Interdune Ponds but does not dominate in these communities.

Crosswalks: *Salix caroliniana / Sacciolepis striata - Boehmeria cylindrica* Scrub Swamp (CEGL004222).
G777 Atlantic & Gulf Coastal Interdunal Swale Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: The Willow Subtype occurs in wet dune swales in sheltered parts of barrier islands.

Soils: Soils are sands, potentially with a shallow muck surface layer. They may be mapped as Conaby (Histic Humaquept) or Duckston (Typic Psammaquent) or may be inclusions of these soils in other map units.

Hydrology: Hydrology is probably similar to that of the Dogwood Subtype, with fluctuating water levels that may cover the surface for entire seasons or may drop to saturated but not flooded conditions.

Vegetation: The Willow Subtype is an open to potentially closed tall shrubland dominated by *Salix caroliniana*. Associated vegetation is not well characterized. Some *Acer rubrum* or other swamp tree species may be present in small numbers, and other trees rooted in adjacent communities may overhang. *Morella cerifera* or other shrubs may be present on the edges. Associated herbs may include *Thelypteris palustris* var. *pubescens*, *Chasmanthium laxum, Hydrocotyle tribotrys, Mikania scandens, Persicaria punctata, Boehmeria cylindrica*, and potentially additional species shared with other subtypes.

Range and Abundance: Ranked G2? The range and abundance of this community are not well understood. Only a handful of examples are known, though a few others may have been overlooked or not reported. The equivalent association was described in North Carolina and is also attributed to South Carolina.

Associations and Patterns: The Willow Subtype occurs in small patches, often in complexes with Maritime Shrub Swamp (Dogwood Subtype), Interdune Marsh, or Interdune Pond. It may be surrounded by Maritime Upland Forest or Maritime Grassland communities.

Variation: Nothing is known of variation.

Dynamics: Because *Salix* is often an early successional species, it is likely that this subtype represents an earlier stage of primary succession than the other woody Maritime Wetlands. However, it can be associated with other woody wetlands. The Buxton Woods example is in the younger, more seaward part of the site compared to the Dogwood Subtype and Maritime Swamp Forest.

Comments: This subtype is particularly poorly understood. It was described as an association in the NVC, but the description there says little other than that the community is dominated by *Salix*. The few CVS plots attributed to the association are uncertain representatives. Examples have been observed by the author in the Buxton Woods area and on Currituck Banks, but description is limited. High water levels hampered observation, and may have prevented plots from being collected for the initial NVC description. More work is needed to characterize the community and to determine its conservation status, but it appears to represent vegetation that occurs naturally in North Carolina and cannot readily be classified as another community.

Rare species: No rare species are known to be specifically associated with this community.

ESTUARINE FRINGE PINE FOREST (LOBLOLLY PINE SUBTYPE)

Concept: Estuarine Fringe Pine Forests are strongly pine-dominated forests and woodlands adjacent to sounds or marshes, whose lower strata are indicative of estuarine influence rather than consisting of species of Coastal Plain Nonalluvial Wetlands or Peatland Pocosins. The Loblolly Pine Subtype covers examples in which *Pinus taeda* dominates.

Distinguishing Features: Estuarine Fringe Pine Forests are distinguished from Pond Pine Woodland and Nonriverine Swamp Forest by having a shrub layer dominated or codominated by *Morella cerifera*. *Persea palustris* and *Ilex glabra* may be abundant in all, but other typical pocosin shrubs such as *Cyrilla racemiflora* are largely or completely absent. *Osmunda spectabilis* or *Lorinseria areolata* are generally the dominant herbs, though *Anchistea virginica* may be present. Other species shared with Tidal Freshwater Marshes and not typical of pocosins are usually present.

The Loblolly Pine Subtype is distinguished from the Pond Pine Subtype by the dominant canopy species. The Loblolly Pine Subtype may be difficult to tell from successional loblolly pine forests or plantations, and the two can occur adjacent to each other. Estuarine Fringe Pine Forest may be recognized by wet, mucky soil and by vegetation as described below, which shares species with tidal marshes and does not contain upland species.

Crosswalks: *Pinus taeda / Morella cerifera / Osmunda regalis var. spectabilis* Swamp Forest (CEGL006137).
G039 Mid-Atlantic & Northern Coastal Plain Swamp Group.
Central Atlantic Coastal Plain Maritime Forest Ecological System (CES203.261).

Sites: Estuarine Fringe Pine Forests occur on the shoreline of estuaries or behind tidal marshes, on flats that are low-lying but are above the level of tidal flooding. Most examples are on the mainland but at least one is known on the sound side of a barrier island.

Soils: The Loblolly Subtype occurs on a variety of organic-rich soils. Most are mapped as mucky mineral soils such as Stockade (Umbric Endoaqualf), Icaria (Typic Umbraquult), Wasda (Histic Humaquept), Conaby (Histic Humaquept), and Murville (Typic Haplaquod). A few are mapped as true organic soils such as Ponzer or Currituck (Terric Haplosaprist).

Hydrology: Estuarine Fringe Pine Forests are permanently or semipermanently saturated and may sometimes have shallow surface water. The water table is probably kept near the surface by the flat topography and their location near sea level. They are not flooded by regular or extreme tides, but they may be flooded by brackish or oligohaline water during storm surges. They probably are wetted primarily by rainwater but may receive sheet flow from inland. All known examples are associated with estuaries with wind tides or limited tidal range, and it is possible that this is crucial for their development.

Vegetation: The Loblolly Pine Subtype is strongly dominated by *Pinus taeda*, in a canopy that may be dense or open. Small amounts of *Nyssa biflora, Acer rubrum*, or *Liquidambar styraciflua* often are present. Occasional examples have a few *Pinus serotina*, *Quercus nigra*, or *Quercus* *virginiana*. The understory is usually dominated by *Persea palustris*. Sometimes no other species are noted, but *Magnolia virginiana* is fairly frequent and *Ilex opaca* may occur. The shrub layer may be dense or sparse. *Morella cerifera* is constant and usually dominates. Other frequent shrubs include *Arundinaria tecta, Vaccinium fuscatum, Ilex glabra*, and *Lyonia lucida*. Less frequent but characteristic species include *Baccharis halimifolia*, *Decodon verticillatus*, and *Sabal minor*. Vines are sometimes dense. *Smilax rotundifolia, Gelsemium sempervirens*, and *Muscadinia rotundifolia* are most frequent, and *Nekemias arborea, Toxicodendron radicans, Berchemia scandens, Campsis radicans*, and other species of *Smilax* may occur. The herb layer may be sparse or dense. The most frequent species are *Chasmanthium laxum, Osmunda spectabilis, Lorinseria areolata,* and *Osmundastrum cinnamomeum*. One example that had burned recently had a dense herb layer of *Carex hyalinolepis*. Other herbs that may occur include *Anchistea virginica, Centella erecta, Pluchea purpurascens, Pluchea foetida, Hydrocotyle verticillata/tribotrys/umbellata, Saururus cernuus, Pteridium pseudocaudatum, Juncus effusus, Echinochloa walteri, Samolus parviflorus, Persicaria* spp., *Peltandra virginica*, and *Bacopa monnieri*. *Sphagnum* clumps are occasional. Various other species shared with tidal marshes may be present at low frequency.

Range and Abundance: Ranked G3. Estuarine Fringe Pine Forests of the Loblolly Pine Subtype are scattered throughout the northern half of the tidewater zone of the Coastal Plain, around Currituck, Albemarle, and Pamlico Sounds and the Neuse River estuary. They are not known farther south. About 20 occurrences are known and a few more are likely to be found. The equivalent association is found northward to New Jersey.

Associations and Patterns: Estuarine Fringe Pine Forests are large patch communities. Most examples are tens to hundreds of acres in size, but they are not a regular or predictable part of the landscape mosaic. They occur inland of Brackish Marsh or Tidal Freshwater Marsh or on the shoreline. Inland, most examples are bordered by altered vegetation, but they might naturally grade to Nonriverine Swamp Forest or to various upland communities. At least one example occurs on the Currituck Banks, where it is associated with Maritime Evergreen Forest.

Variation: The Loblolly Pine Subtype is a relatively uniform community, with less variation among and within examples than most communities. Examples may vary somewhat with wetness and with time since natural disturbance.

Dynamics: The natural dynamics of the Loblolly Pine Subtype are not well documented. These communities are dominated almost exclusively by species that tend to establish after severe disturbance but that do not dominate with chronic stress or disturbance such as frequent fire. They occur adjacent both to communities that naturally burned and to tidally flooded communities. Rare saltwater intrusion during storm surges is thought to act as a natural disturbance that causes canopy regeneration and that prevents less salt-tolerant species from persisting. Because they occur on exposed edges of open water and are not dominated by trees resistant to wind throw, wind is also an important disturbance. It may thus be one of the few natural communities in North Carolina that is regularly maintained by catastrophic disturbance. At the same time, the rarity of such disturbances allows the canopy to mature and prevent shrub or herb species from dominating.

The role of fire in the Loblolly Pine Subtype is unclear. Cecil Frost, who wrote site reports for multiple examples, believed that they naturally burned very frequently, as he believed about the marshes that adjoined many of them, and that their natural state was as a savanna with a dense herb layer. Several examples he saw had been burned along with the adjacent marshes for wildlife management. He emphasized the vigorous response of *Carex hyalinolepis* to fire, but this species was not found in other burned examples. Many other examples have sparse enough herbaceous fuel that they seem unlikely to burn. Not all examples are connected to large contiguous marshes. Some may have been connected to upland longleaf pine communities or canebrakes which burned frequently, but others are associated with Nonriverine Swamp Forest and other communities that are not as flammable.

Given the ongoing rise in sea level, any given occurrence of Estuarine Fringe Pine Forest may be transient on the scale of decades, though all appear to have persisted in the several decades since the community was first recognized. Because of their marginally greater elevation, they appear to be more persistent than the exposed edges of Tidal Swamp. Because of the greater salt tolerance of the dominant tree species, they tend to persist longer than the Pond Pine Subtype.

All known examples of this community in North Carolina occur in areas influenced by wind tides rather than regular lunar tides. This, or the small tidal range that accompanies it, may be important for their occurrence. Soils probably never drain as much as they do at low tide in areas with larger tidal range. However, lunar tides predominate in states to the north where the synonymized association is believed to occur.

Comments: The NVC association synonymized with this subtype appears to be a broader concept, including barrier island and marsh island sites in states to the north. In North Carolina, *Pinus taeda*-dominated vegetation is only known in drier Maritime Evergreen Forest or Maritime Deciduous Forest, though it is possible a true Estuarine Fringe Pine Forest could occur on the back of a barrier island.

The hierarchical placement of the Estuarine Fringe Pine Forest communities has been problematic. They do not fit well in the Maritime Wetlands theme but are a poorer match for all other themes. The link to the Central Atlantic Coastal Plain Maritime Forest (CES203.261) ecological system is problematic in the same way. At the same time, the placement in the broader G039 Northern Coastal Plain Swamp Group is problematic for our examples, which do not appear to have more northern ecological affinities than the communities that surround them.

This community was newly recognized, under the name of Estuarine Fringe Loblolly Pine Forest, shortly before publication of the 3rd Approximation. It was not obviously documented in earlier site descriptions before that time, though the similarity to artificial successional vegetation may make it difficult to recognize in earlier literature. It has been well documented since that time in site reports and several CVS plots.

Rare species: No rare species are known to be specifically associated with this community.

ESTUARINE FRINGE PINE FOREST (POND PINE SUBTYPE)

Concept: Estuarine Fringe Pine Forests are strongly pine-dominated forests and woodlands adjacent to sounds or marshes, whose lower strata are indicative of estuarine influence rather than consisting of species of Coastal Plain Nonalluvial Wetlands or Peatland Pocosins. The Pond Pine Subtype covers examples with *Pinus serotina*-dominated canopies.

Distinguishing Features: Estuarine Fringe Pine Forests are distinguished from Pond Pine Woodland and Nonriverine Swamp Forest by having a shrub layer dominated or codominated by *Morella cerifera*. *Persea palustris* and *Ilex glabra* may be abundant in all, but other typical pocosin shrubs such as *Cyrilla racemiflora* are largely or completely absent. *Osmunda spectabilis* or *Lorinseria areolata* are generally the dominant herbs, though *Woodwardia virginica* may be present. Other species not typical of pocosins, many shared with Tidal Freshwater Marshes, are usually present. The Pond Pine Subtype is distinguished from the more common Loblolly Pine Subtype by the canopy dominant.

Crosswalks: *Pinus serotina / Morella cerifera / Osmunda regalis var. spectabilis* Swamp Woodland (CEGL003669).
G037 Southern Coastal Plain Mixed Evergreen Swamp Group.
Atlantic Coastal Plain Peatland Pocosin and Canebrake Ecological System (CES203.267).
Pond Pine Woodland (3rd Approximation).

Sites: Estuarine Fringe Pine Forests occur on the shoreline of estuaries or behind tidal marshes, on flats that are low-lying but are above the level of tidal flooding. The Pond Pine Subtype generally occurs where large or medium sized peatlands lie near shoreline.

Soils: Soils in the Pond Pine Subtype are often organic soils such as Belhaven (Terric Haplosaprist), Dorovan, Dare, or Pungo (Typic Haplosaprists). They may also often be organic-rich mineral soils such as Hyde (Typic Umbraquult) or Wasda (Histic Humaquept). Some are mapped as less organic soils such as Leon (Aeric Haplohumod), but these may be inclusions.

Hydrology: Estuarine Fringe Pine Forests are permanently or semipermanently saturated and may sometimes have shallow surface water. The water table is probably kept near the surface by the flat topography and this community's location near sea level. Though not flooded by regular or extreme tides, they may be flooded by brackish or oligohaline water during storm surges. These forests probably are wetted primarily by rainwater but may receive sheet flow from inland. All examples are associated with estuaries with wind tides or limited tidal range, and it is possible that this is crucial for their development.

Vegetation: The Pond Pine Subtype is universally dominated by *Pinus serotina*, usually strongly, but the canopy may be fairly dense or very open. The understory is dominated by *Persea palustris*. Small numbers of *Acer rubrum* var. *trilobum* or *Nyssa biflora* may be present in the canopy, or more often, in the understory. Other understory species that occur with moderate frequency in CVS plot data and site descriptions are *Magnolia virginiana* and *Liquidambar styraciflua*. The shrub layer is dominated by *Morella cerifera*, sometimes exclusively, sometimes with *Ilex glabra* codominant. Other frequent shrubs include *Vaccinium fuscatum, Aronia arbutifolia, Lyonia lucida*, and *Baccharis halimifolia*. Less frequent shrubs include *Eubotrys racemosus, Vaccinium formosum, Lyonia ligustrina*, *Rosa palustris*, and *Decodon verticillatus*. A variety of vines may be present, most frequently *Toxicodendron radicans, Smilax glauca, Smilax rotundifolia, Gelsemium sempervirens*, and *Parthenocissus quinquefolia*, sometimes *Smilax laurifolia*. The herb layer may be sparse to dense. *Anchistea virginica* and *Osmunda spectabilis* are highly constant and one or both are usually dominant. *Sphagnum* spp. may be present in small or large amounts. Other herbs may include *Peltandra virginica, Thelypteris palustris, Cladium jamaicense, Hydrocotyle verticillata/umbellata*, *Carex striata, Boehmeria cylindrica, Lorinseria areolata, Persicaria punctata, Proserpinaca palustris, Centella erecta,* and *Triadenum virginianum*.

Range and Abundance: Ranked G2? The Pond Pine Subtype is scattered throughout the northern half of the tidewater zone of the Coastal Plain, around Currituck, Albemarle, and Pamlico Sounds. There are about a dozen occurrences in the state. This community may potentially occur in adjacent Virginia. The NVC association is questionably attributed to South Carolina, but occurrence there is much less likely.

Associations and Patterns: Estuarine Fringe Pine Forests are large patch communities. Examples of the Pond Pine Subtype may be hundreds of acres in size, with the larger up to 2000 acres, but they are not present in most peatland or estuarine landscapes. They occur inland of Brackish Marsh or Tidal Freshwater Marsh or on the shoreline. Inland, most examples are bordered by Pond Pine Woodland or other pocosin communities.

Variation: The Pond Pine Subtype is a relatively uniform community, with less variation among and within examples than most communities. Examples vary with the stage of transition, with some more resembling Pond Pine Woodland, some Tidal Freshwater Marsh.

Dynamics: The dynamics of the Pond Pine Subtype are somewhat different from the Loblolly Pine Subtype. The Pond Pine Subtype appears to represent a more short-lived transitional community, developed from Pond Pine Woodland by rising sea level and increasing estuarine influence, and clearly undergoing a slow or rapid transition to marsh. The *Pinus serotina* canopy is relict and never appears to regenerate under current conditions. Instead, as trees are lost, it becomes more open and ultimately disappears. *Nyssa biflora* and *Acer rubrum* var. *trilobum*, more tolerant of current conditions, could potentially come to dominate the site, but the fate of most examples appears to become Tidal Freshwater Marsh (Wax Myrtle Subtype). The shrub layer often shows the transition clearly. *Morella cerifera*, largely absent in pocosins but quick to establish in suitable sites, is codominant or dominant. Shrubs retained from the earlier Pond Pine Woodland community are often represented as standing dead stems if they are no longer alive. *Lyonia lucida* dies first, while *Ilex glabra* persists longer. Shrubs more characteristic of tidal communities, such as *Baccharis halimifolia* and even *Rosa palustris,* may be starting to establish. The vine and herb layers show the transition too, with the *Anchistea virginica* and *Smilax laurifolia* characteristic of pocosins present along with the *Osmunda spectabilis*, *Thelypteris palustris*, and *Toxicodendron radicans* that are more typical of tidal communities.

The crucial environmental factors that drive the transition are not definitively known. Increasingly permanent surface saturation as sea level drives a rise in the water table may be important, despite the saturation tolerance of all the plant species involved. Tidal waters do not appear to penetrate these communities, which are not obviously influenced by salt. It is possible that diffusion of salt through the soil is important. It is possible that, even where salt is not significant, addition of sulfur leads to increased oxidation in the organic soil. Increased nutrient levels may favor competitive opportunist species such as *Morella cerifera*. Actual intrusion of estuarine water, even oligohaline water, during storm surges may stress or kill intolerant plants. Any substantial intrusion tends to kill the remaining canopy trees and lead to rapid transition to shrubby marsh. *Pinus serotina* does not show any tendency to regenerate after such disturbance.

Fire may potentially be important in the Pond Pine Subtype. Examples are usually connected to flammable marsh and pocosin communities. Most of the plants present are able to sprout after fires, so recovery may be rapid in some cases. However, a surface fire may result in more fern dominance, slowing the establishment of *Morella*. In contrast, a more intense fire may kill the pines and hasten the development of marsh.

Comments: This subtype was formerly treated within Pond Pine Woodland. However, despite the canopy, it appears to be more ecologically similar to *Pinus taeda*-dominated examples than to most Pond Pine Woodlands. Nevertheless, it is unclear how ecologically similar the two subtypes are. The Loblolly Pine Subtype appears to be stable, having occupied sites for many years. All well-known examples of the Pond Pine Subtype appear to be transitional communities, developing from true Pond Pine Woodland communities as rising sea level brings occasional storm flooding and salt influence. However, at present rates of sea level rise, this community apparently can persist for years and can occupy sizeable areas.

Even more than for the Loblolly Pine Subtype, the hierarchical placement of the Pond Pine Subtype has been problematic. They do not fit well in the Maritime Wetlands theme but are a poorer match for all other themes. The link to the Central Atlantic Coastal Plain Maritime Forest (CES203.261) ecological system is problematic in the same way. The placement in the broader G039 Northern Coastal Plain Swamp Group is a particularly poor fit, given the southern affinities of *Pinus serotina*.

Rare species:
Vascular plants – *Peltandra sagittifolia*.

ESTUARINE BEACH

Concept: The Estuarine Beach community type covers chronically disturbed shorelines of freshwater or oligohaline estuaries, with vegetation that is more open than Tidal Swamp, Estuarine Fringe Pine Forest, or Tidal Freshwater Marsh. These communities likely are not frequently flooded by tides, though they are wet, but are more influenced by storm waves.

Distinguishing Features: This type is distinguished conceptually by occurrence on a chronically disturbed estuarine shoreline that is above regular high tides and has wetland vegetation that is more indicative of severe disturbance than in any other freshwater tidal or estuarine community type. Vegetation may include young trees or sparse relict trees, sand binding species such as *Spartina patens*, or a mix of oligohaline or brackish marsh species with ruderal species.

Crosswalks: *Acer rubrum / Sambucus nigra* ssp. *canadensis / Nekemias arborea - Sicyos angulatus* Tidal Forest (CEGL004698).
G759 Southern Ash - Elm - Willow Floodplain Forest Group.
Southern Atlantic Coastal Plain Tidal Wooded Swamp Ecological System (CES203.240).

Sites: Shorelines of estuaries, subject to periodic wave action or disturbance too severe to allow persistence of other marsh or swamp communities. Sites may have the form of a berm, slightly raised above an adjacent marsh or swamp, but potentially could occur along the edge of a higher shoreline.

Soils: Soils may be quite variable, consisting of sand or organic material present before being exposed to the estuary by erosion, reworked by wave action.

Hydrology: Generally saturated or with a permanent water table near the surface because of low elevation, but not frequently flooded by lunar or wind tides.

Vegetation: This community is defined conceptually by the environment at present, and potentially is highly variable in vegetation structure and composition. Vegetation may also change substantially with time in a given site. Species of marshes, especially *Spartina patens*, may be present at low to moderate density. One of the few well-described examples has the grass sparsely mixed with ruderal species such as *Melothria pendula, Physalis walteri, Cynodon dactylon, Eupatorium capillifolium, Phytolacca americana,* and *Diodia virginica*, as well as *Panicum amarulum*, sparse *Morella cerifera, Amorpha fruticosa*, and young *Pinus taeda* and *Taxodium distichum*. The other example, at the mouth of the Roanoke River, has a vegetation plot with an open canopy of *Acer rubrum* and *Acer negundo*, with smaller amounts of *Nyssa biflora* and *Taxodium distichum* (Rice and Peet 1997). However, a later visit by the author to the same vicinity, several years after a hurricane, found only a few young trees, along with an overall composition that was different in many ways. This site has extensive cover of vines, with *Nekemias* (*Ampelopsis*) *arborea* dominant, and *Parthenocissus quinquefolia*, *Muscadinia rotundifolia*, *Smilax rotundifolia*, *Clematis crispa*, and *Berchemia scandens* abundant. In the plot, *Sicyos angulata* also was abundant. *Sambucus canadensis* was the most abundant shrub. Herbs include *Laportea canadensis*, *Boehmeria cylindrica*, *Impatiens capensis*, *Elymus* sp., *Saururus cernuus*, *Onoclea sensibilis* var. *sensibilis, Viola* spp., *Dichanthelium* sp., *Rumex verticillatus*, *Commelina virginica*, *Persicaria punctata*, *Peltandra virginica*, *Physalis* sp., *Xanthium strumarium*, and a wide variety of others, all at low density. Other examples may be quite different from either of these.

Range and Abundance: Ranked G2. There is substantial uncertainty about abundance because of uncertain circumscription. If interpreted narrowly, as described in the NVC, it should be G1, if not GX. As defined more broadly in the 4th Approximation, this community should probably be G2G3 or G2?. It is potentially present on any exposed estuarine shoreline, but conditions for its occurrence apparently are quite rare. However, examples may be overlooked and not described in reports. At present, this community is known only in the wind tidal areas of North Carolina.

Associations and Patterns: Examples may grade inland to Tidal Swamp, Estuarine Fringe Pine Forest, or potentially to upland communities. In the best known example, the offshore side is bordered by sparse trees rooted in the water.

Variation: This community is defined conceptually, and examples may vary substantially in vegetation structure and composition, both among sites and temporally at a single site. At present, each known example bears little resemblance to the others. Variation reflects the accidents of establishment of species after natural disturbances, but also reflects thet seed rain from adjacent communities. Species composition may vary with the setting, reflecting association with brownwater or blackwater rivers or with isolated estuarine shorelines.

Dynamics: These communities are subject to significant natural disturbance by wind, wave action in storms, and potentially salt intrusion in storms. Disturbance is frequent enough that closed swamp or marsh vegetation does not form, though the environment would otherwise be capable of supporting it. Trees may seldom live long, though the Roanoke River plot contained a few trees up to a foot in diameter. These may be regarded as primary successional communities, or as a cyclic succession caused by periodic severe natural disturbance. As with other chronically disturbed communities, they appear particularly susceptible to invasion by exotic plants.

Comments: This is one of the least well known or well defined communities in the 4th Approximation, yet its environment and vegetation appear to justify its recognition. It was initially defined and added to the NVC on the basis of the single plot at the mouth of the Roanoke River, and the NVC name describes that plot. It may be that no other example with that particular vegetation will be found, and the vegetation at that location has already substantially changed. But a conceptual community, based on the distinctive environment, ecological dynamics, and more general characteristics of the flora, seems appropriate at least for the present. Based on the one plot, this community was initially called Estuarine Beach Forest. However, the more typical condition is probably sparse vegetation, as the plot location now has. A rather different community described by Frost (1989) on lower Albemarle Sound has sparser trees.

This community does not fit cleanly into any theme. It is placed in the Maritime Wetlands theme because of its wetland hydrology, association with estuaries, but lack of regular tidal flooding. However, it appears to be closely associated with Freshwater Tidal Wetlands communities. It might almost as readily be placed there, but it does not have regular or frequent tidal flooding.

Rare Species: No rare species are known to be specifically associated with this community.

FRESHWATER TIDAL WETLANDS THEME

Concept: Freshwater Tidal Wetlands are marshes and swamps that experience regular lunar tidal or irregular wind tidal flooding with water less salty than brackish. Salinity ranges from oligohaline to fully fresh, though saltier water may intrude along the bottom of adjacent estuaries and saltier water may flood them during storm tides.

Distinguishing Features: Freshwater Tidal Wetlands are distinguished from all other themes by the occurrence of tidal flooding along with vegetation indicative of freshwater or oligohaline conditions. The distinction of Tidal Swamps from riverine swamps can be especially subtle; canopies may be the same but often show a composition more intermediate between blackwater and brownwater swamps, marking a change from vegetation upstream. Lower strata are usually but not always more diverse. *Morella cerifera* and *Rosa palustris* are frequently abundant in Tidal Swamps but scarce or absent in riverine swamps. Other indications of tidal influence include appearance of patches of Tidal Freshwater Marsh, with the Broadleaf Pondlily, Narrowleaf Pondlily, and Southern Wild Rice subtypes, in particular, occurring inland to near the upstream extent of tidal influence.

Within the theme, Tidal Freshwater Marshes are distinguished by dominance of herbaceous or shrub or mixed vegetation, with trees present only as sparse canopies (occasionally up to 50% tree cover). Floating-leaf aquatic plants (*Nuphar* spp.) are also included. The Freshwater Marsh Pool community has submerged aquatic vegetation in small areas surrounded by other Tidal Freshwater Wetlands. More extensive submersed aquatic vegetation is not yet represented in this classification but might also be placed within this theme. Tidal Red Cedar Swamp is distinguished by an open canopy of *Juniperus silicicola* in a matrix of herbaceous vegetation, often associated with substantial fine-scale microtopography that allows the species to coexist. Tidal Swamps are dominated by trees of other species in closed or open canopies.

Sites: These communities occur on broad flats and intertidal bands along the shorelines of estuaries and tidally influenced rivers. They range from sea level to a few feet above, depending on the tidal range.

Soils: Soils range from alluvial soils to marsh soils. They are usually organic but may be mucky mineral soils.

Hydrology: Tidal flooding ranges from lunar to wind tidal. The distinction between these may create important differences in dynamics (Odum et al. 1984). In the southern part of the state, where barrier islands are short and tidal ranges the highest, semidiurnal lunar (astronomical) tidal fluctuations propagate up rivers and creeks upstream of where salt or brackish water floods the banks. Partially this is caused by water damming — the high tide downstream blocking the flow of the river's fresh water. Penetration of a salt wedge along the bottom of rivers may also push fresh or oligohaline surface water into adjacent wetlands without subjecting them to higher salinity. In the northern part of the state, continuous barrier islands with few inlets and low tidal range in the ocean result in little lunar tidal influence. At the same time, the broader estuaries are more subject to effects of persistent winds, which can raise or lower water levels by one or two feet, in tidal fluctuations that can then penetrate upstream on tidal creeks and flood adjacent wetlands. Wind tidal fluctuations may be slow but can be observed to be rapid at times.

Water is fresh or oligohaline because of limited exchange with sea water, combined with dilution by fresh water from rainfall and river flow. Freshwater Tidal Wetlands that are closer to brackish or salt water may be penetrated by saltier water during unusual events such as storm surges, but saltier conditions do not persist.

Vegetation: Vegetation structure ranges from closed forests to dense tall herbaceous vegetation, short dense to sparse herbaceous vegetation, and floating or submersed aquatic plants. Swamps are dominated by combinations of *Nyssa biflora*, *Nyssa aquatica, Taxodium distichum, Acer rubrum*, and *Fraxinus pennsylvanica*. Marshes may be near monocultures of *Spartina cynosuroides, Cladium jamaicense*, *Typha* spp., *Zizaniopsis miliacea*, or a few other species, by virtue of the large size and clonal growth excluding smaller plants. However, they often are more diverse mixtures of other graminoid and broadleaf herbaceous species. Shrubs, especially *Morella cerifera*, but sometimes *Baccharis halimifolia*, *Persea palustris* or other species may also be prominent or dominant. Woody vines, especially *Toxicodendron radicans*, may be abundant. Freshwater Tidal Wetlands usually contain more plant species than the saltier Estuarine Communities, and some subtypes of both Tidal Freshwater Marsh and Tidal Swamp are quite diverse.

Dynamics: Short term dynamics of Freshwater Tidal Wetlands are driven by tidal water movement, which brings nutrients into the ecosystem and makes them more fertile and productive than most nontidal wetlands.

Salt concentration is an important determinant of communities and vegetation zones, separating different Freshwater Tidal Wetland communities from each other as well as driving the boundary between them and Estuarine Communities. Salt acts as a stress that excludes freshwater wetland species from more brackish areas. Transplant studies cited in Gilbert, et al. (2012) found that freshwater marsh sod planted in brackish marshes died quickly from salt stress, while brackish marsh sod planted in freshwater areas died slowly from competition. The occasional penetration of brackish water into freshwater marshes and swamps, driven by hurricanes and other storms, is an important natural disturbance in these communities, but one that may be intensified to abnormal levels by rising sea level and increases in storm frequency. Because these marshes contain many plant species not tolerant of brackish conditions, much of the vegetation is damaged by these events. The frequency and severity of brackish water intrusion likely is responsible for much of the zonation among these communities. Natural shifting of channels and artificial ditching can modify these patterns. Gilbert, et al. (2012) noted that there were studies showing that drought could lead to increases in more salt tolerant species and others that did not show such an effect. Hackney (1990) suggested that nor'easters may be more important because they are not accompanied by as heavy rains as hurricanes are.

Other dynamics may be occurring among different subtypes due to the ability of several dominant plant species to spread vegetatively. These are not well known, but Frost (2000) suggested that fire may be important for maintaining some of the lower stature communities such as the Oligohaline Low Marsh Subtype, from expansion by larger stature subtypes.

The long term dynamics of Freshwater Tidal Wetlands are driven by the ongoing natural and now anthropogenic rise in sea level. Increasing water levels make local areas wetter, extend tidal influence farther inland, and allow more brackish estuarine waters to extend into fresher areas. All Freshwater Tidal Wetlands should be regarded as in transition to wetter and saltier communities. Often this transition is slow, but it may happen abruptly in local areas. Vegetation that is under stress by increased wetness can be killed over sizeable areas by a single salt intrusion event and regenerate as a different community. Many Tidal Swamps can be seen to be under stress, with canopies thinning, individual trees showing reduced crowns, and shrub and herbaceous marsh vegetation establishing beneath them. Vast “ghost forests” of recently dead swamp can be seen along the sounds. This process can be exacerbated and accelerated by artificial alterations. A recent artificial transition from swamp to marsh can often be observed along ditches that are connected to estuarine waters. Hackney (1990) noted that the tidal range of the Cape Fear River estuary has increased with each dredging of the shipping channel, as well as that the sea level has risen by nearly a foot there. All of the colonial era rice fields are in areas now too salty to grow rice. He also noted that some tidal swamps had trees growing on old stumps, but that nearby old rice fields that had no stumps had become marshes.

Though more attention has focused on Salt Marsh and Brackish Marsh, similar processes of gradual drowning, expansion of pools, eventual breakup of marsh patches, and increased shoreline erosion as open water expands also may occur in Tidal Freshwater Marshes. Accumulation of organic or mineral sediment has offset this effect in the past and continues to in many areas, especially those with regular lunar tides or substantial sediment input. However, large expanses of Tidal Freshwater Marsh on open wind tidal estuaries are particularly at risk. The proposed technique of thin layer sediment application being tried experimentally in Salt Marshes is even more problematic in these marshes. Burying their organic soils with mineral sediment represents a more drastic alteration to the ecosystem, while the greater complexity of interactions among their more diverse flora and fauna almost certainly makes them more sensitive to such alteration.

Comments: Tidal Freshwater Marsh has more subtypes than any other community type. Most occur as zones or as apparently random patches in a mosaic. Many are based on a single dominant species that spreads clonally, but other portions of marsh complexes have mixed vegetation that is intermediate between two or more of the subtypes. In particular, the Giant Cordgrass, Sawgrass, Threesquare, and Cattail subtypes tend to occur together. The Needlerush Subtype also is a major part of this mosaic in the Currituck Sound area. It is unclear if these represent stable mosaics or if the subtypes shift over time. With further study, it may be appropriate to lump these into a single subtype. However, the relative amounts of each vary, and some are absent from particular sites, suggesting some value in attempting to track each specifically. The other subtypes are more distinct and are associated with different kinds of sites.

Taxodium distichum / *Typha angustifolia* Woodland (CEGL004231) and several other tidal *Taxodium distichum* woodlands have been recognized in Virginia and attributed to North Carolina. These do not appear to be distinct enough to be appropriate as community elements. *Taxodium* groves may be present in most of the Tidal Freshwater Marsh subtypes.

KEY TO FRESHWATER TIDAL WETLANDS

1. Vegetation a forest or woodland; tree cover generally greater than 25% unless recently disturbed.

2. Canopy dominated by *Nyssa biflora, Nyssa aquatica*, or *Taxodium distichum*, in some combination..**Tidal Swamp (Cypress—Gum Subtype)**

2. Canopy dominated by *Fraxinus pennsylvanica, Pinus taeda, Ulmus americana, Fraxinus profunda* in some combination, or by *Juniperus silicicola*; if *Taxodium* or *Nyssa* are present, they are a minority of the canopy.

3. Canopy dominated by *Juniperus silicicola*; undergrowth consists of herbaceous species of marshes, often larger graminoids or more salt-tolerant forbs ....**Tidal Red Cedar Forest**

3. Canopy dominated by combinations of *Fraxinus pennsylvanica, Pinus taeda, Ulmus americana,* and *Fraxinus profunda*, though *Juniperus silicicola* may be abundant; undergrowth often shared with marshes, sometimes larger graminoids and more salt-tolerant forbs but generally with abundant species less tolerant of salt. .... **Tidal Swamp (Mixed Subtype)**

1. Vegetation not a forest or woodland; tree cover less than 25%, or somewhat more but of relict trees that are not regenerating, or of young trees that are not expected to mature because of normal natural disturbances or salt exposure; vegetation herbaceous, shrub-dominated, or, occasionally, sparse or limited to aquatic plants.

4. Vegetation limited to submerged or floating aquatic plants in deeper water, sparse plants on a mud flat, or small plants on a low fringe of a marsh complex; sites permanently flooded or exposed only during the lowest part of normal tidal ranges.

5. Community largely aquatic, consisting of submersed or floating aquatic vegetation; always flooded.

6. Community consisting of submersed plants in a deep pool surrounded by marsh. .... **Freshwater Marsh Pool**

6. Community consisting of floating-leaf or free-floating plants; occurring in permanent water within a stream or river channel, often bordered by Tidal Swamp and not associated with other marshes.

7. Community dominated by *Nuphar*.

8. Community dominated by *Nuphar advena*. ....**Tidal Freshwater Marsh (Broadleaf Pondlily Subtype)**

8. Community dominated by *Nuphar sagittifolia* .... **Tidal Freshwater Marsh (Narrowleaf Pondlily Subtype)**

7. Community dominated by free-floating plants such as *Hydrocotyle ranunculoides* and presently often *Alternanthera philoxeroides*; occurring in a river or stream channel; normally inland beyond tidal influence but sometimes extending into tidal reaches. ....**Riverine Floating Mat**

5. Community not largely aquatic, consisting of sparse to dense small plants such as *Eleocharis*, *Lilaeopsis*, *Isoetes, Eriocaulon*, or other smaller plants not characteristic of any Tidal Freshwater Marsh subtype.

9. Vegetation sparse; site primarily bare mud; *Isoetes riparia* or other small plants predominate... **Tidal Mud Flat**

9. Vegetation moderate to dense; *Lilaeopsis, Eleocharis, Eriocaulon,* or similar species dominant; occurring as a fringe on the edge of marsh patches. ....**Tidal Freshwater Marsh (Shoreline Lawn Subtype)**

4. Vegetation dense, consisting of shrubs, large graminoids, or medium to large forbs.

10. Vegetation dominated by *Morella cerifera*, often with *Persea palustris, Toxicodendron radicans*, relict trees, and sometimes abundant snags and logs of a former tree canopy. .... **Tidal Freshwater Marsh (Shrub Subtype)**

10. Vegetation dominated by herbs; relict trees may occasionally be present in a sparse to moderate canopy but shrubs are absent or sparse.

11. Vegetation dominated by *Spartina cynosuroides*, sometimes but not always in nearly monospecific stands; usually occurring as a zone on the edges of oligohaline marsh complexes near the tidal channel or estuary .... **Tidal Freshwater Marsh (Giant Cordgrass)**

11. Vegetation not dominated by *Spartina cynosuroides*; settings various.

12. Vegetation dominated by *Cladium jamaicense*, sometimes but not always in dense monospecific stands; usually occurring as an interior zone in oligohaline marsh complexes, but sometimes on edges ...... **Tidal Freshwater Marsh (Sawgrass Subtype)**

12. Vegetation not dominated by *Cladium jamaicense*; settings various.

13. Vegetation dominated by *Juncus roemerianus*; dense or moderate in cover (but mixed with species less tolerant of brackish water that distinguish it from Brackish Marsh); usually occurring as an interior zone in oligohaline marsh complexes............. ....**Tidal Freshwater Marsh (Needlerush Subtype)**

13. Vegetation not dominated by *Juncus roemerianus*; settings various

14. Vegetation dominated by *Schoenoplectus (Scirpus) pungens*; sometimes but not always in dense monospecific stands; usually occurring as an interior zone in oligohaline marsh complexes, but sometimes on edges. .... **Tidal Freshwater Marsh (Threesquare Subtype)**

14. Vegetation not dominated by *Schoenoplectus pungens*; settings various

15. Vegetation dominated by *Typha latifolia, Typha angustifolia*, or *Typha domingensis*; sometimes but not always in dense monospecific stands; usually occurring as an interior zone in oligohaline marsh complexes, but sometimes on edges. .... **Tidal Freshwater Marsh (Cattail Subtype)**

15. Vegetation not dominated by *Typha* sp.; settings various.

16. Vegetation dominated by *Zizaniopsis miliacea*; most often occurring with no other marsh subtypes or only with the Broadleaf Pondlily or Narrowleaf Pondlily subtypes, but sometimes as a zone in the interior of oligohaline or fresher marsh complexes; usually in fresher water rather than oligohaline....................... .... **Tidal Freshwater Marsh (Southern Wild Rice Subtype)**

16. Vegetation not dominated by *Zizaniopsis miliacea*; vegetation generally a dense stand of medium size or small plants in a more diverse mix.

17. Vegetation generally dominated by forbs such as *Peltandra, Sagittaria, Pontederia*, or *Impatiens*, though smaller graminoids such as *Carex* may also be abundant; water fresher than oligohaline; many species intolerant of moderate salt levels present; *Juncus roemerianus, Cladium jamaicense, Spartina patens*, and *Schoenoplectus pungens* generally absent; usually occurring alone or only with the Broadleaf Pondlily, Narrowleaf Pondlily, or Southern Wild Rice subtypes.. .... **Tidal Freshwater Marsh (Mixed Freshwater Subtype)**

17. Vegetation variable but generally with abundant *Eleocharis* sp., along with *Sagittaria lancifolia* var. *media* (*falcata*), *Pontederia cordata*, and a wide variety of both graminoids and forbs; water oligohaline; species intolerant of moderate salt levels may be present but species more typical of oligohaline conditions such as *Cladium jamaicense, Schoenoplectus pungens*, *Juncus roemerianus*, and *Spartina cynosuroides* are generally present; occurring in the interior of oligohaline marsh complexes, associated with the Sawgrass, Threesquare, Needlerush, Giant Cordgrass, or Cattail Subtype. .... **Tidal Freshwater Marsh (Oligohaline Low Marsh Subtype)**

TIDAL FRESHWATER MARSH (GIANT CORDGRASS SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Giant Cordgrass Subtype covers the common, though often narrow, zones dominated by *Spartina cynosuroides*. This subtype has a broad range of salt tolerance and may occur with marginally brackish to fully fresh water.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Giant Cordgrass Subtype is distinguished from all other subtypes by the strong or weak dominance of *Spartina cynosuroides*. Because this species is more tolerant of salt, it may sometimes occur in association with Brackish Marsh as well as with other subtypes of Tidal Freshwater Marsh.

Crosswalks: *Spartina cynosuroides* South Atlantic Tidal Marsh (CEGL009014).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Giant Cordgrass Subtype community occurs on intertidal flats and shorelines along the sounds and tidal creeks and rivers. It is most often in zoned mosaics with other subtypes, usually forming a band on the edge of the open water or larger tidal channels.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Currituck (Terric Haplosaprist) but often Lafitte, Hobonny, or Dorovan (Typic Haplosaprists). A few may be mineral soils such as Chowan (Thapto-histic Fluvaquent).

Hydrology: The Giant Cordgrass Subtype is regularly or irregularly flooded by lunar or wind tides in oligohaline waters, occasionally in areas that are nearly brackish in salinity. The salinity tolerance of this subtype slightly overlaps that of Brackish Marsh.

Vegetation: The Giant Cordgrass Subtype consists of dense tall herbaceous vegetation dominated by *Spartina cynosuroides*. This may be almost the only species in some areas, but it may be mixed with any of a number of other species and be only weakly dominant. Based on 32 CVS plots of this subtype in North Carolina, species that are sometimes codominant or abundant include *Juncus roemerianus, Cladium jamaicense, Typha angustifolia, Typha domingensis, Zizaniopsis miliacea, Schoenoplectus pungens, Bolboschoenus robustus, Spartina patens*, *Carex hyalinolepis, Thelypteris palustris* var. *pubescens, Morella cerifera, Baccharis halimifolia*, and, beneath the taller vegetation, *Eleocharis* spp. Other species frequently present include *Hibiscus moscheutos, Kosteletzkya pentacarpos, Rosa palustris, Amorpha fruticosa, Sagittaria lancifolia* var. *media*, *Persicaria sagittata, Iresine rhizomatosa, Ptilimnium capillaceum, Amaranthus cannabinus, Hydrocotyle verticillata, Persicaria punctata, Boehmeria cylindrica*, and *Osmunda spectabilis*.

Range and Abundance: The newly defined association crosswalked to the subtype does not yet have a global rank. It probably is G4.

Associations and Patterns: The Giant Cordgrass Subtype most often occurs in zoned mosaics with the Sawgrass, Needlerush, Cattail, Threesquare, and Shrub subtypes, but it can also be with the Southern Wild Rice, Oligohaline Low Marsh, or other subtypes or with Freshwater Marsh Pool. It often is primarily a narrow band along tidal channels and shorelines, with the other subtypes forming a mosaic in the interior. Occasionally it occurs alone in extensive dense patches. It may occasionally occur in association with Brackish Marsh, usually upstream of it along tidal creeks but possibly inland of it in a marsh complex.

Variation: Two variants are recognized, based on flooding dynamics and presumed differences in animal and microbial components and in ecosystem processes, though these are not associated with known vegetation differences. Plot data show some differences in species composition, but most are in species with low constancy and do not reflect any known association with the regions. A possible exception is abundant *Schoenoplectus pungens* in northern wind tidal areas.

1. Wind Tidal Variant occurs in areas remote from tidal inlets, where tidal flooding is irregular and largely driven by wind.

2. Lunar Tidal Variant occurs in areas with closer connection to the ocean or larger tidal range, with regular semidiurnal tidal flooding.

Dynamics: Dynamics are typical of the theme, but by occurring along channels and shorelines, this subtype likely is more subject to saltwater intrusion and to erosion or disturbance by wave action.

Comments: *Spartina cynosuroides* Salt Marsh (CEGL004195) was formerly the primary crosswalk for this community. Its definition was changed to make it a more narrowly northern association that does not apply to North Carolina. Another association, *Spartina cynosuroides - Panicum virgatum - Phyla lanceolata* Salt Marsh (CEGL007741), is a rare specialized *Spartina cynosuroides* community in the wind tidal areas of southern Virginia. It is not known to occur in North Carolina but possibly could be found. *Panicum virgatum* is sometimes present in North Carolina's examples of the Giant Cordgrass Subtype but without high constancy. A general vegetational distinction between wind tidal and lunar tidal examples has not been recognized in North Carolina.

Although recognized in the NVC, the Giant Cordgrass, Sawgrass, Cattail, and Needlerush subtype may be only marginally distinct. They usually occur in mosaics with each other, may share dominants with each other, and have substantial floristic overlap. Because it is associated with the shoreline, the Giant Cordgrass is the most distinct of the four.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Bolboschoenus novae-angliae, Boltonia asteroides* var. *glastifolia, Carex decomposita, Eleocharis fallax?, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*)?, *Lilaeopsis carolinensis, Limosella australis, Ludwigia alata,*

Ludwigia brevipes, Oenothera riparia, Ptilimnium ahlesii, Ptilimnium costatum?, Ranunculus hederaceus, Spartina pectinata and *Utricularia macrorhiza*.

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Laterallus jamaicense, Malaclemys terrapin, Nerodia sipedon williamengelsi,* and *Notropis bifrenatus*.

Invertebrate animals – *Catinella pugilator, Euphyes dukesi dukesi, Meropleon cinnamicolor,* and *Problema bulenta*.

TIDAL FRESHWATER MARSH (SAWGRASS SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Sawgrass Subtype covers the common zones in oligohaline areas, dominated by *Cladium jamaicense*.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Sawgrass Subtype is distinguished from all other subtypes by the dominance of *Cladium jamaicense*. It is one of the most salt-tolerant subtypes and may extend into areas approaching brackish.

Crosswalks: *Cladium mariscus* Tidal Salt Marsh (CEGL004178).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Sawgrass Subtype occurs on broad intertidal flats and shorelines, most often in zoned mosaics with other subtypes. Patches may be in either the marsh interior or on the edges adjacent to tidal channels.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Currituck (Terric Haplosaprist), but often Lafitte, Hobonny, or Dorovan (Typic Haplosaprists). A few may be on mineral soils such as Chowan (Thapto-histic Fluvaquent).

Hydrology: The Sawgrass Subtype is regularly or irregularly flooded by lunar or wind tides in oligohaline waters, occasionally in areas that are nearly brackish in salinity. The salinity tolerance of this subtype slightly overlaps that of Brackish Marsh.

Vegetation: The Sawgrass Subtype consists of dense tall herbaceous vegetation dominated by *Cladium jamaicense*. Dominant species of other subtypes may sometimes be abundant or even codominant, including *Spartina cynosuroides, Typha angustifolia*, *Typha domingensis,* or *Schoenoplectus pungens*. Exotic *Phragmites australis* may become established and displace nearly all native plants. The native *Phragmites americana* may also occur, though its distribution is not well known. While some patches may be nearly monospecific *Cladium*, many are quite diverse. In 16 CVS plots of this subtype in North Carolina, other frequent species were *Osmunda spectabilis*, *Hibiscus moscheutos, Thelypteris palustris* var. *pubescens, Sagittaria lancifolia*, and *Mikania scandens*. Other species occasionally abundant to codominant were *Kosteletzkya pentacarpos, Juncus roemerianus, Centella erecta, Hydrocotyle bonariensis,* and *Symphyotrichum* sp. Approximately 110 additional plant species were found in the 16 plots at low frequency. Woody species are often present at low density, most frequently *Morella cerifera*, *Toxicodendron radicans*, *Baccharis halimifolia*, and *Rosa palustris*, but sometimes *Persea palustris*, *Pinus taeda*, *Acer rubrum*, or *Taxodium distichum*.

Range and Abundance: Ranked G4? This community is abundant in the freshwater tidal zones of North Carolina, and usually is one of the most extensive subtypes. The equivalent association ranges from North Carolina southward and westward to Louisiana.

Associations and Patterns: The Sawgrass Subtype most often occurs in zoned mosaics with the Giant Cordgrass, Needlerush, Cattail, Threesquare, and Shrub Subtype, sometimes with Oligohaline Low Marsh or other subtypes or with Freshwater Marsh Pool. It usually occurs as extensive patches in the marsh mosaic, both along channels and in the marsh interior. It occasionally occurs in association with Brackish Marsh, usually upstream of it along tidal creeks or landward of it in marsh complexes.

Variation: Two variants are recognized, based on flooding dynamics and presumed differences in animal and microbial components and in ecosystem processes. Plot data show some differences in species, but these are not believed to be related to environmental or regional differences:

1. Wind Tidal Variant occurs in areas remote from tidal inlets, where tidal flooding is irregular and largely driven by wind.

2. Lunar Tidal Variant occurs in areas with closer connection to the ocean or greater tidal range, with regular semidiurnal tidal flooding.

Dynamics: Dynamics are typical of the theme. This subtype usually occurs in association with other subtypes, and it is unclear if the patches are stable or shift over time. Patches could be a simple result of clonal growth and dominance by *Cladium*, part of a long term successional trajectory, or a reflection of microsite differences.

Comments: Although recognized in the NVC, Giant Cordgrass, Sawgrass, Cattail, and Needlerush subtypes may be only marginally distinct. They usually occur in mosaics with each other, may share dominants with each other, and have substantial floristic overlap. However, patches dominated by any one of these species may cover many acres in a marsh complex. Additionally, *Cladium* and *Spartina cynosuroides* are more salt-tolerant than most of the other dominants, and they subtypes can thus extend into areas where the other subtypes are absent. The contrasting names of the NVC association and group indicate the broad salt tolerance of this subtype.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Bolboschoenus novae-angliae, Boltonia asteroides var. glastifolia, Eleocharis fallax, Eleocharis parvula, Eleocharis uniglumis* (*halophila*), *Lilaeopsis carolinensis, Ludwigia alata, Ludwigia brevipes, Ptilimnium ahlesii, Ptilimnium costatum,* and *Utricularia macrorhiza.*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Circus cyaneus, Ixobrychus exilis, Laterallus jamaicensis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Catinella pugilator, Meropleon cinnamicolor, Poanes aaroni aaroni,* and *Problema bulenta.*

TIDAL FRESHWATER MARSH (NEEDLERUSH SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Needlerush Subtype covers the zones dominated or codominated by *Juncus roemerianus* in wind tidal oligohaline areas in the northeastern part of the state.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Needlerush Subtype is distinguished from all other subtypes by the dominance or codominance of *Juncus roemerianus* in an oligohaline setting. It is distinguished from the Needlerush Subtype of Brackish Marsh by the presence of less salt-tolerant plants such as *Thelypteris palustris* var. *pubescens*, *Osmunda spectabilis*, *Sagittaria falcata*, *Eleocharis fallax*, *Pontederia cordata*, or by association with other Tidal Freshwater Marsh subtypes.

Crosswalks: *Juncus roemerianus - Pontederia cordata* Tidal Marsh (CEGL004660).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Needlerush Subtype occurs on intertidal flats and shorelines of oligohaline estuaries, most often in zoned mosaics with other subtypes. Patches are most often in the marsh interior but may extend to the shoreline or occur along tidal channels. The most extensive areas are on the back side of the Currituck Banks and appear to be relict flood tidal deltas, similar to back-barrier salt marshes elsewhere.

Soils: Most occurrences have organic soils, most often Currituck (Terric Haplosaprist) but often Hobonny (Typic Haplosaprists). A few may be mineral soils such as Conaby (Histic Humaquept).

Hydrology: All known examples of the Needlerush Subtype have wind tidal flooding and are along oligohaline estuaries.

Vegetation: The Needlerush Subtype consists of dense tall herbaceous vegetation dominated by *Juncus roemerianus*. Dominant species of other subtypes may sometimes be abundant or even codominant, including *Spartina cynosuroides, Typha angustifolia*, *Typha domingensis, Cladium jamaicense*, or *Schoenoplectus pungens*. Exotic *Phragmites australis* may become established and displace nearly all native plants. The native *Phragmites americana* may also occur, though its distribution is not well known. In 9 CVS plots for this subtype in North Carolina, other species frequently abundant were *Mikania scandens, Sagittaria lancifolia* var. *media*, *Hibiscus moscheutos*, *Schoenoplectus* spp., and *Ptilimnium capillaceum*. Other species occasionally abundant included *Galium obtusum*, *Hydrocotyle verticillata*, *Osmunda spectabilis, Persicaria sagittata*, *Proserpinaca palustris, Persicaria arifolia,* and *Thelypteris palustris* var. *pubescens*. Some 50 additional species were present in the plots at low frequency, and any species of the associated subtypes could also potentially occur. Woody species may be present at low density, including *Morella cerifera*, *Toxicodendron radicans*, *Baccharis halimifolia*, *Rosa palustris*, *Persea palustris*, *Pinus taeda*, *Acer rubrum*, and *Taxodium distichum*.

Range and Abundance: Ranked G2G3. This community is known only in the northeastern part of the state, primarily in and around Currituck Sound. It is also known from adjacent Virginia in this area. It can be fairly extensive in these areas.

Associations and Patterns: The Needlerush Subtype most often occurs in zoned mosaics with the Giant Cordgrass, Sawgrass, Cattail, Threesquare, and Shrub Subtype, sometimes with Oligohaline Low Marsh or other subtypes or with Freshwater Marsh Pool. It is most often in the marsh interior, where it may form large patches.

Variation: No variants are recognized.

Dynamics: Dynamics are uncertain. The primary range for this subtype, Currituck Sound and its vicinity, is isolated from the ocean by continuous barrier islands, but this is a relatively recent situation. The last inlet on the Currituck Banks closed in 1828. The Tidal Freshwater Marshes have developed since that time in areas that were previously salt and brackish. It has been suggested that the *Juncus roemerianus* marshes are relict from a time of saltier water. This would suggest that they developed their distinctive composition by the addition of salt-intolerant species, while also receding in the face of invasion of vegetative spread by the dominants of the other subtypes. Such invasion would have to be irregular, since the present pattern is one of a mosaic of subtypes. A decrease in area of this subtype over time should be looked for, but so far has not been documented.

The long-term fate of this subtype is highly uncertain. Rising sea level and a future period of increased storm intensity likely will eventually breach the Currituck Banks. Once a new inlet forms, it is unclear if tides will keep it open. Tidal range remains low in this area, and the processes that closed previous inlets may continue to operate. If long-lasting new inlets form, the oligohaline marshes in the sound, including the vast majority of acreage of this subtype, probably will disappear.

Comments: Although recognized in the NVC, the Giant Cordgrass, Sawgrass, Cattail, and Needlerush subtypes may be only marginally distinct. They usually occur in mosaics with each other, may share dominants with each other, and have substantial floristic overlap.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Bolboschoenus novae-angliae, Eleocharis fallax, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*), *Lilaeopsis carolinensis, Limosella australis, Ludwigia alata, Ludwigia brevipes, Ranunculus hederaceus,* and *Utricularia macrorhiza.*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon*.

Invertebrate animals – *Catinella pugilator* and *Euphyes dukesi dukesi*.

TIDAL FRESHWATER MARSH (THREESQUARE SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Threesquare Subtype covers the uncommon zones dominated or codominated by *Schoenoplectus* (*Scirpus*) *pungens* in association with other salt-intolerant plants. These zones generally occur in the interior of oligohaline marshes.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Threesquare Subtype is distinguished from all other subtypes by the dominance of *Schoenoplectus pungens* or by its codominance with species other than the dominants of other subtypes.

Crosswalks: *Schoenoplectus pungens* - (*Osmunda regalis* var. *spectabilis*) Tidal Marsh (CEGL004189).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Threesquare Subtype occurs on intertidal flats, usually in the interior of zoned mosaics with other subtypes.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Currituck (Terric Haplosaprist) but often Lafitte, Hobonny, or Dorovan (Typic Haplosaprists). A few may be mineral soils such as Chowan (Thapto-histic Fluvaquent).

Hydrology: The Threesquare Subtype is regularly or irregularly flooded by lunar or wind tides in oligohaline waters. Though this is not clear, this subtype may be associated with interior areas where water pools, so that evaporation concentrates salt more than in the rest of the marsh.

Vegetation: The Threesquare Subtype consists of dense or moderate tall herbaceous vegetation dominated by *Schoenoplectus pungens*. Woody species may be sparsely present, as in other subtypes. In 6 CVS plots of this subtype, other species that were frequently abundant were *Juncus roemerianus, Distichlis spicata, Spartina patens*, *Mikania scandens*, and *Pluchea odorata*. Other species occasionally abundant to codominant were *Sagittaria lancifolia* var. *media*, *Bacopa monnieri, Eleocharis vivipara, Eleocharis obtusa, Bolboschoenus robustus, Proserpinaca pectinata, Osmunda spectabilis, Hydrocotyle verticillata, Typha angustifolia*, and *Baccharis halimifolia*. At least in the plots, this subtype's species richness is lower than the associated subtypes, with only about 20 additional species found in the plots, and an average of only 8 plant species per 10x10 meter plot.

Range and Abundance: Ranked G2G3. As defined, this subtype is confined to North Carolina. It is known both from the wind tidal marshes of the Embayed Region and the lunar tidal freshwater marshes of southeastern North Carolina.

Associations and Patterns: The Threesquare Subtype often occurs in mosaics with the Giant Cordgrass, Sawgrass, Needlerush, Cattail, Oligohaline Low Marsh Subtype. It may grade particularly gradually into the latter.

Variation: No variants are recognized. Examples vary with the transition to other subtypes.

Dynamics: Dynamics appears to be similar to those of associated subtypes. The hypothesis of ponding of water and concentration of salt by evaporation is uncertain, but the frequent presence of *Distichlis spicata*, more than in other subtypes, suggests it. The lower species richness would also be consistent with this. Thus, this subtype may be in a more stressful environment and have lower productivity.

Comments: There has been confusion over the nomenclature and identity of the dominant species. Some site descriptions list *Scirpus americanus* or *Schoenoplectus americanus* as dominant, but presumably these are the same species now known as *Schoenoplectus pungens*.

Schoenoplectus pungens Tidal Salt Marsh (CEGL004188) is a more northern, but also more brackish, association in states to the north. The existence of this more northern association appears to be why this equivalent association is defined with so narrow a range.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Bolboschoenus novae-angliae, Carex hormathodes, Eleocharis fallax, Eleocharis parvula, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*), *Lilaeopsis carolinensis, Ludwigia alata, Ludwigia brevipes, Ptilimnium ahlesii, Ptilimnium costatum, Ranunculus hederaceus,* and *Utricularia macrorhiza*.

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Laterallus jamaicensis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Catinella pugilator, Euphyes dukesi dukesi,* and *Problema bulenta*.

TIDAL FRESHWATER MARSH (CATTAIL SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Cattail Subtype covers Tidal Freshwater Marsh zones dominated or codominated by *Typha latifolia, Typha angustifolia*, or *Typha domingensis*. These generally occur in the interior of oligohaline marshes.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Cattail Subtype is distinguished from all other Tidal Freshwater Marsh subtypes by the dominance of some species of *Typha,* or by the codominance of *Typha* with species other than the dominants of other subtypes. It is distinguished from other communities which may be dominated by *Typha*, such as Interdune Marsh and Coastal Plain Semipermanent Impoundment, by occurring in tidal wetlands and by being associated with species typical of those communities. Brackish Marsh (Transitional Subtype) may have local patches of *Typha*, which might dominate a small vegetation plot but are unlikely to cover a larger area.

Crosswalks: *Typha angustifolia – Typha latifolia* South Atlantic Tidal Marsh (CEGL009011).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Cattail Subtype occurs on intertidal flats and shorelines, in zoned mosaics with other subtypes. Patches are usually in the marsh interior.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Currituck (Terric Haplosaprist) but often Hobonny or Dorovan (Typic Haplosaprists). A few may be mineral soils such as Chowan (Thapto-histic Fluvaquent).

Hydrology: The Cattail Subtype is regularly or irregularly flooded by lunar or wind tides in oligohaline waters.

Vegetation: The Cattail Subtype is dominated by *Typha angustifolia, Typha domingensis*, or *Typha latifolia*, most often by *T. angustifolia*. The dominants of other subtypes, particularly *Juncus roemerianus, Spartina cynosuroides, Schoenoplectus pungens*, and *Cladium jamaicense,* may be abundant or occasionally codominant. In 11 CVS plots, frequent species include *Sagittaria lancifolia* var. *media*, *Ptilimnium capillaceum, Hydrocotyle verticillata, Hydrocotyle umbellata, Mikania scandens, Pontederia cordata, Osmunda spectabilis, Galium obtusum, Solidago sempervirens, Solidago mexicana, Eleocharis fallax, Pluchea* spp., *Hibiscus moscheutos*, and *Kosteletzkya pentacarpos*. Other fairly frequent species include several *Persicaria* species, *Bolboschoenus robustus, Carex hyalinolepis, Apios americana, Thelypteris palustris, Spartina patens*, *Lythrum lineare, Amaranthus cannabinus, Triadenum virginianum, Triadenum walteri, Sium suave, Cicuta maculata,* and *Toxicodendron radicans*. Woody species may be present at low density, including remnant *Taxodium distichum*, young *Acer rubrum*, *Morella cerifera, Baccharis halimifolia*, and less frequently, *Persea palustris* and other species of Tidal Swamps. Some examples are nearly monospecific stands, but many are very diverse. A large number of additional freshwater wetland species may be present.

Range and Abundance: The newly defined association crosswalked to the subtype does not yet have a global rank. It probably is G4. This subtype is widespread in North Carolina, occurring throughout the tidal regions of the state. It may range into South Carolina. The NVC association, which is only partially synonymous, is defined as widespread, ranging north to Maine. This large span of climate suggests the association may warrant splitting.

Associations and Patterns: The Cattail Subtype most often occurs in zoned mosaics with the Giant Cordgrass, Needlerush, Sawgrass, Threesquare, and Shrub Subtype, sometimes with Oligohaline Low Marsh or other subtypes or with Freshwater Marsh Pool. It usually occurs as extensive patches in the marsh mosaic, both along channels and in the marsh interior. It occasionally occurs in association with Brackish Marsh, usually upstream of it along tidal creeks.

Variation: Examples are extremely variable, but variation is not well understood. Variants could be recognized based on either flooding dynamics or dominant species. The *Typha* species are likely to reflect differences in salinity tolerance or biogeography. In cases with multiple species present, the variant can be named by the predominant species:

1.Narrowleaf Cattail Variant is dominated by Typha angustifolia.
2.Broadleaf Cattail Variant is dominated by Typha latifolia.
3.Southern Cattail Variant is dominated by Typha domingensis.

Dynamics: Dynamics are typical of the theme. This subtype usually occurs in association with other subtypes, and it is unclear if the patches are stable or shift over time. Patches could be a simple result of clonal growth and dominance by *Typha*, part of a long term successional trajectory, or a reflection of microsite differences.

Comments: The NVC association previously crosswalked to this community, *Typha angustifolia* - *Hibiscus moscheutos* Salt Marsh (CEGL004201), was narrowed in definition to be defined as a more northern community. It was a poor fit to this community. At this publication, there is no association that fits this subtype.

The vegetation description here is drawn from a combination of CVS plot data and NHP site descriptions. Both kinds of data are fairly abundant, but in both kinds of data there is uncertainty about the identity of the community in some examples. Some plots may be in marsh ecotones rather than this subtype, and many site descriptions do not distinguish this subtype from others. Both sources of information show substantial variability among examples. The different species of *Typha* have different levels of salt tolerance, and it may be inappropriate to lump them into a single subtype.

Although recognized in the NVC, the Giant Cordgrass, Sawgrass, Cattail, and Needlerush subtypes may be only marginally distinct. They usually occur in mosaics with each other, may share dominants with each other, and have substantial floristic overlap.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Bolboschoenus novae-angliae, Boltonia asteroides* var. *glastifolia*, *Carex decomposita, Carex hormathodes, Eleocharis fallax, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*), *Lilaeopsis carolinensis, Ludwigia alata, Ludwigia brevipes, Mononeuria (Sabulina) paludicola, Ptilimnium ahlesii, Ptilimnium costatum,* and *Utricularia macrorhiza,*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi.*

Invertebrate animals – *Catinella pugilator* and *Problema bulenta*.

TIDAL FRESHWATER MARSH (SOUTHERN WILD RICE SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Southern Wild Rice Subtype covers fringing marshes and marsh zones dominated by *Zizaniopsis miliacea*.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Southern Wild Rice Subtype is distinguished from all other subtypes by the dominance by *Zizaniopsis miliacea* or by the codominance of *Zizaniopsis* with species other than the dominants of other subtypes. It is distinguished from Interdune Ponds and other areas where *Zizaniopsis* may dominate by occurrence of lunar or wind tidal flooding or occurrence in association with other Tidal Freshwater Marsh or Tidal Swamp subtypes.

Crosswalks: *Zizaniopsis miliacea* Tidal Marsh (CEGL004705).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Southern Wild Rice Subtype sometimes occurs in marsh mosaics in intertidal flats with either lunar or wind tidal flooding. It also occurs along banks of tidal rivers and streams upstream of other Tidal Freshwater Marsh subtypes, adjacent to Tidal Swamp communities. The sites there are probably relict river bars, as they usually occur in similar positions along the channel.

Soils: Most examples have organic soils, generally mapped as Dorovan (Typic Haplosaprist). A few may occur on mineral soils such as Muckalee (Typic Fluvaquent). Small patches bordering rivers are not distinguished in soil mapping; they generally are included in organic soil map units of the adjacent swamps.

Hydrology: The Southern Wild Rice Subtype is regularly or irregularly flooded by lunar or wind tides, most often in fully fresh waters but sometimes in oligohaline waters.

Vegetation: The Southern Wild Rice Subtype consists of tall herbaceous vegetation dominated by *Zizaniopsis miliacea*, which may be moderate to very dense. Many occurrences are nearly monospecific, others are fairly diverse. Associated species typically are those less tolerant of salt, including *Boehmeria cylindrica, Elymus virginicus, Triadenum walteri, Peltandra virginica, Persicaria arifolia, Saururus cernuus, Persicaria punctata,* and *Mikania scandens*. Some examples have woody plants at low density, and those on river banks may have cover from trees or shrubs rooted in adjacent communities. Frequent woody species include *Taxodium distichum, Acer rubrum, Alnus serrulata*, and *Rosa palustris*.

Range and Abundance: Ranked G3G5. The acreage of this subtype in North Carolina is less than several other subtypes, because its patches tend to be smaller, but occurrences are numerous enough that G3 probably is inappropriate. The related association ranges from Virginia to Louisiana.

Associations and Patterns: The Southern Wild Rice Subtype often occurs as small patches along the banks of tidal rivers, where it may extend upstream nearly to the beginning of tidal influence. There it is bordered by Tidal Swamp and may be associated with the Broadleaf Pondlily, Narrowleaf Pondlily, or Mixed Freshwater Subtype. It may also occur in oligohaline marsh mosaics with the Threesquare, Sawgrass, Cattail, Giant Cordgrass, and other subtypes.

Variation: The two distinct settings where this subtype occurs are recognized as variants:

1. Riverbank Variant occurs in upstream settings in small patches on the banks of tidal rivers, alone or with subtypes dominated by floating-leaf plants or forbs. This variant usually is very low in species richness, sometimes containing no other species other than overhanging woody plants.

2. Mosaic Variant occurs in downstream settings in small to large patches in mosaics with other subtypes dominated by large graminoid plants, such as the Giant Cordgrass, Threesquare, and Cattail Subtype.

Dynamics: Dynamics of the Mosaic variant are similar to those of most other subtypes. The dynamics of the Riverbank Variant may be somewhat different but are very poorly known. Its patchy distribution along the shoreline of tidal rivers suggests establishment on bars or lower areas than the adjacent Tidal Swamps. Along with the Broadleaf and Narrowleaf Pondlily Subtypes, it is the first to become established as the reach of a river becomes tidally influenced. Presumably those patches can be expected to expand, both upstream and in width, as rising sea level increases stress on the adjacent Tidal Swamps. However, as they get wider, they also begin to evolve into other Tidal Freshwater Marsh subtypes.

Being usually on the shoreline of rivers, the Southern Wild Rice Subtype is less subject to natural wave action than those along wider estuaries; however, patches may be subject to disturbance by wakes created by motorboats.

Comments: There is very little literature on this subtype, and very few CVS plots in North Carolina. The riverbank variant has been overlooked or not described even in many qualitative site reports, and many patches are narrower than standard plot sizes. Much of the description comes from recent observations by the author.

Earlier versions of the 4th Approximation had a Wild Rice Subtype, dominated by *Zizania aquatica*, based on attribution of an association of that species to North Carolina. But no examples have been found. Although *Zizania* occurs in Tidal Freshwater Marsh communities in North Carolina, and may dominate in Interdune Marsh communities, there appear to be no *Zizania*-dominated Tidal Freshwater Marsh communities in North Carolina.

Alnus serrulata / (Zizania aquatica, Zizaniopsis miliacea) Tidal Shrubland (CEGL004627) is a shrubby tidal marsh association known from as near as the lower Waccamaw River in South Carolina. Something like it could occur in North Carolina, though tidal influence on the

Waccamaw River does not extend as far as the state line. It is unclear how distinct it is from the association crosswalked to this subtype. *Alnus serrulata* is common on banks of tidal rivers, where it may lean over some patches of Tidal Freshwater Marsh but it is rarely rooted within North Carolina examples.

Rare species:
Vascular plants – *Bidens trichosperma, Carex decomposita, Coreopsis palustris, Ludwigia sphaerocarpa, Oenothera riparia, Potamogeton amplifolius,* and *Thalictrum macrostylum.*

Vertebrate animals – *Alligator mississippiensis*.

Invertebrate animals – *Helisoma eucosmium*.

TIDAL FRESHWATER MARSH (OLIGOHALINE LOW MARSH SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Oligohaline Low Marsh Subtype encompasses the interior zones of oligohaline marshes that are dominated by often-diverse mixtures of shorter herbs such as *Eleocharis fallax*, *Eleocharis rostellata*, *Sagittaria lancifolia* var. *media*, or *Pontederia cordata*. As defined, it is a diverse and highly variable association.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Oligohaline Low Marsh Subtype is distinguished from almost all other subtypes by the dominance of *Eleocharis fallax*, *Eleocharis rostellata*, *Sagittaria lancifolia* var. *media*, or *Pontederia cordata* or by a mixture of similar small-stature herbs with no clear dominants, and by occurrence in the interior of marsh complexes. The Estuarine Shoreline Lawn Subtype, also dominated by small-stature herbs, occurs on the edges of open water and is generally dominated by *Eriocaulon parkeri*, *Lilaeopsis chinensis*, or *Lilaeopsis carolinensis*.

Crosswalks: *Eleocharis fallax* - *Eleocharis rostellata* - *Schoenoplectus americanus* - *Sagittaria lancifolia* Tidal Marsh (CEGL004628).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Oligohaline Low Marsh Subtype occurs on intertidal flats in the interior of marsh complexes.

Soils: All known examples are on organic soils, most on Currituck (Terric Haplosaprist), a few on Hobonny (Typic Medisaprist) or other series.

Hydrology: The Oligohaline Low Marsh Subtype is known only in wind tidal areas with oligohaline water. The occurrence of most patches in the interior of marshes, away from channels, presumably indicates reduced tidal exchange of water. Interior areas that trap water may have salt concentrated by evaporation, but interior areas that shed water may alternatively have salinity and nutrients diluted by rainfall.

Vegetation: The Oligohaline Low Marsh Subtype is dominated by dense herbaceous vegetation that is shorter than most of the associated subtypes. It may be dominated by beds of *Eleocharis fallax*, *Eleocharis rostellata*, or other species of *Eleocharis*, or by forbs such as *Sagittaria lancifolia* var. *media*, *Pontederia cordata*, *Peltandra virginica*, or *Osmunda spectabilis.* Often it has a diverse mix with no strong dominant. Large herbs typical of other subtypes, such as *Juncus roemerianus*, *Typha domingensis,* or *Scirpus pungens,* may be present but are not dominant. Other abundant species may include *Panicum virgatum, Spartina patens*, *Galium obtusum, Mikania scandens, Centella erecta,* and *Hibiscus moscheutos*. Also frequent are *Hydrocotyle verticillata,* *Hydrocotyle umbellata, Iris virginica, Lythrum lineare, Juncus acuminatus, Persicaria punctata*, *Persicaria hydropiperoides, Persicaria arifolia, Ptilimnium capillaceum, Phyla lanceolata, Proserpinaca palustris, Cladium mariscoides, Lycopus rubellus, Pluchea foetida, Hypericum walteri, Oenothera fruticosa*, and *Ludwigia alata*.

Range and Abundance: Ranked G1G2. In North Carolina, this subtype occurs only in the northeastern corner of the state, with most occurrences in the Northwest River-North Landing River area and only one occurrence outside of Currituck County. The related association ranges from North Carolina north to Delaware, but it is questionable if it is comparable to the North Carolina subtype throughout this range. Similar communities occur in adjacent Virginia and are somewhat more abundant there.

Associations and Patterns: The Oligohaline Low Marsh Subtype often occurs in the central part of mosaics with the Giant Cordgrass, Sawgrass, Needlerush, and Cattail, and Threesquare subtypes, and often grades particularly gradually into the latter.

Variation: Examples are extremely variable in dominants, but no pattern has been discerned to the variation and no variants have been identified.

Dynamics: The dynamics of this subtype, as distinct from other subtypes, are obscure. Cecil Frost, who originated the concept of this subtype, suggested in multiple 1989 reports to the Natural Heritage Program that fire may be important for maintaining it. Without fire, invasion by larger herbs would suppress its distinctive flora and turn it into one of the other subtypes. Many of the good examples of this subtype have been burned in the period of the surveys to improve conditions for waterfowl hunting. Fire is a likely natural occurrence in some extensive freshwater marsh complexes, where they are contiguous with flammable vegetation on adjacent areas. However, Frost also described other areas where it was associated with low wet basins and might be being drowned by rising sea level, suggesting a successional trajectory toward Freshwater Marsh Pool. As waterfowl hunting and burning of marshes in the Currituck Sound region has declined, investigation of the current state of these communities is needed.

Where patches occur in the interior of large marsh patches, the distinctive hydrology and nutrient dynamics in this setting may be crucial for maintaining the distinctive character of these communities. As in the Threesquare Subtype, it is conceivable that concentration of salt by evaporation keeps this subtype in shorter vegetation and free of larger plants. However, the higher diversity of plants, including many not tolerant of higher salt levels, suggests lower fertility associated with greater rainwater dominance is a more likely cause.

Comments: Five CVS plots and a large number of plots in adjacent Virginia have been sampled in the Oligohaline Low Marsh Subtype. The concept of this subtype was initially reported by Cecil Frost in the course of Natural Heritage Program inventories around Currituck Sound. As defined, this subtype is broad and includes complex variation from site to site and within sites. It is the most species rich of the subtypes and may harbor rare species. *Aeschynomene virginica* has been found in similar communities in Virginia and could occur in this subtype in North Carolina.

Rare species:
Vascular plants – *Aeschynomene virginica, Bacopa innominata, Bolboschoenus novae-angliae, Carex hormathodes, Eleocharis fallax, Eleocharis rostellata, Eleocharis uniglumis* (*halophila*), *Iris prismatica, Lilaeopsis carolinensis, Limosella australis, Ludwigia alata, Ludwigia brevipes, Spartina pectinata,* and *Utricularia macrorhiza.*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Catinella pugilator*.

TIDAL FRESHWATER MARSH (MIXED FRESHWATER SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Mixed Freshwater Subtype covers tidal marshes of more inland locations, where water is completely fresh, species less tolerant of salt are present, and vegetation is dominated by broadleaf herbs or graminoids not characteristic of other subtypes.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Mixed Freshwater Subtype is distinguished from other Tidal Freshwater Marshes by occurrence on more inland, freshwater tidal sites, and by the presence of species intolerant of oligohaline conditions. These typically include abundant *Peltandra virginica* and *Sagittaria* spp. and may include *Carex stricta*, *Spartina pectinata*, *Impatiens capensis, Apios americana*, *Zizania aquatica*, *Lilium superbum*, and *Bidens frondosa*, as well as small numbers of *Swida foemina* (*Cornus stricta*) or *Cephalanthus occidentalis.* They lack *Juncus roemerianus*, *Cladium jamaicense*, *Schoenoplectus pungens*, *Eleocharis fallax*, and *Eleocharis rostellata*. The Southern Wild Rice Subtype, Broadleaf Pondlily Subtype, and Narrowleaf Pondlily Subtype also occur in freshwater rather than oligohaline situations but are low-diversity communities dominated by the nominal species.

Crosswalks: *Carex stricta - Peltandra virginica - Sagittaria (lancifolia* ssp. *media, latifolia)* Tidal Marsh (CEGL004314).
G913 South Atlantic & Gulf Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Mixed Freshwater Subtype occurs on shoreline bars and medium size intertidal flats on edges of freshwater tidal rivers. Many of the occurrences are near the mouths of tributary streams at larger tidal rivers or estuaries.

Soils: Most examples have organic soils, generally mapped as Dorovan (Typic Haplosaprist). A few are mapped as mineral soils such as Muckalee (Typic Fluvaquent). Small patches bordering rivers are not distinguished in soil mapping; they generally are included in organic soil map units.

Hydrology: The Mixed Freshwater Subtype is flooded by regular or irregular lunar or wind tides in fully fresh waters. These conditions occur in the estuaries most remote from seawater inlets, such as the Chowan River and upper Albemarle Sound, and in large rivers with substantial flow, such as the Cape Fear.

Vegetation: The Mixed Freshwater Subtype consists of dense herbaceous vegetation of medium height, generally a diverse mix of forbs and graminoids. Weakly dominant or codominant species in site descriptions may include *Carex stricta, Persicaria arifolia, Persicaria punctata, Pontederia cordata, Carex hyalinolepis, Carex alata*, and, though less strongly dominant than in other subtypes, *Typha latifolia* or *Spartina cynosuroides*. *Spartina pectinata* is occasionally abundant. Other frequent species in site descriptions include *Cicuta maculata/mexicana, Sagittaria lancifolia* var. *media, Peltandra virginica, Osmunda spectabilis, Hibiscus moscheutos, Thelypteris palustris, Zizaniopsis miliacea, Zizania aquatica, Boehmeria cylindrica*, and *Physostegia leptophylla*. These communities often are quite diverse, with several dozen species in an occurrence and with a large species pool occurring at low frequency.

Range and Abundance: Ranked G2? This subtype may be scattered throughout the tidewater region, but the specialized conditions that produce it are limited, and the community is rare throughout the state. The equivalent association is attributed only to North Carolina. Virginia has wind-tidal oligohaline marshes but lacks fully freshwater ones. However, several lunar-tidal freshwater marsh associations occurring farther north in Virginia are related to this subtype fairly closely.

Associations and Patterns: The Mixed Freshwater Subtype usually occurs in fairly small patches. It often occurs adjacent to Tidal Swamps, without other marsh subtypes, but it may occur in association with the Narrowleaf Pondlily, Broadleaf Pondlily, Southern Wild Rice Subtype, or Shrub Subtype.

Variation: This subtype is variable in vegetation, but no distinct variants or subdivisions have been identified. It may warrant subdivision with further study and more data.

Dynamics: The origin and dynamics of this subtype may be different from other subtypes, but they are particularly poorly known. It likely is less susceptible to natural disturbance by salt intrusion. The lack of salt makes their environment similar to that of Tidal Swamps, and it would appear capable of supporting trees. Indeed, many examples appear to have shrubs or young trees invading them. Cecil Frost suggested they might be primary successional communities on recent deposits and noted the presence of young forest behind some examples. The sites near the mouths of tributary streams or rivers may be associated with areas of new deposition, though given the limited currents in the wind tidal areas, it is unclear what would produce such deposits.

Comments: This subtype is virtually unrepresented by plots. Cecil Frost provided early support for recognition of this subtype, with descriptions of occurrences near the Chowan River, and listed a number of species not associated with oligohaline marshes nearby. Many of those species have since been found occasionally in oligohaline marshes elsewhere, but the pattern of salt-intolerant plants and weak dominance appears to be valid.

Earlier drafts of the 4th approximation included a Wild Rice Subtype, dominated by *Zizania aquatica*, based on an NVC association. It appears that there are no Tidal Freshwater Marshes dominated by *Zizania* in North Carolina. *Zizania* is sometimes present in the Mixed Freshwater Subtype.

Aeschynomene virginica has been found in similar habitats in Virginia and could occur here.

Rare species:
Vascular plants – *Carex decomposita, Ludwigia alata, Lathyrus palustris, Oenothera riparia, Scirpus lineatus, Spartina pectinata,* and *Thalictrum macrostylum*.

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Catinella pugilator* and *Helisoma eucosmium*.

TIDAL FRESHWATER MARSH (SHORELINE LAWN SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Shoreline Lawn Subtype includes distinctive short, regularly flooded to semipermanently flooded graminoid or phyllodial vegetation along the shores of estuaries and tidal channels. As defined, it is a diverse and highly variable association that is not well understood. It usually occurs as narrow fringes or small patches. This may be a rare community, as most marsh edges are barren mud flats or are scarped and have abrupt edges to other subtypes rather than a distinctive vegetated edge zone.

Distinguishing Features: The Shoreline Lawn Subtype may be distinguished from other subtypes by occurrence in lower, wetter areas on the edges of patches, along with dominance by *Eriocaulon parkeri*, *Lilaeopsis chinensis*, *Lilaeopsis carolinensis*, *Eleocharis* spp., or similar plants. Only larger patches should be recorded as occurrences of this subtype. Estuarine Beach Forest would be distinguished by being higher in elevation and on higher energy shorelines with sparse vegetation or plants adapted to high energy.

Crosswalks: *Eriocaulon parkeri - Polygonum punctatum* Tidal Marsh (CEGL006352).
G914 North Atlantic Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: Shoreline Lawns occur along estuaries and tidal channels where a surface within a few centimeters of sea level is present. Sites generally border marsh patches of other subtypes but could occur as fringes adjacent to higher areas.

Soils: This community tends to be smaller than the minimum map unit for soil mapping and is not distinguished. Soils may potentially be either organic or mineral soils.

Hydrology: The few examples described are in oligohaline wind tidal areas, and this community may be confined to them.

Vegetation: Vegetation is dominated by *Lilaeopsis chinensis, Lilaeopsis caroliniensis, Eleocharis flavescens*, or potentially by other *Eleocharis* species or by *Eriocaulon parkeri*. Other species may include *Samolus parviflorus*, *Sabatia calycina*, or *Ludwigia* spp.

Range and Abundance: Ranked G2. It is unclear how abundant this community is in North Carolina. It is seldom reported but likely is overlooked. The NVC association is described as ranging from North Carolina northward into Canada. However, the relationship of this community in North Carolina to that association is weak and may not be warranted. Also, given the range of climate and tidal conditions in which it is purported to occur, that association must be extremely heterogeneous and likely warrants splitting.

Associations and Patterns: The Shoreline Lawn Subtype might potentially occur adjacent to most other subtypes of Tidal Freshwater Marsh, and potentially adjacent to Tidal Swamp or even to non-tidal wetlands or uplands.

Variation: Nothing is known of variation.

Dynamics: Nothing is known of the dynamics of this community, beyond the very frequent to constant flooding. It likely is subject to occasional wave disturbance as well as potentially to intrusion by salt water. It probably is extremely sensitive to rising sea level, though it is possible that new sites are created as old are destroyed.

Comments: This community needs much more investigation, and this subtype is defined largely as a place holder. It is one of the most poorly known communities, as it is often overlooked and unreported. There are no plots for it. It may be invisible at times of high water. It is not entirely clear if it is extensive enough to be recognized as a distinct community at all. The crosswalked association is only a partial match, and possibly a very poor one. This subtype was formerly synonymized with CEGL004303 *Eriocaulon parkeri.* That association was merged into the one named above.

Rare species:
Vascular plants – *Bacopa innominata, Eleocharis palustris, Eleocharis rostellata, Lilaeopsis carolinensis, Limosella australis,* and *Ludwigia alata*.

Vertebrate animals – *Alligator mississippiensis, Botaurus lentiginosus,* and *Malaclemys terrapin*.

TIDAL FRESHWATER MARSH (BROADLEAF PONDLILY SUBTYPE)

Concept: The Broadleaf Pondlily Subtype is a tidally influenced community dominated by *Nuphar advena* or, occasionally, *Nymphaea odorata*, occurring along tidal rivers and in pools in marsh complexes. It is permanently flooded or exposed only at very low tides. The water is generally fully fresh.

Distinguishing Features: The Broadleaf Pondlily Subtype is distinguished from all other communities by the dominance of *Nuphar advena* or *Nymphaea odorata* in tidally influenced water. It is distinguished from Coastal Plain Semipermanent Impoundment, Small Depression Pond, and other communities with floating-leaved plants by occurring in areas flooded by wind or lunar tides. Comparable communities dominated by *Nuphar sagittifolia* are treated as the Narrowleaf Pondlily Subtype. No *Nuphar advena* community is known along upstream non-tidal rivers in North Carolina, but the occurrence of such a community is possible.

Crosswalks: *Nuphar advena* Tidal Marsh (CEGL004472).
G914 North Atlantic Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Broadleaf Pondlily Subtype usually occurs in shallow water along the banks of tidal rivers or in backwater channels of them. It less frequently occurs along the shorelines of freshwater estuaries or in pools within marsh complexes.

Soils: Soils are generally not mapped, but examples are associated with organic soils such as Dorovan (Typic Haplosaprist).

Hydrology: This subtype is permanently flooded, at least shallowly, with standing water absent only at unusually low tides. Tides may be either lunar or wind-driven, though most examples are in wind tidal parts of the state. Water is usually fully fresh but apparently may be oligohaline.

Vegetation: The Broadleaf Pondlily Subtype is dominated by dense to fairly sparse floating beds of *Nuphar advena* or occasionally *Nymphaea odorata*. Usually, no emergent plants are rooted in the community, though *Taxodium distichum, Nyssa biflora, Alnus serrulata*, or other large plants on the bank may partially shade it. Submersed aquatic plants such as *Ceratophyllum demersum, Utricularia gibba, Elodea nuttallii*, or free-floating plants such as *Spirodela polyrhiza* may be present or abundant. Floating *Alternanthera philoxeroides* may become established.

Range and Abundance: Ranked G4G5. The abundance of this community in North Carolina is poorly known, because it was not recognized as a community before the 4th approximation and was seldom reported. It probably is frequent, at least in northeastern North Carolina. The synonymized NVC association is widespread, ranging northward to Maine, with North Carolina at the southern end of its range. It may warrant further splitting, given the extremely broad range of climate represented.

Associations and Patterns: The Broadleaf Pondlily Subtype sometimes occurs with the Southern Wild Rice or Mixed Freshwater Subtype, occupying deeper water than those subtypes. It is often adjacent to Tidal Swamps. It extends farther upstream than most other subtypes. Where it occurs in larger marsh complexes, it may be associated with any of the subtypes.

Variation: Too little is known to define variants. It may be appropriate to recognize variants for wind tidal and lunar tidal occurrences in the future. The inclusion of the single known *Nymphaea odorata* tidal marsh in this subtype is based on limited knowledge and is mainly for convenience. It may warrant recognition as a distinct subtype, or at least a variant, with further study. Alternatively, it may prove more closely related to the Freshwater Marsh Pool community.

Dynamics: Little is known of the dynamics of this subtype, which may be different from most other subtypes. Flooding is essentially permanent, perhaps making the environment more stable and less stressful than in other subtypes. The disturbing effect of infrequent saltwater penetration presumably occurs as it does in other subtypes but may be rare because this subtype is usually farther upstream on tidal rivers. Disturbance by motorboat wakes and propellor damage may be common.

Where it occurs, the Broadleaf Pondlily Subtype is a series of patches, generally in discontinuous narrow bands along the bank. It is unclear what determines where patches occur. They may occupy submerged bars, but they may merely be shallower parts of the channel bed. They generally do not extend out into the center of the channel, suggesting a need for still water or at least weak current, but their occurrence may be tied more simply to water depth. The vegetation presumably traps sediment as well as producing organic matter, and this may help aggrade the bottom as sea level rises.

Comments: This subtype is very poorly known. No plot data are known for it, and it is rarely described in site reports. The reported *Nymphaea odorata*-dominated marsh pools are included here but need much more investigation. They may be more closely related to the Marsh Pool community.

This community has some of the simplest vegetation in North Carolina, often consisting of only one vascular plant species.

The treatment of this community as a subtype of Tidal Freshwater Marsh is somewhat tenuous. Creation of a tidal floating aquatic community type might be appropriate.

Rare species: No rare species are known to be specifically associated with this community.

TIDAL FRESHWATER MARSH (NARROWLEAF PONDLILY SUBTYPE)

Concept: The Narrowleaf Pondlily Subtype is a tidally influenced community dominated by *Nuphar sagittifolia* (*lutea ssp. sagittifolia*), occurring along tidal rivers. The water is fully fresh.

Distinguishing Features: The Narrowleaf Pondlily Subtype is distinguished from all other communities by the dominance of *Nuphar sagittifolia* in tidally influenced water. It is distinguished from Coastal Plain Semipermanent Impoundment, Small Depression Pond, Sand and Mud Bar, Natural Lake Shoreline Marsh, and other communities which may contain *Nuphar sagittifolia* by occurring in areas flooded by wind or lunar tides.

Crosswalks: *Nuphar sagittifolia* Tidal Marsh (CEGL006094).
G914 North Atlantic Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Narrowleaf Pondlily Subtype usually occurs in shallow water along the banks of tidal rivers or in backwater channels of them.

Soils: Soils are not generally mapped. Occurrences may be associated with organic soils, such as Dorovan (Typic Haplosaprist) or flooded mineral soils such as Muckalee (Typic Fluvaquent).

Hydrology: This subtype is essentially permanently flooded, at least shallowly; standing water is absent only at the lowest tides. All examples are in the lunar tidal portions of the state, and regular tidal fluctuations may be as much as 3 feet.

Vegetation: The Narrowleaf Pondlily Subtype is dominated by dense to fairly sparse floating beds of *Nuphar sagittifolia*. Usually, no other emergent plants are rooted in the community, though *Taxodium distichum, Nyssa biflora, Alnus serrulata*, or other large plants on the bank may partially shade it. Submersed aquatic plants or free floating aquatic plants may be present, but these have not been documented. Unlike *Nuphar advena*, *Nuphar sagittifolia* often has extensive underwater leaves, which likely reduce the amount of associated submersed vegetation.

Range and Abundance: Ranked G1G2. The abundance of this community in North Carolina is poorly known, because it was not recognized as a community before the 4th approximation and was seldom reported. The dominant species is rare enough to be on the NHP watch list and was studied for potential federal listing. The dominant species has a narrow, but odd, global range. It is largely centered in southeastern North Carolina, barely ranging into adjacent South Carolina and not extending north of the Neuse River, but with a small disjunct population area on the Chickahominy River of east-central Virginia. It is unclear if Chickahominy River supports a similar community.

Associations and Patterns: The Narrowleaf Pondlily Subtype sometimes occurs with the Southern Wild Rice or Mixed Freshwater Subtype, occupying deeper water than those subtypes. It is often adjacent to Tidal Swamps. Along with the Southern Wild River subtype, it may extend farther upstream than most other subtypes, up to near the limit of tidal influence.

Variation: Too little is known to define variants. Because the community can occur in the tidal reaches of both blackwater and brownwater rivers, they may prove a basis for defining variants.

Dynamics: Little is known of the dynamics of this subtype. As with the Broadleaf Pondlily Subtype, flooding is essentially permanent, perhaps making the environment more stable and less stressful than in other subtypes. Because tidal ranges are greater and tidal currents stronger, the Narrowleaf Pondlily Subtype may have more mechanical stress than the Broadleaf Pondlily Subtype. The disturbing effect of infrequent saltwater penetration presumably occurs as it does in other subtypes but may be rare because this subtype is usually farther upstream on tidal rivers. Disturbance by motorboat wakes and propellor damage may be common.

As with the Broadleaf Pondlily Subtype, the Narrowleaf Pondlily Subtype occurs as a series of patches, generally in discontinuous narrow bands along the bank, and it is unclear why patches occur where they to. The vegetation presumably traps sediment as well as producing organic matter, and this may help aggrade the bottom as sea level rises.

Comments: This subtype is very poorly known. No plot data are known for it, and it is rarely described in site reports.

This community has some of the simplest vegetation in North Carolina, often consisting of only one vascular plant species. The idea that a different subtype is warranted for dominance by a different species in the same genus is somewhat speculative and needs more data for support. However, the different habit of *Nuphar sagittifolia*, with more extensive submersed cover, as well as the different tidal dynamics, suggests reasons for separation.

The treatment of this community as a subtype of Tidal Freshwater Marsh is somewhat tenuous. Creation of a tidal floating aquatic community type might be appropriate.

Rare species: No rare species are known to be specifically associated with this community.

TIDAL FRESHWATER MARSH (SHRUB SUBTYPE)

Concept: Tidal Freshwater Marshes are very wet herbaceous wetlands, permanently saturated and regularly or irregularly flooded by lunar or wind tides with fully fresh or oligohaline water. The Shrub Subtype covers transitional zones between Tidal Freshwater Marsh and Tidal Swamp or other forests, where the vegetation is naturally dominated by shrubs, though herbs typical of other Tidal Freshwater Marsh subtypes generally are abundant. Relict or young trees may be present in areas that have recently developed into Tidal Freshwater Marsh in response to rising sea level.

Distinguishing Features: All Tidal Freshwater Marsh communities are distinguished from Brackish Marsh and Salt Marsh by occurring in oligohaline to fresh water and containing plants intolerant of brackish water. The Shrub Subtype is distinguished from other Tidal Freshwater Marshes by dominance or codominance of shrubs along with herbaceous plants in a freshwater or oligohaline tidal setting. Its boundary with Tidal Swamp and Estuarine Fringe Pine Forest is placed where trees no longer form a substantial canopy; relict trees may be present but with 30% cover or less.

Crosswalks: *Morella cerifera* - *Rosa palustris* / *Thelypteris palustris* var. *pubescens* Tidal Shrubland (CEGL004656).
G914 North Atlantic Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: The Shrub Subtype occurs on intertidal flats and shorelines, most often in zoned mosaics with other subtypes. Patches are most often on the inland edge of the marsh complex but may occur on shoreline berms or on local rises.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Currituck (Terric Haplosaprist) but often Lafitte, Hobonny, or Dorovan (Typic Haplosaprists). A few may be mineral soils such as Chowan (Thapto-histic Fluvaquent).

Hydrology: The Shrub Subtype may occur with lunar or wind tides in oligohaline waters and may occasionally be adjacent to areas that are nearly brackish in salinity.

Vegetation: The Shrub Subtype vegetation is an open shrubland dominated by *Morella cerifera*. *Rosa palustris* may also be abundant, as may young *Acer rubrum* or *Pinus taeda*. Remnant larger trees, particularly *Taxodium distichum, Nyssa biflora*, or *Fraxinus* spp., may be present. Other frequent woody species include *Toxicodendron radicans, Muscadinia rotundifolia, Smilax walteri, Smilax laurifolia, Smilax rotundifolia, Salix nigra, Baccharis halimifolia*, *Persea palustris*, and *Liquidambar styraciflua*. Large herbs are dense between the shrubs and often beneath them. Frequently species with high cover in CVS plots include *Thelypteris palustris, Osmunda spectabilis, Cladium jamaicense, Peltandra virginica*, and *Carex* spp. Less frequently, *Typha* spp., *Pontederia cordata*, *Iris virginica, Eleocharis fallax*, or *Hydrocotyle verticillata* may be dominate patches of the herb layer. Other frequent species include *Mikania scandens, Hibiscus moscheutos,* *Saururus cernuus, Sagittaria lancifolia* var. *media, Persicaria sagittata, Apios americana, Ptilimnium capillaceum, Triadenum walteri, Cicuta maculata, Boehmeria cylindrica, Persicaria arifolia, Persicaria hydropiperoides, Centella erecta, Pluchea foetida*, and *Bidens* spp. Any other species of other Tidal Freshwater Marsh subtypes might also be present. *Phragmites australis* may invade and come to dominate patches.

Range and Abundance: Ranked G4. The Shrub Subtype is frequent and often extensive in oligohaline marsh complexes throughout North Carolina. The association ranges from North Carolina to Delaware and Maryland.

Associations and Patterns: The Shrub Subtype often grades into the Sawgrass, Cattail, Threesquare, Needlerush, or Estuarine Low Marsh Subtype. Inland, it usually gives way to Tidal Swamp or Estuarine Fringe Pine Forest, but it may also border other wetland or upland communities. The transitions may be particularly gradual in either direction, reflecting the gradual succession that occurs with rising sea level.

Variation: Examples are extremely variable, with herbs varying with the transition to neighboring subtypes. Variants are recognized based on tidal dynamics. It is not clear if there are obvious vegetational differences associated with them but other aspects of ecosystem function are presumed to be different. Other variations that could be recognized as subtypes or variants include the presence or absence of *Taxodium*, which might persist as a sparse savanna canopy for many years.

1. Wind Tidal Variant occurs in areas remote from tidal inlets, where tidal flooding is irregular and largely driven by wind.

2. Lunar Tidal Variant occurs in areas with closer connection to the ocean and with regular semidiurnal tidal flooding.

Dynamics: The Shrub Subtype usually represents an obvious transitional stage between forested wetlands and open marshes, though one that may persist for many years. As Tidal Swamps and Estuarine Fringe Pine Forests are increasingly stressed by rising sea level, trees stop regenerating and the shrubs and herbs of this community establish beneath the thinning canopy. The transition to the Shrub Subtype may occur gradually or quickly, as enough trees die to allow the lower strata to dominate. If *Taxodium* is present in the swamp, it may persist as an open stand for many years due to its tolerance of water and salt, while pine forests and swamps with only *Nyssa* and other hardwoods lose the relict trees more quickly. If the canopy trees were killed by a storm surge or other transient event, young trees, especially *Acer rubrum* or *Pinus taeda,* may appear and persist with the shrubs. However, the author has not observed them to form a true forest canopy again.

With continued sea level rise, the shrubs become sparser, and the community develops into one of the other subtypes. Fire may accelerate either the transition from swamp to the Shrub Subtype or the transition from the Shrub Subtype to other subtypes, by killing individuals of woody species that are unable to regenerate. The recent development and transitional nature of this subtype is often apparent by the presence of numerous standing or fallen dead trees. A few examples of the Shrub Subtype could be successional in the opposite direction, representing a transition from a herbaceous marsh to a forest as trees establish in areas that were disturbed or that are newly established on new sediment deposits.

The Shrub Subtype appears to occur in less wet settings than other subtypes and presumably is flooded less often and less deeply.

Comments: The common abundance of fallen logs, along with the shrubs and vines, makes this one of the most difficult communities to explore, while standing snags can make it dangerous. There is a moderate number of plots representing it, but all are in the wind tidal area.

Morella cerifera - *Toxicodendron radicans / Spartina bakeri* Tidal Shrubland (CEGL004789) is a more southern equivalent from South Carolina to Florida. *Morella cerifera - Baccharis halimifolia / Eleocharis fallax* Tidal Shrubland (CEGL006846) is a more northerly equivalent from Virginia, Maryland, and Delaware.

Rare species:
Vascular plants – *Bacopa innominata, Bidens trichosperma, Eleocharis rostellata, Lilaeopsis carolinensis, Ludwigia alata,* and *Spartina pectinata*.

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Catinella pugilator* and *Euphyes dukesi*.

TIDAL MUD FLAT

Concept: Tidal Mud Flats are communities of soft, fine-textured sediments that are regularly or irregularly flooded by tides. This is presently a conceptual community that is poorly studied in North Carolina. The range and vegetation of this type are not well known. It covers all intertidal areas of fresh to brackish estuaries that have vegetation sparser or of smaller stature than the recognized marsh communities. Most patches may be too small to map, but larger patches are possible.

Distinguishing Features: The Tidal Mud Flat type is distinguished from other tidal communities by predominance of small plants other than the characteristic dominants of the marshes. Vegetation is usually sparse. While *Isoetes riparia* may dominate, other sparsely vegetated tidal mud flat vegetation should be placed here as well.

Crosswalks: *Isoetes riparia* Tidal Marsh (CEGL006058).
G914 North Atlantic Coastal Tidal Freshwater Marsh Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: Intertidal Mud Flats occur in marsh complexes and around estuaries, generally in still waters such as bays or along tidal channels. They may be either on barrier islands or on the mainland.

Soils: Soils are newly deposited clay, silt, or loamy sediments without developed soil horizons. They are not generally distinguished in soil mapping.

Hydrology: Tidal Mud Flats are flooded regularly or irregularly by either lunar or wind tides. In the current broad conceptual definition, the water may be salt, brackish, oligohaline, or fresh.

Vegetation: The range of vegetation in North Carolina's Tidal Mud Flats is unknown. *Isoetes riparia, Sagittaria subulata, Sagittaria calycina, Eriocaulon parkeri, Eleocharis obtusa, Heteranthera reniformis*, or other species may occur.

Range and Abundance: The equivalent association does not yet have a global rank. Its global abundance is particularly unclear. This community appears to be scattered through the freshwater estuaries in the northern part of the state and may occur on tidal rivers in the southern part as well. Examples are not well tracked, and its abundance is not known. Patches are small, and the overall acreage may be limited. The NVC association ranges northward to Massachusetts, but it may be heterogeneous and call for subdivision.

Associations and Patterns: Tidal Mud Flats occur in association with Tidal Freshwater Marsh or Brackish Marsh, potentially with other Freshwater Tidal Wetlands.

Variation: Nothing is known of variation in these communities.

Dynamics: The dynamics of this community are particularly poorly known. They probably generally are primary successional communities, where further colonization by plants and deposition of sediment will eventually allow them to develop to marsh communities. Some may be chronically disturbed areas, where reworking of sediment prevents development of more substantial vegetation. All are affected by rising sea level, which may lead to their submergence and disappearance.

Comments: This community is very poorly understood in North Carolina and is included only provisionally. The Tidal Mud Flat community is recognized in states to the north and appears to occur here, but it is generally not described in site reports. No CVS plots exist. Clontz (1994) noted a zone of fine muck with abundant fiddler crab burrows in what may be this community but noted no plants.

There has been confusion about its salinity characteristics, which appear to range between the salinity levels of Tidal Freshwater Marsh and Brackish Marsh, but this is difficult to tell. In the 4th Approximation Guide in 2012, it was treated as an Estuarine Community, believed to occur primarily in brackish waters. However, following the current NVC description that suggests it is primarily in fresher water, it has been moved to the Freshwater Tidal Wetlands theme. It may be that a salt version needs to be created in addition. Several subtypes are likely to be distinguished with further study.

Sagittaria subulata - *Limosella australis* Tidal Marsh (CEGL004473) is a northern equivalent of this type that ranges southward into Virginia.

Rare species: No rare species are known to be specifically associated with this community.

FRESHWATER MARSH POOL

Concept: Freshwater Marsh Pools are vegetated permanently flooded portions of Tidal Freshwater Marsh complexes, with floating or submersed aquatic vegetation.

Distinguishing Features: Freshwater Marsh Pools may be distinguished from most Tidal Freshwater Marsh subtypes by dominance by submersed aquatic vegetation or detached floating plants in enclosed waters. Tidal channels and adjacent large estuaries are not included; they would be treated as submersed aquatic vegetation that is not yet defined. The Broadleaf Pondlily and Narrowleaf Pondlily Subtypes also occur in permanent flooded areas and may have floating or submerged vegetation but are dominated by the rooted floating-leaf *Nuphar* or *Nymphaea* species.

Crosswalks: *Ceratophyllum demersum* - *Utricularia macrorhiza* - *Nymphaea odorata* Aquatic Vegetation (CEGL004661).
G114 Group Eastern North American Freshwater Aquatic Vegetation Group.
Atlantic Coastal Plain Embayed Region Tidal Freshwater Marsh Ecological System (CES203.259).
Atlantic Coastal Plain Central Fresh and Oligohaline Tidal Marsh Ecological System (CES203.376).

Sites: Freshwater Marsh Pools occur in shallow permanently flooded areas on intertidal flats. Pools may be isolated in marsh complexes or may be connected by tidal channels.

Soils: Freshwater Marsh Pools are generally associated with organic soils, such as Currituck (Terric Haplosaprist) or less likely Hobonny (Typic Medisaprist) or other series.

Hydrology: The known Freshwater Marsh Pools are in wind tidal areas with oligohaline water. Pools may be connected by tidal channels, so that they are quickly subject to all tidal fluctuations, or they may be isolated so that tidal flooding occurs only when the tide overflows the adjacent marshes.

Vegetation: Freshwater Marsh Pool vegetation may include any of the submersed or floating aquatic plants tolerant of oligohaline water. The few examples that are well described have *Nymphaea odorata* and *Spirodela polyrhiza*. Submersed plants include *Ceratophyllum demersum, Utricularia gibba, Utricularia biflora, Najas guadalupensis*, and *Ruppia maritima*. Algae and the liverwort *Riccia fluitans* may also be prominent. *Eleocharis* sp. and *Juncus* sp. also may be present, and there may be a more diverse zone of emergent marsh plants around the edge. The NVC description, based on Virginia data, also includes *Utricularia macrorhiza, Utricularia purpurea, Elodea nuttallii, Wolffiella gladiata*, and *Lemna* spp.

Range and Abundance: Ranked G3?. Only a handful of examples are documented, but more may occur in northeast North Carolina. The NVC association is attributed to Virginia as well as North Carolina. The synonymized association may not be completely parallel and may be more broadly defined.

Associations and Patterns: Freshwater Marsh Pools occur in Tidal Freshwater Marsh complexes, associated with the Sawgrass, Needlerush, Threesquare, Cattail, Giant Cordgrass, and Estuarine Low Marsh subtypes.

Variation: Examples appear to be very variable, but patterns have not been elucidated.

Dynamics: Dynamics of Freshwater Marsh Pools are particularly poorly known. There is concern that pools in marshes are associated with marsh deterioration. If sediment accumulation does not keep pace with rising sea level, productivity will decline first in the lowest areas, vegetation will eventually drown, and open water pools will form. Once formed, they can expand by shoreline erosion, as well as proliferate as additional areas drown. It is not clear that the vegetated Freshwater Marsh Pools represented by this community are the same phenomenon. Stable vegetated pools should be regarded as natural communities, though they, like marshes, are at risk of being replaced by deep water as sea level continues to rise. The wind tidal areas where the known examples occur are in the Embayed Region, where geological subsidence exacerbates global sea level rise. No major rivers feed this area, and there is very little mineral sediment input. This area has been fresh (oligohaline) only for around a century, when the last nearby inlet closed. Before that, it had regular saltwater tides but still limited sediment input. The marshes have kept pace with past sea level rise largely by accumulation of organic matter, apparently in both circumstances.

Comments: There is a great need to clarify the distinction between natural Freshwater Marsh Pool communities and openings that are part of the deterioration of marshes due to rising sea level. The increasing interest in sediment deposition in marshes represents a threat to natural Freshwater Marsh Pools.

Rare species: No rare species are known to be specifically associated with the community.

TIDAL SWAMP (CYPRESS–GUM SUBTYPE)

Concept: Tidal Swamps are closed or open-canopy wet forests or woodlands along rivers, creeks, or estuarine shorelines influenced by tidal waters with minimal salt content. Tides may be either lunar or wind tides. The Cypress–Gum subtype covers the most common swamps, dominated by some combination of *Nyssa biflora, Nyssa aquatica*, and *Taxodium distichum*.

Distinguishing Features: Tidal Swamps are distinguished from other swamps by the occurrence of regular or irregular tidal flooding. Evidence of non-trivial tidal fluctuation may be taken as distinguishing this type, but this can be difficult to recognize during brief visits. Tidal influence is accompanied by the presence of characteristic species such as *Morella cerifera*, *Rosa palustris*, and numerous herbaceous species shared with Tidal Freshwater Marshes. The transition from a blackwater or brownwater Cypress–Gum Swamp is often also marked by a blurring of the distinction, with both *Nyssa biflora* and *Nyssa aquatica* abundant, and this may offer evidence of tidal influence. Also present is evidence of increased wetness and permanent saturation, with trees often showing stress caused by rising sea level, in the form of increased mortality and crown thinning. With the increasing openness of the canopy often comes an increase in herbaceous diversity, which is generally low in riverine Cypress—Gum Swamps. A further sign of tidal influence is the presence of Tidal Freshwater Marsh patches, which are usually of the Broadleaf Pondlily, Narrowleaf Pondlily, or Southern Wild Rice subtypes.

The transition from Nonriverine Swamp Forest is marked by a loss of the characteristic shrub and herb species such as *Ilex glabra, Lyonia lucida, Anchistea virginica*, and *Sphagnum* spp.

The Cypress–Gum Subtype is distinguished from the Mixed Subtype by the dominance of *Nyssa biflora, Nyssa aquatica*, or *Taxodium distichum*, along with *Acer rubrum*. *Fraxinus* spp., *Ulmus americana*, and *Pinus taeda* are absent or less abundant.

Crosswalks: *Nyssa biflora - (Taxodium distichum, Nyssa aquatica) / Morella cerifera - Rosa palustris* Tidal Forest (CEGL004484).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Southern Atlantic Coastal Plain Tidal Wooded Swamp Ecological System (CES203.240).

Sites: Tidal Swamps occur on the margins of freshwater sounds and at the mouths of both blackwater and brownwater rivers. They may have regular or irregular lunar or wind tides of fresh water. In rivers, most Tidal Swamps are underlain by deep organic deposits that bury the fluvial topography formed at lower stands of sea level.

Soils: Most occurrences in both lunar and wind tidal areas have organic soils, most often Dorovan (Typic Haplosaprist), but frequently Pungo (Terric Haplosaprist) or other organic series. A sizeable minority have mineral soils, including Chowan (Thapto-Histic Fluvaquent), Muckalee (Typic Fluvaquent), and Masontown (Cumulic Humaquept).

Hydrology: Tidal Swamps are influenced by lunar or wind tides in fully fresh waters. Examples may be high enough that only higher tides inundate them, or they may be covered by one or two feet of water with every high tide. Examples on large rivers may be subject to river flooding as well as tidal flooding. The distinctive character of blackwater and brownwater is blurred by the tidal mixing but retains some influence.

Vegetation: The tree canopy may be closed except where broken by small gaps, but it is often open and can grade to woodland structure. *Nyssa biflora* is most often dominant, with *Taxodium distichum* frequent and sometimes codominant. *Nyssa aquatica* is present in many examples and may be codominant. As in other swamps, the abundance of *Taxodium* probably has generally been reduced by past logging but it is unclear how dominant it once was in any given site. Other frequent canopy trees are *Acer rubrum* var. *trilobum*, *Liquidambar styraciflua, Pinus taeda*, and *Fraxinus pennsylvanica*, while *Quercus laurifolia* is occasional. The understory is usually dominated by *Acer rubrum* var. *trilobum*, but occasionally is dominated by *Fraxinus caroliniana* or *Carpinus caroliniana*. Other frequent understory trees in CVS plots and site reports are *Ilex opaca, Persea palustris*, and *Magnolia virginiana*. The shrub layer often is dense near the shoreline, and moderate to sparse in the interior. *Morella cerifera*, *Itea virginica, Rosa palustris,* and *Eubotrys racemosus* are usually most abundant. Other frequent or occasionally abundant shrubs include *Clethra alnifolia, Viburnum nudum, Alnus serrulata, Cyrilla racemiflora, Sabal minor, Arundinaria tecta, Baccharis halimifolia, Vaccinium fuscatum*, *Vaccinium formosum*, and *Lyonia ligustrina*. Vines are often prominent, especially *Toxicodendron radicans, Parthenocissus quinquefolia*, and *Smilax rotundifolia*, but also including *Hydrangea (Decumaria*) *barbara, Smilax walteri, Smilax laurifolia*, and other species. The herb layer may be very dense in examples with an open canopy and is usually at least moderate in density. Frequent dominant herbs are *Osmunda spectabilis, Saururus cernuus, Peltandra virginica, Boehmeria cylindrica*, *Lorinseria areolata*, and a number of species of *Carex*. Other frequent herbs include *Triadenum walteri, Cicuta maculata, Persicaria* spp. (*arifolia, hydropiperoides, punctata*, and others), *Iris virginica, Lycopus rubellus, Osmundastrum cinnamomeum*, *Mitchella repens*, and epiphytic *Tillandsia usneoides* and *Pleopeltis michauxiana*. *Murdannia keisak* sometimes invades and becomes dense. In more open-canopy examples, many of the species of Tidal Freshwater Marsh communities can also be found. In contrast to other kinds of swamps, these communities usually have high species richness. CVS plots average 52 species per plot.

Range and Abundance: Ranked G3G4. This subtype should perhaps be ranked lower, as large acreages exist, but uncertainty prevails because of the potential effects of rising sea level. This community is frequent and extensive in the tidewater region of North Carolina, with some occurrences covering thousands of acres. The association ranges southward to Florida and Mississippi. A different tidal swamp association is recognized in southern Virginia. The dominant species reach their northern range limit there, and no similar communities occur northward.

Associations and Patterns: Tidal Swamps often occur in large contiguous patches, but they may also occur in medium-to-small patches and as bands of fringing wetlands along the shores of the sounds. They may be associated with small patches of Tidal Freshwater Marsh, particularly the Southern Wild Rice, Mixed Freshwater, Broadleaf Pondlily, or Narrowleaf Pondlily subtypes. They usually grade into more extensive Tidal Freshwater Marsh communities downstream along rivers and may be bordered by them along larger estuaries. They grade upstream to Cypress–Gum Swamp and other Coastal Plain Floodplain communities, often with a very gradual transition where it can be difficult to find the boundary. In this transition zone, Tidal Swamp may occupy low areas while bottomland hardwoods or levee forest may occur on higher ridges. In the large peat-filled river valleys in northeastern North Carolina, Nonriverine Swamp Forest or Peatland Atlantic White Cedar Forest communities may lie inland of them or may occur as patches embedded within them on slightly higher ground.

Variation: While systematic vegetational variation has not been found in floristic analysis, variants are recognized based on tidal flooding dynamics and contributing water, which are likely to affect ecosystem dynamics and fauna.

1. Lunar Tidal Brownwater Variant occurs on the lower Cape Fear River, where regular tidal flooding and significant tidal amplitude is combined with brownwater sediment input. In addition to the more frequent but never long-duration tidal flooding, lunar tides reflect greater connection to the ocean and greater potential for saltwater intrusion.

2. Lunar Tidal Blackwater Variant occurs on lower blackwater rivers and smaller creeks in areas where lunar tides predominate. This includes the Black, Northeast Cape Fear, White Oak, New, and smaller tidal creeks.

3. Wind Tidal Brownwater Variant occurs on the lower Tar River and Roanoke River, where brownwater input meets a microtidal estuary. It is uncertain, but the lower Neuse River probably fits here because of the limited lunar tidal amplitude.

4. Wind Tidal Blackwater Variant occurs on the Chowan and numerous smaller blackwater streams around the sounds that are remote from the ocean.

Examples adjacent to nonriverine wetlands would be placed in the blackwater variants. Wind tidal variants are more affected by rising sea level and brackish water intrusion than lunar tidal variants. This distinction between brownwater and blackwater is reduced in tidal swamps but appears pronounced enough to recognize variants. Brownwater Variant occurrences can be expected to have more *Nyssa aquatica* and other species shared with brownwater rivers. Such species may reflect differences in water chemistry and soils, but they may also be relict from a time before rising sea level brought tidal influence to the area.

Taxodium distichum / Typha angustifolia Woodland (CEGL004231) and several other tidal *Taxodium distichum* woodlands have been recognized in Virginia and attributed to North Carolina. These do not appear to be distinct enough to be appropriate as community elements, at least in North Carolina. Some appear to be ecotonal or transitional to Tidal Freshwater Marsh. These are not recognized as distinct communities in the 4th Approximation, but could be treated as an additional variant, or as an additional series of variants corresponding to each of the above variants. They represent Tidal Swamps in the middle of transition to Tidal Freshwater Marsh, with only *Taxodium* remaining from the former swamp canopy, and are likely to be relatively short-lived. Because *Taxodium* is more tolerant of salt than *Nyssa*, the presence or absence of these variants depends on whether *Taxodium* was present in large enough numbers previously and on whether it was removed by earlier logging.

Dynamics: Examples associated with large rivers may be subject to river floods as well as regular or irregular tidal flooding. Both riverine and tidal flooding bring in nutrients and make these communities more fertile than blackwater river floodplains or nonriverine swamps.

Upstream examples with closed canopies have tree dynamics similar to other swamp forests, with canopies that are naturally old growth. Most canopy gaps are small, with larger disturbances rare. *Taxodium* is the longest-lived tree species in the state. Canopies are naturally multi-aged, but tree establishment may be irregular and dependent on unusual weather and water conditions. *Taxodium* and *Nyssa* are both resistant to wind throw and survive hurricanes that cause extensive tree mortality in other forests. Flood scouring only very locally acts as a natural disturbance. Past logging has turned most examples into more even-aged forests that are more dominated by *Nyssa*, but ancient *Taxodium* trees are sometimes left in the swamps.

Most examples are affected to some degree by the ongoing rise in sea level, with those in the wind tidal areas often dramatically affected. The wind tidal areas are located in the Embayed Region, where geologic subsidence exacerbates the global sea level rise. Wind tidal areas have less natural fluctuation in water levels, and rarer times when low tides allow soils to drain. These areas also have slower accumulation of sediment to offset the sea level rise.

As rising sea level increases stress on tree canopies, tree reproduction in gaps ceases, tree crowns thin, and tree mortality increases. Affected stands have open canopies with numerous standing snags; change may happen gradually or may be induced quickly by storm tides or salt intrusion. As the canopy becomes more open, shrubs and herbs of Tidal Freshwater Marsh establish in the swamp, so that the marsh vegetation is generally well established when the canopy is finally lost. If trees are killed by a storm tide, young trees may establish, but the transition to marsh continues. The term "ghost forest" has come to be used for the final stage of this transition, when most or all trees are standing dead. Because of long term geologic subsidence and sea level rise, a zone of transition has long been present, but its extent and rate of formation has increased as sea level rise has accelerated. It has apparently increased further on the lower Cape Fear River, an area without ongoing geologic subsidence, because of dredging of the river channel for ocean-going ships. The deepened channel allows the denser salt water at the bottom to travel upstream to Wilmington in increased amounts.

Rising sea level also causes Tidal Swamps to spread to higher and more inland areas. Many Tidal Swamps have developed relatively recently from Cypress–Gum Swamp or Nonriverine Swamp Forest. They have canopy trees established under the earlier hydrologic regime but have the less tolerant lower strata already replaced by characteristic tidal species. The upstream extent of Tidal Swamps is greater than has often been recognized.

Comments: Besides the *Taxodium* woodland association discussed above, an additional Virginia association, *Nyssa biflora - Nyssa aquatica - Taxodium distichum / Saururus cernuus* Forest (CEGL004696) was mentioned in early drafts of the 4th Approximation as being problematically attributed to North Carolina. It was later merged and is no longer recognized in the NVC.

Pinus taeda - Nyssa biflora - Taxodium distichum / Morella cerifera / Osmunda regalis var. *spectabilis* Tidal Forest (CEGL004651) is an association defined in southeast Virginia. It has pronounced hummock-and-hollow topography, coarse fibric peat, and little *Nyssa aquatica*. While these characteristics are present in some North Carolina examples of this type, no distinct community of this sort has been found.

Tidal Swamps are not as well studied in North Carolina as inland Coastal Plain river communities; those on the Roanoke River were a focus of Tingley (1985) and were covered by Rice et al. (2001). A large number of CVS plots exist, but they are not reliably distinguished from inland floodplain communities at present.

Rare species:
Vascular plants – *Bacopa caroliniana, Bacopa innominata, Cardamine longii, Carex decomposita, Carex disjuncta* (*canescens* var. *disjuncta*), *Carex lupuliformis, Chasmanthium nitidum, Coreopsis palustris, Eleocharis halophilus, Epidendrum conopseum, Heteranthera pauciflora* (*multiflora*), *Lilaeopsis carolinensis, Oenothera riparia, Ponthieva racemosa, Pycnanthemum setosum, Sagittaria weatherbiana,* and *Thalictrum macrostylum*.

Nonvascular plants – *Acanthothecis paucispora*.

Vertebrate animals – *Elanoides forficatus*.

Invertebrate animals – *Acronicta perblanda* and *Iridopsis cypressaria*.

TIDAL SWAMP (MIXED SUBTYPE)

Concept: Tidal Swamps are closed or open-canopy wet forests or woodlands along rivers, creeks, or estuarine shorelines influenced by tidal waters with minimal salt content. Tides may be either lunar or wind tides. The Mixed Subtype covers examples dominated by *Fraxinus pennsylvanica* or *Ulmus americana*, sometimes by *Pinus taeda* or other *Fraxinus* species. This subtype is presently known only in the middle coastal areas around the New and White Oak River, where it seems to be confined to areas farther downstream and more associated with substantial tidal marsh complexes than most examples of the Cypress–Gum Subtype.

Distinguishing Features: Tidal Swamps are distinguished from other swamps by the occurrence of regular or irregular tidal flooding. Evidence of non-trivial tidal fluctuation may be taken as distinguishing this type, but this can be difficult to recognize during brief visits. Tidal influence is accompanied by the presence of characteristic species such as *Morella cerifera*, *Rosa palustris*, and numerous herbaceous species shared with Tidal Freshwater Marshes. The Mixed Subtype is distinguished by the canopy dominants. Because these species don't tend to occur in adjacent related communities, this subtype should be much easier to distinguish from other types than the Cypress–Gum Subtype. Note, however, that Brownwater Levee Forest (Low Levee Subtype) can occur in association with Tidal Swamp (Cypress—Gum Subtype) farther inland. This Tidal Swamp subtype may be distinguished from Brownwater Levee Forest by the presence of species in the lower strata that are indicative of tidal influence, increased wetness, and increased light levels. *Morella cerifera* and *Juniperus silicicola* are both good indicators, as are a number of herbs shared with Tidal Freshwater Marsh.

Crosswalks: *Fraxinus pennsylvanica - (Ulmus americana) - Pinus taeda / Morella cerifera - Juniperus virginiana var. silicicola* Tidal Forest (CEGL004483).
G033 Bald-cypress - Tupelo Floodplain Forest Group.
Southern Atlantic Coastal Plain Tidal Wooded Swamp Ecological System (CES203.240).

Sites: The known examples of the Mixed Subtype occur along tidal creeks and smaller rivers in the middle part of the coast. All have predominantly lunar tides rather than wind tides. They occur well downstream in the tidal creek, where substantial marshes are present.

Soils: Most examples of the Mixed Subtype are mapped a Dorovan (Typic Haplosaprist).

Hydrology: The Mixed Subtype occurs along waters subject to lunar tides in fresh-to-brackish waters. It is unclear how frequently tidal waters actually flood examples. This subtype appears to be slightly above normal high tide levels or in places where the salt content of the tidal water is mitigated by freshwater input.

Vegetation: The Mixed Subtype is a closed or open forest dominated by varying combinations of *Fraxinus pennsylvanica, Fraxinus profunda, Ulmus americana*, and *Pinus taeda*. *Acer rubrum* var. *trilobum* and *Juniperus silicicola* are often abundant, and *Nyssa biflora*, *Taxodium distichum, Quercus laurifolia*, or *Liquidambar styraciflua* may sometimes occur. The understory primarily consists of the same species, but *Persea palustris* may also be abundant. The primary shrub is *Morella cerifera*, but *Baccharis halimifolia* and potentially *Rosa palustris* or other species shared with Tidal Freshwater Marsh may be present. *Toxicodendron radicans* and *Muscadinia rotundifolia* may occur. The herb layer consists largely of species shared with Tidal Freshwater Marsh or even Brackish Marsh. *Cladium jamaicense* or *Juncus roemerianus* may dominate, or the herb layer may be mixed. Other herb species may include *Pontederia cordata, Sagittaria lancifolia, Typha latifolia, Typha domingensis, Osmunda spectabilis, Echinochloa walteri, Fimbristylis castanea, Lythrum lineare, Persicaria punctata, Solidago mexicana, Juncus pylaei, Kosteletzkya pentacarpos, Spartina cynosuroides, Hydrocotyle tribotrys (triradiata), Cyperus odoratus*, *Carex leptalea, Ptilimnium capillaceum, Cicuta maculata, Peltandra virginica*, and *Saururus cernuus*.

Range and Abundance: Ranked G1G2. Only a handful of examples are known, currently only in Onslow County, on the New and White Oak Rivers and their tributaries. This subtype has not been reported in any other states.

Associations and Patterns: The Mixed Subtype is a large patch community, potentially occupying hundreds of acres where it occurs. It is often associated with Tidal Freshwater Marsh, sometimes with Brackish Marsh. It may occur adjacent to the tidal creek channel or may form a zone between the marsh and the upland. It can be associated with Tidal Red Cedar Forest, where it tends to occur farther upstream. Where the Cypress—Gum Subtype occurs nearby, it is farther upstream.

Variation: Examples vary in the predominant canopy species, from those with codominant *Pinus taeda* to those that are largely hardwood.

Dynamics: Details of the dynamics of the Mixed Subtype are not known. They are subject to natural disturbance by saltwater intrusion and flooding associated with storms. This may be catastrophic, killing much of the canopy. It may drive the transition of the swamp forest to marsh, but it is possible for the canopy to regenerate.

Comments: This community was recognized and described by Richard LeBlond in the course of natural area surveys of Onslow County and Camp Lejeune. It is unclear if it is confined to this small area or is overlooked elsewhere. It represents a repeating assemblage in this area. Though its vegetation appears quite distinctive, the aspects of the environment that lead to its occurrences are poorly known. This portion of the coast has medium size tidal rivers, and it has regular lunar tides but limited tidal amplitude. Intermediate between the wind-tide-driven estuaries farther north and the areas with greater tidal amplitude in the Cape Fear River basin, it appears to be associated with saltier water than the Cypress–Gum Subtype in this area, yet the Cypress-Gum Subtype occurs without it in other salty areas.

The 4th Approximation Guide mentioned an apparently similar association called *Fraxinus pennsylvanica / Cornus foemina / Carex bromoides* Forest (CEGL007742), which had been described from the Northwest River in Virginia. It is called a riverine community rather than tidal, but it sounds like it is very similar to this type. That association was later dropped from the NVC. It was less tidally influenced and was lumped with a river swamp association.

Rare species: No rare species are known to be specifically associated with this community.

TIDAL RED CEDAR FOREST

Concept: Tidal Red Cedar Forest is an open woodland dominated by *Juniperus silicicola,* with marsh species beneath, occurring adjacent to brackish or salt tidal waters or marshes and at least partially flooded by tides. An irregular ground surface allows the trees to root above normal tide levels, while brackish marsh species occur beneath them.

Distinguishing Features: Tidal Red Cedar Forest is distinguished from Marsh Hammock by being lower and wetter, with tidal waters regularly penetrating the lower microsites. Marsh Hammock communities may have some marsh flora present, but the marsh species are more incidental, occurring near the edges and in sandy or dry soils not typical of their primary habitat. Closely related to Tidal Swamp (Mixed Subtype), Tidal Red Cedar Forest may be distinguished by having only limited presence of *Pinus taeda* and hardwoods and having *Juniperus* dominant.

Crosswalks: *Juniperus virginiana var. silicicola / Morella cerifera / Kosteletzkya virginica - Bacopa monnieri* Tidal Woodland (CEGL007166).
G759 Southern Ash - Elm - Willow Floodplain Forest Group.
Southern Atlantic Coastal Plain Tidal Wooded Swamp Ecological System (CES203.240).

Sites: Tidal Red Cedar Forest occurs on low flats along salt to brackish estuaries, adjacent to the channel or to tidal marshes. At least some of the known sites have significant microrelief which affects the amount of tidal flooding. Hummocks appear to be slightly above the level of normal tides while low areas may regularly receive shallow flooding.

Soils: Soils of Tidal Red Cedar Forest may be either organic or mineral. Examples are mapped as either marsh soils such as Hobonny or Lafitte (Typic Haplosaprist) or as floodplain soils such as Dorovan (Typic Haplosaprist) or Muckalee (Typic Fluvaquent). The occurrence of organic hummocks appears to be a crucial part of the soil environment.

Hydrology: Tidal Red Cedar Forests are known in areas with both lunar and wind tides. The water is most often brackish but may be more or less salty. The hummocks where the trees are rooted probably are inundated only in the most severe storm surges. The lower areas appear to flood irregularly but presumably more frequently.

Vegetation: Tidal Red Cedar Forest has a woodland or somewhat open forest canopy of short stature, dominated by *Juniperus silicicola*. Small numbers of *Pinus taeda, Acer rubrum var. trilobum, Ulmus americana*, and *Persea palustris* are often present. The shrub layer is dominated by *Morella cerifera* and may contain *Baccharis halimifolia, Kosteletzkya pentacarpos,* and *Persea palustris*. *Toxicodendron radicans* occurs with high constancy, and *Parthenocissus quinquefolia, Smilax bona-nox*, or other vines may occur. The herb layer may be sparse or dense and tends to contain species typical of Tidal Freshwater Marsh or Brackish Marsh. Species that have been observed to be dominant, at least locally, include *Juncus roemerianus, Spartina patens, Distichlis spicata, Bacopa monnieri, Bolboschoenus robustus, Triglochin striata, Typha angustifolia, Fimbristylis castanea, Schoenoplectus pungens*, and *Persicaria punctata*. Other fairly frequent herbs include *Solidago mexicana, Osmunda spectabilis, Amaranthus cannabinus, Samolus parviflorus, Ipomoea sagittata*, *Lythrum lineare,* and *Cladium jamaicense*.

Range and Abundance: Ranked G1? This community is known from a handful of scattered locations in North Carolina. It is also known from Georgia. The global abundance is uncertain because of questions about circumscription of the community.

Associations and Patterns: Tidal Red Cedar Forest is a large patch community, with patches occupying tens to hundreds of acres. It usually borders Brackish Marsh or one of the saltier subtypes of Tidal Freshwater Marsh.

Variation: Little is known of variation but, as with other Freshwater Tidal Wetlands, the difference between lunar and wind tidal flooding may be significant.

Dynamics: Dynamics of Tidal Red Cedar Forest are not well known. The community appears to depend on a narrow range of salt exposure and may also depend on microrelief that allows species of different tolerance to coexist. It is periodically disturbed by storms and penetration of salt water during storms, but trees may be able to regenerate after these disturbances. The origin of the hummocks, which are more pronounced than in nearby marshes, is uncertain, but they may be formed on old logs, tip up mounds, or tree bases. It also appears that wind throw of trees could destroy hummocks. While the community clearly can be expected to change and perhaps be locally destroyed by rising sea level, it is unclear if it is stable over long periods at current rates of sea level rise, or if it is inherently a short-lived community. It is not present in most marsh patches and does not appear to simply be a zone in the transition between marsh and upland.

Comments: There are questions about the appropriate circumscription of this community. The concept was initially formulated by Richard LeBlond in the course of natural area inventories in Onslow County and Camp Lejeune. He emphasized the microtopography in what appeared to be a distinctive, if repeating, kind of site. These are all brackish areas with regular lunar tides but limited tidal range, on tidal creeks and small rivers. But woodlands of *Juniperus silicicola* occur in wet marsh-edge settings in other parts of the state, including on wind-tidal oligohaline and brackish estuaries and on marsh edges on barrier islands. A number of CVS plots document them in this range of settings in the state, and there is at least one similar plot in South Carolina. If the community is conceived this broadly, many more undocumented occurrences probably exist, and the G1 rank is probably incorrect. If it is a true G1 community driven by a rare combination of environmental factors, another community needs to be recognized for other *Juniperus* woodlands.

Rare species:
Vascular plants – *Eleocharis fallax* and *Eleocharis parvula*.

ESTUARINE COMMUNITIES THEME

Concept: The Estuarine Communities theme encompasses coastal zone communities whose character depends primarily on flooding by salt or brackish water. Most are tidal marshes influenced by full-strength or somewhat diluted brackish seawater. Also included, though they are somewhat different, are the communities of beaches and low sand spits, which are not regularly flooded but are frequently flooded or battered by seawater.

Distinguishing Features: Estuarine Communities are distinguished by tidal flooding by brackish or salt water or by occurrence on ocean beaches or low-lying spits. They have vegetation dominated by a limited number of plant species that are able to tolerate regular or at least frequent exposure to salt. Beyond *Spartina alterniflora, Spartina patens, Juncus roemerianus, Salicornia virginica, Salicornia ambigua, Distichlis spicata, Borrichia frutescens, Iva frutescens, Cakile edentula, Cakile harperi*, and *Limonium carolinianum*, most plant species are limited to the few least extreme Estuarine Communities and occur in much greater abundance in Freshwater Tidal Wetlands or other themes. Freshwater Tidal Wetlands share some species, but all those communities also contain additional species less tolerant of salt.

Within this theme, communities can be divided into the small group of the Upper Beach and Sand Flat communities and the marsh communities. Marsh communities occur in and around estuaries, on both the mainland and the back of barrier islands. They usually occur in zoned complexes that may contain multiple communities, though one often dominates the majority of the complex. Marsh communities are divided based on the level of salinity, with Salt Marshes being flooded by full-strength seawater. Brackish Marshes are somewhat less salty, either because they are flooded with diluted seawater or because they are less frequently flooded by full-strength seawater and salinity is reduced between flooding events. Salt Shrub communities are less salty still, enough to be able to support woody vegetation. Salt Flats, on the other hand, have higher salt concentrations than sea water.

The Upper Beach and Sand Flat communities are not flooded by normal high tides but are the most frequently flooded by seawater during storms. They are distinguished by sparse vegetation, frequent reworking of the sand, and strong salt spray.

Sites: Estuarine Communities occur on both barrier islands and the mainland, around large estuaries, narrow lagoons, tidal creeks, or on the ocean shoreline. All occur at or only slightly above mean sea level.

Soils: Soils range from organic deposits to clay or silt to wave-worked sand.

Hydrology: Most sites are permanently saturated, but those on beaches and on raised marsh edges may be well drained at times. Tidal flooding may be regular, occurring twice a day with the lunar tides; it may be irregular but frequent, occurring with wind tides; or it may be irregular but infrequent, occurring only at the higher tides or during storms. Salinity varies with connection to the ocean. Areas on the ocean shoreline and within a few miles of inlets are subject to full strength sea water. Estuarine areas more distant from inlets have brackish water because the seawater is diluted by fresh water. Local areas where seawater is trapped and evaporated have higher salt concentrations than seawater.

Vegetation: Vegetation of Estuarine Communities may be sparse to very dense, but it is low in diversity. Most communities are strongly dominated by one or a few plant species that are specialized to tolerate salt. *Spartina alterniflora, Spartina patens, Juncus roemerianus, Salicornia virginica, Salicornia ambigua, Distichlis spicata, Borrichia frutescens, Iva frutescens, Cakile edentula,* or *Cakile harperi* may dominate in different communities. A few additional species, such as *Limonium carolinianum*, are present in multiple communities. More species may occur, especially in the least extreme communities such as Brackish Marsh (Transitional Subtype), but they remain limited to the small set of the species most able to survive periodic saltwater flooding.

Dynamics: As with the maritime communities, Estuarine Communities are often extremely dynamic. Waves, storms, erosion, and deposition of sediments, along with unusual processes such as wrack deposition, may disturb communities. Even in these salt-tolerant and frequently flooded communities, increases in salt concentrations or prolonged flooding can be significant disturbances. Changes in the balance of salt and freshwater input caused by droughts, upstream dams, dredging of navigation channels, and rising sea level can shift community zones or can stress communities and kill vegetation temporarily or permanently (extensive literature reviewed in Gilbert et al. 2012). Most Estuarine Communities are able to develop quickly in newly suitable sites.

In addition, all communities in this theme are strongly affected by rising sea level. As with natural disturbances, they adapt well to the background level of rise, with most communities accreting material and raising their elevation to keep pace. However, they may be threatened or detrimentally altered by accelerated sea level rise or by a combination of rise with increased disturbance. There is also a potential for drastic changes on a broad scale. Existing community patterns based on the current configuration of tidal inlets and barrier islands will change quickly if many new inlets form or if the barrier islands are eroded to elevations below sea level.

In many of the communities, tidal flushing drives ecosystem function. Tidal flows provide a steady supply of nutrients, leading to high productivity. They carry organic matter from the marsh to the estuarine waters, providing the basis for a productive food web there. They provide habitat for many animals, including commercially important fisheries. Additional organic matter accumulates in marsh sediments, providing important sinks for carbon.

Comments: This theme contains some of the best studied and least studied communities in North Carolina. The extensive communities in this theme lie near research stations, are contained in public lands, and are of great interest for their role in ecosystem services. A number of regional vegetation studies and a few focused specifically on marshes have provided a good understanding of community patterns. However, several unusual communities are newly recognized or have usually been overlooked, and these are not well understood.

The inclusion of Upper Beach and Sand Flat communities in this theme is marginal. They are different in many ways but appear to fit somewhat better here than in Maritime Grasslands.

KEY TO ESTUARINE COMMUNITIES

1. Community on an ocean beach or low-lying sand spit; not subject to normal tidal flooding but readily flooded by seawater in moderate storms; vegetation sparse.
   2. Community on a low-lying, largely featureless, sand spit..**Sand Flat**
   2. Community on the upper beach, seaward of the foredunes.
      3. Community in the northern part of the coast, north of Cape Hatteras; *Cakile edentula* abundant, though *Cakile harperi* may be present. ....**Upper Beach (Northern Subtype)**
      3. Community in the southern part of the coast, south of Cape Hatteras; *Cakile harperi* predominant over *Cakile edentula*. ....**Upper Beach (Southern Subtype)**
1. Community not on a beach; if on a sand spit then influenced by normal tidal flooding; vegetation dense or sparse; community on the landward side of a barrier island or around an inland estuary, generally in a complex of marsh communities or as a fringing wetland.
   4. Community occurring in salt pannes, where seawater is trapped and evaporates to produce hypersaline conditions; vegetation sparse to moderately dense, dominated by *Distichlis spicata* or *Salicornia*; *Spartina alterniflora* and *Borrichia frutescens*, if present, with low cover...**Salt Flat**
   4. Community not occurring in salt pannes; salinity equal to seawater or less.
      5. Community dominated by shrubs; on the upland edge of a marsh.
         6. Community dominated by *Borrichia frutescens*......................**Salt Shrub (Low Subtype)**
         6. Community dominated by *Iva frutescens, Baccharis halimifolia, Morella cerifera*, or other species.
            7. Community moderately to strongly dominated by combinations of *Iva frutescens* or *Baccharis halimifolia*, sometimes with *Morella cerifera* codominant. ....**Salt Shrub (High Subtype)**
            7. Community weakly dominated by shrubs, more typically herbaceous; shrubs may include *Baccharis, Iva, Morella*, or small *Juniperus* or *Pinus taeda* ....**Brackish Marsh (Transitional Subtype)**
      5. Community dominated by herbs; shrubs sparse or absent.
         8. Community dominated by *Spartina alterniflora*.
            9. *Lilaeopsis chinensis* or other species less tolerant of salt abundant along with *Spartina alterniflora*. .... **Brackish Marsh (Smooth Cordgrass Subtype)**
            9. Only highly salt-tolerant species such as *Limonium carolinianum*, *Distichlis spicata*, *Salicornia ambigua*, or *Salicornia virginica* present with *Spartina alterniflora*.. **Salt Marsh**
         8. Community not dominated by *Spartina alterniflora*; dominated by *Spartina patens, Juncus roemerianus*, or a mix of species.
            10. Community dominated by *Juncus roemerianus*; often few or no other species present ....**Brackish Marsh (Needlerush Subtype)**
            10. Community not dominated by *Juncus roemerianus*; dominated by *Spartina patens* or a mix of species.
               11. Community dominated by *Spartina patens*, with few associated species other than *Juncus roemerianus, Spartina alterniflora, Borrichia frutescens*, *Limonium carolinianum*, or species of similar salt tolerance. ....**Brackish Marsh (Salt Meadow Cordgrass Subtype)**

11. Community a mix of species, *Spartina patens* is often present but does not strongly dominate; multiple species less tolerant of salt, such as *Fimbristylis castanea, Schoenoplectus pungens, Bolboschoenus robustus, Typha angustifolia, Panicum virgatum, Mikania scandens, Thelypteris palustris*, and *Osmunda spectabilis* present; some shrubs and small trees may also be present. .... **Brackish Marsh (Transitional Subtype)**

SALT MARSH

Concept: Salt Marshes are *Spartina alterniflora*-dominated marshes regularly flooded by salt water at or near full seawater salinity.

Distinguishing Features: Salt Marshes are distinguished by dominance by *Spartina alterniflora* in association with near-full-strength seawater. *Distichlis spicata*, *Salicornia* spp., *Limonium carolinianum*, and other salt-tolerant species occur in limited amounts, but species less tolerant of salt, even estuarine species such as *Lilaeopsis chinensis*, are scarce or absent.

Crosswalks: *Spartina alterniflora* South Atlantic Salt Marsh (CEGL004191).
G982 South Atlantic & Gulf Coast Salt Marsh Group. Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: Salt Marshes occur on intertidal flats near tidal inlets, where seawater is little diluted by fresh water. They may occur on or near barrier islands on relict or active flood tidal deltas, or on overwash deposits. Some are contiguous expanses, though fed by dendritic tidal channels, others are clusters of small to medium size islands. On the mainland, they may occur on low flats along estuaries or in bands along tidal creeks.

Soils: Salt Marshes occur on sandy or finer-textured mineral soils such as Carteret (Typic Psammaquent) or Bohicket (Typic Sulfaquent). Some Salt Marsh soils are cat clays (acidic sulphate soils), in which drying leads to a change from neutral pH to extreme acidity as sulfides oxidize to sulfuric acid.

Hydrology: Salt Marshes are regularly flooded by saltwater, with flooding driven primarily by lunar tides. The water is euhaline (30-40 parts/thousand).

Vegetation: Salt Marsh is strongly dominated by *Spartina alterniflora*. No other vascular plant species has high constancy in CVS plot data or site reports, but *Limonium carolinianum* and *Salicornia virginica* are fairly frequent. *Distichlis spicata* and *Salicornia ambigua* sometimes occur. *Juncus roemerianus, Spartina patens, Borrichia frutescens, Symphyotrichum tenuifolium*, and a few other species may occur in the transition to adjacent communities.

Range and Abundance: Ranked G5. Salt Marsh is abundant on the coast of North Carolina, occurring over large expanses in the state south of Cape Hatteras. Because of the scarcity of inlets, it is virtually absent north of Cape Hatteras at present. This community ranges from North Carolina to Florida.

Associations and Patterns: Salt Marsh is best regarded as a matrix community, occurring as a regular part of the landscape mosaic of barrier islands and saltwater estuaries. It is associated with other salt-tolerant estuarine communities. Salt Flat patches may be embedded in it. Brackish Marsh, Salt Shrub, or Salt Flat may occur immediately inland of it.

Variation: Salt Marshes have very low vascular plant diversity and show little variation in vegetation. Many descriptions of marshes emphasize zonation (e.g., Adams 1963). Many authors make a distinction between low marsh and high marsh or between the short form and tall form of *Spartina alterniflora*. Low marsh, flooded more regularly, is more productive and has taller *Spartina alterniflora*. High marsh appears to refer to several different kinds of vegetation. Some are covered by other communities in the 4th Approximation, such as Brackish Marsh subtypes, Salt Flat, or Salt Shrub. It may also be ecotonal Salt Marsh, where species of these communities mix with *Spartina alterniflora*. The *Spartina* often is noted as being shorter in the high marsh, because of reduced input of nutrients and because evaporation increases salt concentration. However, additional species may be present in it.

In additiona to zonal variation, Salt Marshes may differ subtly with variation in tidal amplitude. North Carolina's examples range from less than one foot to over five feet, and examples in South Carolina and Georgia experience even greater amplitudes.

Dynamics: Salt Marshes are well known for their high productivity, considered among the highest in the world for broad ecosystem types. Though their vascular plant diversity is limited by salinity, the environment is very favorable for specialized plants. Regular tidal flushing provides a steady supply of plant nutrients and exports organic matter to the adjacent estuary. Because of this, they are particularly important for estuarine food webs and for commercial fisheries. Salt Marshes are also important for nutrient cycling. Uptake of nutrients by plants enhances water quality in the adjacent waters. Denitrification recycles excess fixed nitrogen back to the atmosphere.

Salt Marshes are usually stable, with patches persisting for long periods, but some portions may be very dynamic. Those adjacent to open water may be affected by shoreline erosion, while some on the back sides of barrier islands may be buried by overwashed sand. Patches may be lost if sand deposition raises the surface above tide levels. New Salt Marsh environments may form behind barrier islands as inlets migrate or open, creating new flood tidal deltas. Storm surges and storm waves may affect salt marshes. These marshes are often important in protecting upland shorelines from storm erosion. The complex structure of the grass diffuses wave energy better than bare shorelines and better than most kinds of vegetation. Some other processes documented to disturb marshes in other states may potentially affect North Carolina's marshes. For example, Silliman et al. (2005) described die-off of marsh patches from South Carolina to Louisiana driven by drought-related increases in salinity but exacerbated by excess grazing by periwinkles (*Littorina*).

A crucial dynamic for Salt Marshes at present is the effect of rising sea level. Marshes may keep pace with rising sea level if production of organic matter and deposition of sediment is fast enough. This has clearly been happening in many places in North Carolina, but it is not clear whether it will continue to keep up if sea level rise accelerates.

Comments: Salt Marshes are well studied. They are recognized in most vegetation studies, such as Au (1974), Godfrey and Godfrey (1976), and Rosenfeld (2004). Numerous other studies, not cited here, focus on their ecosystem ecology and ecosystem services.

The concept of Salt Marsh has been narrowed from that in the 3rd Approximation. Previously, it conceptually included all the upper zones, including potentially large areas of *Spartina patens*, *Juncus roemerianus*, or other species. This is the area often referred to as high marsh. Brackish Marsh (Transitional Subtype) now covers these upper zones along upland ecotones, while larger expanses are treated as the Needlerush or Salt Meadow Cordgrass Subtype of Brackish Marsh.

Because of the inclusion of higher and more mixed zones, it is unclear which rare species previously listed as occurring in Salt Marsh are likely to truly be in this community.

Salt Marshes are notable in being regarded as having limited importance for biodiversity, because of their low richness in the taxa typically measured, while being extremely important for ecosystem services. They are an interesting counterexample to the frequent belief that diverse ecosystems are more productive than simple ones, or that the most productive ecosystems will support the most species.

Earlier drafts of the 4th Approximation divided Salt Marsh into a Caroliniana and Virginian Subtype. This distinction followed the lead of the NVC, which recognized a biogeographic break at Cape Hatteras. Shortly before publication, the association on which the Virginian Subtype was based was revised and the biogeographic break placed farther north, leaving only a single association attributed to North Carolina.

Salt Marsh communities represent a dilemma for vegetation-based classification because a single species dominates their simple vegetation over a huge range while associated animals and non-vascular plants are believed to turn over more rapidly with distance. A break based on biogeography appears called for, but with no cues from the vegetation, the break is somewhat arbitrary. The previous Virginian association was named with the alga *Ascophyllum nodosum* marking the distinction. The description noted that this species, along with *Fuscus versiculosus* and *Ulva* spp., was characteristic, forming extensive mats at the base of the grass culms, but also noted that they could be scarce at the southern end of the range. There was thus nothing to readily distinguish the two associations in North Carolina. Because of the scarcity of tidal inlets in northern North Carolina, there is a natural break in the range of Salt Marshes from Oregon Inlet to near Chesapeake Bay. This makes a better division between associations, though it may disappear at any time if a new inlet opens.

Rare species:
Vertebrate animals – *Ammospiza caudacuta, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

BRACKISH MARSH (SALT MEADOW CORDGRASS SUBTYPE)

Concept: Brackish Marshes are tidal marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. They include marshes of estuarine areas at some distance from oceanic inlets, where the water is brackish, and higher zones of Salt Marshes in areas with salt water. The Salt Meadow Cordgrass Subtype covers examples dominated or codominated by *Spartina patens*. They often occur as higher zones of Salt Marshes, where they are flooded with full strength salt water at less than daily intervals. They also occur in the large marsh complexes in brackish waters.

Distinguishing Features: Brackish Marshes are distinguished from Salt Marshes by having vegetation dominated by *Spartina patens*, *Juncus roemerianus*, or by having *Spartina alterniflora* in combination with less salt-tolerant species such as *Lilaeopsis chinensis*. They are distinguished from Tidal Freshwater Marsh subtypes by lacking salt-intolerant species. The Salt Meadow Cordgrass Subtype is distinguished from the other subtypes of Brackish Marsh by dominance of *Spartina patens*. It is distinguished from Maritime Dry Grassland and Maritime Wet Grassland, which may also be dominated by *Spartina patens*, by the absence of upland species and salt-intolerant species, such as *Rhynchospora colorata* and *Muhlenbergia sericea*. It also usually may be distinguished by the presence of some plant species shared with Salt Marshes, such as *Distichlis spicata* and *Borrichia frutescens*, which are usually absent in maritime grasslands.

Crosswalks: *Spartina patens* - *Distichlis spicata* - *Borrichia frutescens* Salt Marsh (CEGL008740).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: The Salt Meadow Cordgrass Subtype most often occurs on the backs of barrier islands, adjacent to Salt Marsh or to the Needlerush Subtype but at slightly higher elevation. It may also occur on relict flood tidal deltas remote from inlets, on more extensive flats along estuaries, or in marsh complexes in bands along tidal creeks.

Soils: The Salt Meadow Cordgrass Subtype can occur on either organic or mineral soils. Many of North Carolina's examples are mapped as Lafitte (Typic Haplosaprist), some as Carteret (Typic Psammaquent), Hobucken (Typic Hydraquent), or Currituck (Terric Haplosaprist).

Hydrology: Brackish Marshes may be regularly or irregularly flooded by lunar tides or by wind tides. The Salt Meadow Cordgrass more often occurs where the water is close to the salinity of sea water, in upper zones that are flooded only by the highest tides or upstream along tidal creeks where the salinity is reduced.

Vegetation: The Salt Meadow Cordgrass Subtype is dominated or codominated by *Spartina patens*. *Spartina alterniflora*, *Distichlis spicata*, *Juncus roemerianus*, *Borrichia frutescens, Iva frutescens*, or *Baccharis halimifolia* may be abundant, especially in the transition to adjacent communities. Other species that may occur include *Salicornia virginica, Salicornia ambigua, Limonium carolinianum, Fimbristylis castanea, Solidago mexicana, Hydrocotyle bonariensis, Symphyotrichum tenuifolium,* and *Morella cerifera*.

Range and Abundance: The equivalent NVC association does not yet have a global rank. It is likely G4 or G5. In North Carolina, the Salt Meadow Cordgrass Subtype is common throughout the southern two thirds of the coast and in Pamlico Sound, Roanoke Sound, the Neuse River estuary, and smaller sounds. The NVC association ranges from North Carolina to Florida.

Associations and Patterns: The Salt Meadow Cordgrass Subtype is a large patch community. Occurrences may be hundreds of acres, but it is not a reliable part of the landscape mosaic. It often occurs as a zone in marsh complexes, associated with Salt Marsh or Brackish Marsh (Needlerush Subtype). Brackish Marsh (Transitional Subtype), Salt Shrub, or Salt Flat may occur on its upland edges. It may also border Maritime Wet Grassland, Maritime Dry Grassland, or Maritime Shrub.

Variation: Little is known about the variation in this subtype, other than the admixture of species in the transition to other communities. There may be important differences between those associated with Salt Marsh and those associated with the Needlerush Subtype. Though these have not been clarified, they are recognized as variants.

1. Salt Variant occurs in areas with salinity near full strength seawater, occurring in higher portions that get only irregular tidal flooding. It occurs as an upper zone of Salt Marsh and was treated as part of Salt Marsh in the 3rd Approximation. It is often known as high marsh.

2. Brackish Variant occurs in brackish water estuaries, where salinity is lower. It usually occurs in marsh complexes dominated by Brackish Marsh (Needlerush Subtype), where it is noted to occur in the interior of the complexes.

Dynamics: The specific dynamics of the Salt Meadow Cordgrass Subtype are not well known. Most patches appear stable over long periods of time, but those on the back of barrier islands may be disturbed or buried by overwash. Patches may also be subject to shoreline erosion and may be affected by rising sea level.

With its less regular tidal flushing, the productivity of the Salt Meadow Cordgrass Subtype likely is lower than in Salt Marsh, but they may still be important for nutrient cycling and for carbon sequestration.

Mainland marsh complexes often have continuous dense vegetation connected to uplands and probably burned naturally. The effect of fire in the Salt Meadow Cordgrass Subtype is not well known, though the herbaceous plants are likely to respond favorably to it. In Louisiana, Nyman and Chabreck (1993) reported that spring burning promoted *Spartina patens* while winter burning promoted *Scirpus olneyi* (*Schoenoplectus americanus*). They noted that it was unclear if burning would help or hinder organic accumulation to allow the marsh to keep pace with rising sea level. Occurrences of the Salt Meadow Cordgrass Subtype on barrier islands are much less likely to burn naturally, as they typically are associated with sparse upland vegetation and with discontinuous marsh complexes.

Comments: The Salt Meadow Cordgrass has had limited specific study compared to the Needlerush Subtype and to Salt Marsh, but it is recognized in a number of vegetation studies such as Au (1974), Godfrey and Godfrey (1976), and Rosenfeld (2004). It can be difficult to recognize in plot data and can be difficult to distinguish from other marsh communities in site descriptions.

This community was formerly crosswalked to *Spartina patens* - *Distichlis spicata* – *(Juncus* roemerianus) Salt Marsh (CEGL004197). That association has been split into a northern and southern association and the previous name and code retired.

Rare species:
Vascular plants – *Eleocharis cellulosa, Eleocharis rostellata, Ludwigia alata,* and *Sporobolus virginicus.*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Circus hudsonius, Himantopus mexicanus, Ixobrychus exilis, Malaclemys terrapin, Nerodia sipedon williamengelsi,* and *Seminatrix pygaea paludis*.

BRACKISH MARSH (NEEDLERUSH SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. They include marshes of estuarine areas at some distance from oceanic inlets, where the water is brackish, and higher zones of Salt Marshes in areas with salt water. The Needlerush Subtype covers examples dominated by *Juncus roemerianus*, often with few or no other vascular plant species present. This common subtype may occur either as an upper zone of Salt Marshes, in headwaters of tidal creeks upstream from Salt Marshes, or in vast expanses in the brackish sounds. In the sounds, it may be influenced by wind tides or lunar tides.

Distinguishing Features: The Needlerush Subtype is distinguished from most other communities, including subtypes of Brackish Marsh and Salt Marsh, by the dominance by *Juncus roemerianus*. It is distinguished from the Needlerush Subtype of Tidal Freshwater Marsh by the absence of less salt-tolerant plant species such as *Thelypteris palustris*, *Osmunda regalis*, *Sagittaria lancifolia*, and *Pontederia cordata*.

Crosswalks: *Juncus roemerianus* Juncus roemerianus Salt Marsh (CEGL004186).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: Brackish Marshes occur along estuaries, lagoons, and tidal creeks, on barrier islands, on islands within the sounds, and on the mainland. Sites are only slightly above mean sea level, allowing them to be flooded by ordinary tides, at least the higher spring tides or wind tides. Mainland sites are usually small to large expanses of flat organic deposits, but the community may occur as bands lining tidal creeks. Examples on and near barrier islands tend to be on relict flood tidal deltas, often occurring as complexes of small islands separated by tidal channels.

Soils: The Needlerush Subtype can occur on either organic or mineral soils. Most of North Carolina's examples are organic, and are mapped as Lafitte (Typic Haplosaprist), Hobonny (Typic Haplosaprist), or Currituck (Terric Haplosaprist). A minority are Bohicket (Typic Sulfaquent). Clontz (1994) noted gradients in soil chemistry in a large Needlerush Subtype marsh, with nitrate increasing landward and pH and conductivity lower as freshwater input diluted salt.

Hydrology: Brackish Marshes may be regularly or irregularly flooded by lunar tides or by wind tides. The largest examples occur in the sounds where the water is brackish, where tidal flooding may be semidiurnal or irregular. Examples also occur where the water is close to the salinity of sea water, in upper zones that are flooded only by the highest tides or upstream along tidal creeks where the salinity is reduced.

Vegetation: The Needlerush Subtype is generally strongly dominated by *Juncus roemerianus*. In the transition to other communities, it may be codominated by *Spartina alterniflora, Distichlis spicata, Spartina patens*, or *Borrichia frutescens*. Along the estuary shoreline of patches, *Spartina cynosuroides* may codominate or may dominate a narrow band. Other salt-tolerant species found in CVS plots with limited frequency include *Hydrocotyle bonariensis, Solidago mexicana, Limonium carolinianum, Fimbristylis castanea*, *Baccharis halimifolia*, and the exotic *Phragmites australis*. A number of other species may occur in the upland ecotone, including *Panicum virgatum, Lythrum lineare, Ptilimnium capillaceum*, and *Kosteletzkya pentacarpos*.

Range and Abundance: Ranked G5. The Needlerush Subtype is widespread and extensive in all but the northernmost part of North Carolina's coast. Large expanses occur around Pamlico Sound, Roanoke Sound, and the Neuse River estuary, and occur along numerous tidal creeks from there southward. The NVC association is very widespread, extending from North Carolina to Texas.

Associations and Patterns: The Needlerush Subtype is a matrix community, dominating large areas and occurring as a regular part of the landscape mosaic in estuarine and barrier island marsh complexes. It often occurs as the most extensive community in areas such as Cedar Island, Piney Island, mainland Hyde and Dare counties, Pamlico County, and Roanoke Island. There, it may be associated with the Salt Meadow Cordgrass Subtype, with Estuarine Fringe Pine Forest, Marsh Hammock, Estuarine Beach, and less often Salt Shrub. Closer to the coast, it occurs as a smaller zone in marsh complexes, where it is associated with Salt Marsh, Brackish Marsh (Salt Meadow Cordgrass), Salt Flat, Salt Shrub, and maritime communities.

Variation: The Needlerush Subtype often shows little variation in vegetation, but it can vary in the abundance of associated species with the transition to other communities. As in the Salt Meadow Cordgrass Subtype, two variants are recognized that may have different dynamics and associated species.

1. Salt Variant occurs in areas with salinity near full strength seawater, occurring in higher portions that get only irregular tidal flooding. It occurs as an upper zone of Salt Marsh and was treated as part of Salt Marsh in the 3rd Approximation. It is one of several kinds of vegetation known as high marsh.

2. Brackish Variant occurs in brackish water estuaries, where salinity is lower. It usually occurs as the predominant community in marsh complexes. Sometimes it is the only community, sometimes the Salt Meadow Cordgrass Subtype, Estuarine Beach, Estuarine Fringe Pine Forest, or Marsh Hammock may be present. This variant may be regularly flooded by lunar tides or may be irregularly flooded by wind tides, but generally is flooded more frequently.

Dynamics: Needlerush Subtype dynamics probably are intermediate between those of the Salt Meadow Cordgrass Subtype and of Salt Marsh. Where they are frequently flushed by tidal waters, their productivity may contribute substantially to the food webs of the estuary and to removing nutrients from the water. It may also store substantial organic matter on the site, accumulating organic soils. The Salt Variant, flooded less often, probably contributes less.

As with other marshes, Needlerush Subtype patches often are stable for long periods. Because it often occurs as a fringing marsh, it can be important for protecting upland shorelines from wave erosion. However, the Needlerush Subtype may be subject to shoreline erosion, to disturbance by storm surges and waves, and, on the back of barrier islands, by deposition of sand by overwash. Wrack — thick piles of litter and debris deposited by storm tides — may bury local patches of marsh, killing the vegetation and preventing its reestablishment for several years. While this occurs in all tidal marshes, the dense standing dead material in the Needlerush Subtype makes it particularly susceptible, and wrack deposits may form broad bands of considerable length.

Marsh salinity levels may shift gradually or abruptly, as inlets open, close, or migrate. Hackney and Yelverton (1990) noted the changes in tidal amplitude and salinity around Wilmington related to dredging of the Cape Fear River as well as to rising sea level. This may cause marsh communities to give way to different communities.

As with other tidal marshes, many Brackish Marsh patches have been keeping pace with rising sea level by accumulating organic matter and sediment for decades or centuries. Because tidal flushing is generally less than in Salt Marshes, and because sediment supply is often low where they occur, this accumulation has been driven more by primary productivity and accumulation of organic matter than by mineral sediment. It is thus even more uncertain if they will be able to keep up as sea level rise accelerates.

Needlerush marshes are often remarkable in the uniformity of their vegetation, sometimes with only a single plant species present over large areas. Cooper and Waits (1973), analyzing associations among many marsh species, found most to have predictable associations with other species but found *Juncus roemerianus* to have almost no associates. This presumably is because of its dense growth habit and the tendency of its dead culms to stand and form dense shade.

Variation was noted by Clontz (1994). Vegetation height was predicted by salinity, with taller vegetation where salt was diluted by freshwater input from the landward side. Biomass and density appeared to correlate with combinations of phosphorus and nitrogen.

While some Brackish Marsh complexes occur as collections of small to medium size islands, many occur as large expanses connected to the mainland. These can carry fire and would have been subject to natural ignition whenever the adjacent inland communities burned. Burning has been practiced in some larger Brackish Marshes for wildlife management. Fire removes the dense standing crop of deal culms and increases the production of new vegetation. It appears to increase plant diversity by reducing the heavy dominance of *Juncus roemerianus*.

Comments: The Needlerush Subtype is well studied. As a regular part of the landscape, it has been recognized in most coastal vegetation studies, such as Rosenfeld (2004), Au (1974), Adams (1963), and Godfrey and Godfrey (1976). It has also had extensive study focused on ecosystem ecology and ecosystem services.

Rare species:
Vascular plants – *Eleocharis cellulosa, Eleocharis parvula, Eleocharis rostellata, Ludwigia alata.*

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Circus hudsonius, Ixobrychus exilis, Laterallus jamaicensis, Malaclemys terrapin, Nerodia sipedon williamengelsi,* and *Seminatrix pygaea paludis*.

Invertebrate animals – *Poanes aaroni.*

BRACKISH MARSH (SMOOTH CORDGRASS SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. The Smooth Cordgrass Subtype covers examples of regularly flooded brackish to oligohaline tidal rivers or sound shores, dominated or codominated by *Spartina alterniflora*, and having plants intolerant of seawater salinity.

Distinguishing Features: The little-known Smooth Cordgrass Subtype is distinguished from other Brackish Marsh subtypes by the presence of *Spartina alterniflora* and by occurrence in regularly flooded brackish areas. The presence of *Lilaeopsis chinensis* and other plant species intolerant of full sea water salinity distinguishes this subtype from Salt Marsh.

Crosswalks: *Spartina alterniflora* South Atlantic Brackish Marsh (CEGL009013).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: The Smooth Cordgrass Subtype occurs on the shorelines of tidal rivers or estuaries where the water is brackish to oligohaline.

Soils: Details of soil are not known. This subtype potentially occurs on either organic or mineral soil.

Hydrology: The Smooth Cordgrass Subtype is within normal intertidal elevations and may be flooded regularly by lunar tides or irregularly by wind tides.

Vegetation: This community is not well known in North Carolina. It is dominated by *Spartina alterniflora* and includes various other plant species tolerant of brackish to oligohaline conditions but not tolerant of seawater. These may include *Lilaeopsis chinensis* or potentially *Schoenoplectus pungens, Bolboschoenus robustus, Samolus parviflorus, Eleocharis* spp., or other species.

Range and Abundance: Grank uncertain. The range and abundance of this subtype in North Carolina are very poorly known. It is unclear if it is known in any other states, though it is likely to occur in states to the south.

Associations and Patterns: The Smooth Cordgrass Subtype appears to be a small patch community. Where it occurs, it is usually a narrow band several meters wide along lengths of shoreline.

Variation: Examples presumably vary with degree of salinity. It may be appropriate to divide this into brackish and fresh/oligohaline versions.

Dynamics: Dynamics are very little known. Since this subtype occurs on the shoreline of marsh complexes, it presumably is particularly susceptible to wave erosion. These communities may play a role in protecting the marshes behind them. Many estuarine shorelines are scarped or collapsing, and it is possible that examples have been lost to wave erosion in places.

The environmental factors that produce this community are unclear. Given the presence of less salt-tolerant plants, the salt tolerance of *Spartina alterniflora* does not appear to be the most important factor. Given that salinity levels are increasing as sea level rises, they do not appear to be relict stands from a saltier past.

Comments: This community is little known, and it is not entirely clear that it occurs in large enough patches to treat as a distinct community. Its recognition in North Carolina is based on observation by Alan Weakley on the Cape Fear River near Wilmington, where patches of several acres with abundant *Lilaeopsis*, as well as narrow fringes, were seen along oligohaline waters. The author has seen fringes several meters wide along the Brunswick River near the transition of Tidal Freshwater Marsh to Brackish Marsh. Bands dominated by *Spartina alterniflora* have also been reported on the shoreline of Brackish Marsh complexes at Cedar Island and Piney Island. These are tentatively recognized as the same community, but this needs further investigation.

The association uncertainly crosswalked to this community in earlier editions of the 4th Approximation, *Spartina alterniflora* - *Lilaeopsis chinensis* Salt Marsh (CEGL004193), has been narrowed to occur only farther north. The NVC description of the association suggests it is most often in fresher water on large tidal rivers, and notes dynamics caused by dilution of salinity during spring snowmelt.

Rare species: No rare species are known to be specifically associated with this community.

BRACKISH MARSH (TRANSITIONAL SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. The Transitional Subtype is broadly defined to cover the more diverse but highly varied vegetation of the irregularly flooded inland transition zones of Salt Marsh and other Brackish Marsh communities. It is an area of increasing freshwater or inland influence but where other communities are not able to develop because of periodic saltwater flooding.

Distinguishing Features: The Transitional Subtype is distinguished by herbaceous or mixed vegetation on the fringe of a marsh complex, influenced by irregular salt or brackish tidal flooding, not fitting any of the other Brackish Marsh, Salt Marsh, or Salt Shrub communities, and generally with more diverse and mixed composition. It should be recognized only where it covers a substantial area, broader than a narrow ecotone. This subtype may be closely related to Salt Shrub but is distinguished by having relatively small numbers of *Borrichia, Iva*, *Baccharis, Morella*, or other shrubs. A few other shrubs or trees may be present. Where salt shrub is absent, the transition to scrub or forest vegetation is generally clear. The transition to Maritime Wet Grassland on barrier islands may be ambiguous, as these communities share some species. However, presence of species not tolerant of frequent saltwater flooding, such as *Rhynchospora colorata*, *Centella erecta*, and *Muhlenbergia sericea*, should distinguish Maritime Wet Grassland.

Crosswalks: *Spartina patens* - *Panicum virgatum* - *Solidago sempervirens var. mexicana* South Atlantic Brackish Marsh (CEGL009012).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: The Transitional Subtype occurs on the higher edge of other marsh communities, in the transition to uplands or to nontidal wetlands.

Soils: Soils are not well known for the Transitional Subtype. They may have characteristics intermediate between marsh soils such as Bohicket (Typic Sulfaquent) and sandy soils such as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent). In mainland sites they may transition to organic soils.

Hydrology: The Transitional Subtype is at the upper edge of the normal tidal range. It is flooded by the highest tides, which may be lunar or wind tides. Between tidal flooding, salinity presumably is diluted by rainwater or seeping freshwater.

Vegetation: The Transitional Subtype is extremely variable in its flora and dominant plants. *Spartina patens* is usually present and often abundant, even where not dominant in the adjacent marshes. *Schoenoplectus pungens, Bolboschoenus robustus*, *Fimbristylis castanea, Distichlis spicata*, and *Borrichia frutescens* are frequent in the few CVS plots, site descriptions, and published literature (e.g., Adams 1963, Clontz 1994, Cooper and Waits 1973) recognizable as this community. Other species that may occur include *Osmunda spectabilis, Mikania scandens,* *Thelypteris palustris, Solidago mexicana, Hydrocotyle bonariensis, Hydrocotyle verticillata/umbellata, Eleocharis* spp. (*parvula*, *tuberculosa*, and others), *Spartina cynosuroides, Cladium jamaicense, Typha angustifolia, Juncus roemerianus, Panicum amarum, Panicum virgatum, Cyperus odoratus, Sabatia stellaris, Sabatia dodecandra, Ludwigia decurrens, Ludwigia alata, Ptilimnium capillaceum, Agalinis maritima, Symphyotrichum subulatum, Symphyotrichum tenuifolium, Pluchea purpurascens, Echinochloa walteri, Lythrum lineare, Amaranthus cannabinus, Rumex verticillatus, Persicaria* spp., *Kosteletzkya pentacarpos, Iva frutescens, Morella cerifera, Juniperus silicicola*, and *Pinus taeda*.

Range and Abundance: Ranked GNR (likely G4). The abundance in North Carolina is very poorly known, but the Transitional Subtype potentially occurs throughout the barrier islands and other salty or brackish estuaries. The NVC association ranges far to the north, as far as New Hampshire, but it is unclear how much the northern examples resemble North Carolina's. It seems likely that an equivalent community exists in states to the south.

Associations and Patterns: Brackish Marsh (Transitional Subtype) appears to be a small patch community, usually occurring in narrow bands that amount to only a few acres. A few patches may be larger. Further investigation is needed to determine how regularly it is part of marsh landscapes. The Transitional Subtype is always associated with some other subtype of Brackish Marsh or with Salt Marsh. On the upper site, it may be bordered by any barrier island community or by any nonriverine wetland or upland community on the mainland.

Variation: The Transitional Subtype, as defined, is an extremely variable community, but patterns of variation have not been sorted out. Cooper and Waits (1973) recognized what they called mixed type and marginal type of marsh vegetation that appears to correspond to this subtype. This may be a basis for distinction, with the marginal subtype containing more freshwater species. It may also be appropriate to divide the community into northern and southern subtypes.

Dynamics: Little is known specifically about the dynamics of the Transitional Subtype. Tidal flooding is infrequent but is an ongoing environmental stress that controls what plants are present. Flooding by unusually salty water or for longer periods because of major storms may be an important natural disturbance that kills some plants. This community may be particularly susceptible to deposition of wrack by storm surges, burying patches of the community and creating bare patches.

Examples on the mainland likely burn naturally. Cecil Frost believed that with regular fire, savanna-like upland vegetation transitioned directly to marsh along mainland estuaries, but that *Juniperus* and shrubs came to dominate in the absence of fire.

Comments: This subtype is seldom described or sampled with plots; it is very poorly known in North Carolina. Further revision may well be needed as more becomes known. This community resembles a Tidal Freshwater Marsh in having a more diverse flora, but its flora is a subset of Tidal Freshwater Marsh species most tolerant of the more frequent salt exposure.

The association crosswalked to this community in earlier drafts of the 4th Approximation, *Panicum virgatum - Spartina patens – Carex silicea* Salt Marsh (CEGL006150), was a northern community.

Its definition was revised shortly before publication, and it is no longer attributed to North Carolina. The association now crosswalked is a new, more southern association.

Panicum virgatum - (Cladium mariscus ssp. jamaicense, Juncus roemerianus) Herbaceous Vegetation (CEGL004962*)* is a Gulf Coast equivalent community. *Schoenoplectus americanus - Spartina patens* Herbaceous Vegetation (CEGL006612) is another transitional association, questionably attributed to North Carolina. It is reported to occur between low marsh and high marsh, rather than at the edge of high marsh. It is unclear if it occurs in North Carolina and if it would be distinguishable from this subtype if it did.

Rare species:
Vascular plants – *Eleocharis parvula, Eleocharis rostellata, Ipomoea macrorhiza, Ludwigia alata, Lilaeopsis carolinensis,* and *Ludwigia alata*.

Vertebrate animals – *Ammospiza caudacuta, Botaurus lentiginosus, Ixobrychus exilis, Malaclemys terrapin,* and *Nerodia sipedon williamengelsi*.

Invertebrate animals – *Euphyes dukesi* and *Poanes aaroni.*

SALT FLAT

Concept: Salt Flats are communities of salt panne areas in the upper parts of salt marsh complexes, where salt water is concentrated by evaporation between tides. Sparse to moderately dense vegetation is dominated by plants tolerant of hypersaline conditions, such as *Salicornia virginica*, *Salicornia ambigua*, and *Distichlis spicata*.

Distinguishing Features: Salt Flats are distinguished from Salt Marshes and all other communities by the predominance of the above species, with few other species present. Often a white salt crust is visible on the soil.

Crosswalks: *Sarcocornia pacifica - (Batis maritima, Distichlis spicata)* Saline Dwarf-shrubland (CEGL002278).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: Salt Flat communities occur in the upper parts of tidal marshes in areas with near full-strength seawater. They are sometimes visible as slight depressions but often appear flat if water is not standing. Most occur on barrier islands, but occurrences in mainland marshes are possible.

Soils: Soils of Salt Flats are usually sandy and are hypersaline, often visibly crusted with salt. They are generally not distinguished in soil mapping.

Hydrology: Seawater enters these communities during regular or frequent irregular high tides and evaporates rather than draining away, producing hypersaline conditions.

Vegetation: Vegetation of Salt Flats is generally sparse to moderate and consists of the few species tolerant of high salt concentrations. *Distichlis spicata*, *Salicornia ambigua*, or *Salicornia virginica* usually dominate. *Spartina alterniflora* occurs with high frequency but is stunted and at low density. *Borrichia frutescens* and *Limonium carolinianum* are frequent, especially on the edges. Small numbers of other species from adjacent marsh communities may be present in the less extreme patches.

Range and Abundance: Ranked G4. Salt Flats are fairly frequent in the southern and middle parts of North Carolina's barrier islands, wherever the sounds are salty. The NVC association, as defined, ranges from Nova Scotia southward to at least North Carolina and potentially to Georgia.

Associations and Patterns: Salt Flats appear to be small patch communities in North Carolina, though some occurrences exceed the 50 acre rule-of-thumb size. They are a fairly regular feature of the marsh mosaic, which may lead to them being regarded as matrix communities with further study. Salt Flats usually occur with Salt Marsh, sometimes in association with Brackish Marsh or Salt Shrub in high marsh zones.

Variation: Salt Flats vary in degree of development and salt levels, among examples and at a fine scale within examples. The deepest portions may have no vegetation, while shallower examples are transitional to Salt Marsh.

Dynamics: Salt Flat communities are driven by increased concentrations of salt, created by evaporation of seawater that enters at high tide and cannot drain away. They may vary from year to year, as high rainfall or more frequent tidal flushing due to storms may dilute the salt. Little is known of the details of the creation or lifespan of patches. The shallow basins and blocked drainage that create them may form due to sand deposition by storm waves, overwash, or dune movement, potentially even by the accretion of the adjacent marsh. Patches may be destroyed by the same processes or by storm erosion.

Comments: Salt Flats are very distinctive and have been recognized by most authors describing barrier island vegetation, such as Au (1974), Godfrey and Godfrey (1976), Adams (1963), Cooper and Waits (1993), and Rosenfeld (2004). Numerous CVS and NatureServe plots represent it.

The association crosswalked to this community in earlier drafts of the 4th Approximation, *Salicornia* (*virginica, bigelovii, maritima*) - *Spartina alterniflora* Salt Marsh (CEGL004308), was a northern community. Its definition was revised shortly before publication, and it is no longer attributed to North Carolina. There appears to be no association representing North Carolina's community.

Rare species: No rare species are known to be specifically associated with this community.

SALT SHRUB (HIGH SUBTYPE)

Concept: Salt Shrub communities are shrubby zones on the high edges of salt marshes, infrequently flooded with salt water and dominated by the most salt-tolerant shrubs. The High Subtype covers higher, less frequently flooded examples dominated by *Baccharis halimifolia*, *Iva frutescens*, and *Morella cerifera. Spartina patens* is sometimes an important component.

Distinguishing Features: Salt Shrub is distinguished from all other community types by having vegetation dominated or codominated by *Baccharis halimifolia*, *Iva frutescens*, or *Borrichia frutescens*. It may also have a substantial amount of *Morella cerifera* but is distinguishable from Maritime Shrub by the codominance of one of the other species. The High Subtype is distinguished from the Low Subtype by the predominance of *Baccharis halimifolia* or *Iva frutescens* rather than *Borrichia frutescens*.

Crosswalks: *Baccharis halimifolia* - *Iva frutescens* - *Morella cerifera* - (*Ilex vomitoria*) Saline Shrubland (CEGL003920).
G982 South Atlantic & Gulf Coast Salt Marsh Group.
Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270).
Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: Salt Shrub occurs primarily on barriers islands, but it may potentially occur on the mainland. This community is usually located on the upper side of salt marsh complexes, at the transition to Maritime Grassland or Maritime Wetlands communities, at the upper limit of normal tidal flooding.

Soils: Soils are not distinguished in mapping, but they appear to be sandy soils more similar to Corolla (Aquic Quartzipsamment), Duckston (Typic Psammaquent), or Carteret (Typic Psammaquent) than to marsh soils such as Bohicket (Typic Sulfaquent).

Hydrology: The High Subtype is flooded only by the highest tides and by storm surges.

Vegetation: The High Subtype is a dense-to-open shrubland, dominated by combinations of *Baccharis halimifolia, Morella cerifera*, and sometimes *Iva frutescens*. *Borrichia frutescens* may be present in more open portions and in the lower transition. More open examples may have substantial *Spartina patens*, less often *Juncus roemerianus*. Some *Juniperus silicicola, Ilex vomitoria*, or *Persea palustris* may occur. Vines are usually present, most frequently *Toxicodendron radicans* and *Nekemias (Ampelopsis) arborea*, sometimes *Smilax bona-nox, Smilax auriculata*, or *Parthenocissus quinquefolia*. There is often a well-developed herb layer, dominated by *Spartina patens* or *Juncus roemerianus*. This community often is more diverse than either the marshes or maritime grasslands that border it, and often includes plants not found elsewhere on the island. Additional species that are highly constant or at least frequent in the limited plot data and site reports include *Solidago mexicana, Ipomoea sagittata, Hydrocotyle bonariensis, Cladium jamaicense, Andropogon glomeratus, Setaria magna, Setaria parviflora, Mikania scandens,* and *Typha latifolia*. Less frequent species that may occur include *Centella erecta, Persicaria* spp., *Pattalias palustre (Seutera angustifolia, Cynanchum angustifolium*), *Panicum virgatum, Fimbristylis castanea, Elymus virginicus* var. *halophila*, *Pluchea* spp., and *Hydrocotyle verticillata/umbellata*. The exotic *Phragmites australis* may be present and locally dominate.

Range and Abundance: Ranked G4?. This community is believed to be widespread throughout the North Carolina coast, but it is often not documented. The association ranges southward to Florida and westward to Louisiana.

Associations and Patterns: The High Subtype is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. The High Subtype may be bordered by Salt Marsh, Brackish Marsh, or the Low Subtype of Salt Shrub on the lower side. On the upland side, it may be bordered by Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, or potentially Maritime Evergreen Forest.

Variation: Little is known about patterns of variation in this community.

Dynamics: Salt Shrub communities appear to be highly dynamic and subject to frequent natural disturbance. The dominant plants are tolerant of salt spray and limited saltwater flooding, but they can be stressed or killed by longer or more intense exposure. Other plants in the community are more sensitive; they probably are killed and must recolonize to be present after storm events.

Comments: Salt Shrub (High Subtype) appears to be closely related to Brackish Marsh (Transitional Subtype) in its habitat at the upper edge of salt marsh complexes and in much of its nonwoody flora. The ecological factors that lead to the presence or absence of the shrub layer that distinguishes them are not well known and need further study. It is unclear if the two communities readily turn into each other or if there are stable site-related differences.

The link to NVC associations is somewhat uncertain, and was different in earlier drafts of the 4th Approximation. This community was initially linked to *Baccharis halimifolia - Iva frutescens / Panicum virgatum* Shrubland (CEGL003921), a northern association reported to range southward to North Carolina. That association was later narrowed and limited to farther north. The new primary link, *Baccharis halimifolia* - *Iva frutescens* - *Morella cerifera* - (*Ilex vomitoria*) Shrubland (CEGL003920), is a southern association ranging northward to North Carolina. The two are similar enough that if both really occurred in North Carolina they would be difficult to distinguish. The distinction may correspond to the subtle distinction between the Carolinian and Virginian subtypes of Salt Marsh, which was recognized in the past but has been dropped from NVC. This needs further investigation.

Iva frutescens / *Spartina patens* Shrubland (CEGL006848) is a northern association that was previously attributed to North Carolina but has been narrowed to exclude it.

Rare species:
Vascular plants – *Elymus virginicus* var. *halophila*.

SALT SHRUB (LOW SUBTYPE)

Concept: Salt Shrub communities are shrubby zones on the high edges of salt marshes, infrequently flooded with salt water and dominated by the most salt-tolerant shrubs. The Low Subtype covers lower-lying, more frequently flooded examples dominated by *Borrichia frutescens*, often with a substantial component of *Juncus roemerianus*, *Spartina patens*, or *Distichlis spicata*.

Distinguishing Features: The Low Subtype is distinguished from all other communities by having *Borrichia frutescens* as the dominant shrub, with *Baccharis halimifolia, Iva frutescens*, and all species that are less salt-tolerant either scarce and/or confined to higher microsites.

Crosswalks: *Borrichia frutescens* / (*Spartina patens*, *Juncus roemerianus)* Saline Shrubland (CEGL003924).
G982 South Atlantic & Gulf Coast Salt Marsh Group. Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh Ecological System (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh Ecological System (CES203.260).

Sites: Salt Shrub occurs primarily on barrier islands, but it may potentially occur on the mainland. It occurs on the upper side of salt marsh complexes, at the transition to Maritime Grassland or Maritime Wetlands communities, at the upper limit of normal tidal flooding. The Low Subtype occurs at slightly lower elevations than the High Subtype, often by a few inches, where tidal flooding is somewhat more frequent. It may also occur in higher areas where salt is concentrated by evaporation, but that are not salty enough to support Salt Flat communities.

Soils: Soils are not distinguished in mapping, but they appear to be sandy soils more similar to Corolla (Aquic Quartzipsamment), Duckston (Typic Psammaquent), or Carteret (Typic Psammaquent), than to marsh soils such as Bohicket (Typic Sulfaquent).

Hydrology: The Low Subtype is flooded by the highest tides but not daily.

Vegetation: The Low Subtype has an open-to-dense, often patchy, shrub layer dominated by *Borrichia frutescens*. Plot data from CVS and Rosenfeld (2004) show *Spartina patens*, *Distichlis spicata*, and *Juncus roemerianus* as highly constant and *Salicornia virginica* as frequent. All of these species may sometimes codominate. This may partly represent areas of other communities that got included in the edges of plots, but these species also can dominate the areas between dense shrub patches. Other species that occur with high to moderate frequency include *Limonium carolinianum, Fimbristylis castanea, Solidago mexicana, Pattalias palustre (Seutera angustifolia, Cynanchum angustifolium*), *Salicornia ambigua,* and *Symphyotrichum tenuifolium*. *Spartina alterniflora* may be present, and a few species shared with the High Subtype, such as *Iva frutescens, Baccharis angustifolia, Morella cerifera, Hydrocotyle bonariensis,* and *Convolvulus americanus (Calystegia sepium),* may be present.

Range and Abundance: Ranked G4. Salt Shrub apparently is widely distributed in North Carolina, wherever salt marshes occur. However, it is often overlooked in reports and is not fully represented in the database. The NVC association ranges from North Carolina south to Florida and westward potentially to Texas.

Associations and Patterns: The Low Subtype is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. It may occur with or without the High Subtype. It may be bordered by Salt Marsh or Brackish Marsh on the lower side. On the upland side, it may be bordered by the High Subtype or by Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, or potentially Maritime Evergreen Forest. It sometimes grades into Salt Flat with a very gradual transition.

Variation: Little is known about patterns of variation in this community. Examples vary in the extent of shrub cover on a very fine scale, but the species composition appears to vary little across the range in the state.

Dynamics: Salt Shrub communities appear to be highly dynamic and subject to frequent natural disturbance. The Low Subtype contains few of the less salt-tolerant species found in the High Subtype, reflecting the more frequent saltwater flooding. It therefore is less disturbed by saltwater intrusion in storms. *Borrichia* is the most salt-tolerant of native shrubs. Wrack deposition also is a local natural disturbance.

Rare species: No rare species are known to be specifically associated with this community.

UPPER BEACH (NORTHERN SUBTYPE)

Concept: Upper Beaches are sparsely vegetated areas between the unvegetated intertidal beach and the foredunes, where regular tidal flooding does not occur but where salt spray is intense and heavy disturbance by waves occurs frequently during storms. The Northern Subtype covers examples from Cape Hatteras northward, where *Cakile edentula* (*Cakile edentula* ssp. *edentula*) dominates.

Distinguishing Features: Upper Beaches are distinguished from Sand Flats by occurrence in higher energy environments, on the ocean beach, generally between the shoreline and a line of dunes that focuses wave energy. They are distinguished from adjacent Dune Grass by the absence of significant cover of *Uniola paniculata* or *Calamagrostis* (*Ammophila*) *breviligulata*. The seaward edge is the portion of the beach where all vascular plants are absent because of more regular tidal flooding and wave disturbance. The Northern Subtype is distinguished by being dominated by *Cakile edentula* ssp. *edentula* rather than *Cakile harperi (edentula* ssp. *harperi*).

Crosswalks: *Cakile edentula* ssp. *edentula* - *Chamaesyce polygonifolia* Sparse Beach Vegetation (CEGL004400).
G660 North Atlantic Coastal Beach Group.
Central Atlantic Coastal Plain Sandy Beach Ecological System (CES203.064).

Sites: Upper Beach communities occur on barrier islands in the sparsely vegetated zone below the foredunes. They may also occur on a few back-barrier islands that are exposed to high wave energy and salt water.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Upper beaches are above normal tide levels but are reached by saltwater and waves during storms and possibly at the highest tides. They are subject to heavy salt spray. The sand is excessively drained and presumably xeric when not flooded.

Vegetation: Upper Beach communities are sparsely vegetated, and short-lived plants are characteristic. *Cakile edentula* is the most frequent species of the Northern Subtype. Other species that may occur include *Euphorbia (Chamaesyce) polygonifolia, Amaranthus pumilus, Polygonum glaucum, Salsola kali, Atriplex arenaria, Sesuvium maritimum*, *Sesuvium portulacastrum*, *Chenopodium album*, and *Ipomoea imperati*. Small numbers of species of Dune Grass may be present, including *Uniola paniculata, Calamagrostis* (*Ammophila*) *breviligulata, Panicum amarum, Triplasis purpurea*, and *Hydrocotyle bonariensis*.

Range and Abundance: Ranked G4G5. In North Carolina, this community potentially occurs along the coast from Cape Hatteras northward, though it may be degraded in portions by vehicle and foot traffic. The equivalent NVC association ranges northward to Maine.

Associations and Patterns: Upper Beach is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. They usually occur adjacent to Dune Grass communities. Seaward is an unvegetated intertidal beach.

Variation: Little is known about natural variation. Because plants are short-lived, composition and population sizes and can vary substantially from year to year in response to natural disturbance.

Dynamics: Upper Beach communities are probably the community most subject to heavy natural disturbance in all of North Carolina. The frequent saltwater flooding comes with surf focused on this zone rather than dissipated by overwash. Moslow and Heron (1994) noted that waves are the most important coastal process on the Outer Banks, from a geological perspective, and that this area has the highest wave height of anywhere on the east coast. However, overall wave energy varies with location. Coast lines with northeastern exposure, such as northern Hatteras Island, have the highest energy. The effect of this variation on Upper Beach communities should be investigated.

Besides wave disturbance, Upper Beaches occur at the wrack line, where there is regular deposition of floating material. While mats are not generally heavy as they are in marshes, they are more likely to include driftwood and other large objects that may cause local disturbance.

Beach renourishment projects and enhancement of dunes to make them more continuous are human processes that may alter the dynamics of this community, though the effect of this alteration is somewhat unclear. Many beaches have vehicle traffic that further disturbs part of the Upper Beach.

Comments: This community is often not mentioned in site descriptions and is represented by almost no plots. The two subtypes are recognized provisionally. They represent a low-diversity community with an enormous range of geographic regions and climate, which calls for some division even if there is not a strong floristic break. The subtypes follow a distinction recognized in NVC, one that is believed to correlate well with biogeography. However, the ranges of the two species of *Cakile* that mark it appear to overlap substantially in North Carolina. It is not clear how the two subtypes interact in the range of overlap, and this needs further investigation.

The communities covered by the Sand Flat type were included in this type in earlier drafts of the 4th approximation, as well as in the 3rd approximation, but are now recognized as separate.

Rare species:
Vascular plants – *Amaranthus pumilus, Chenopodium berlandieri* var. *boscianum, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum,* and *Sesuvium portulacastrum*.

Vertebrate animals – *Calidris canutus rufa, Caretta caretta, Charadrius melodus circumcinctus, Charadrius melodus melodus, Charadrius wilsonia, Chelonia mydas, Dermochelys coriacea, Haematopus palliatus, Himantopus mexicanus, Hydroprogne caspia, Lepidochelys kempii,* and *Rynchops niger*.

UPPER BEACH (SOUTHERN SUBTYPE)

Concept: Upper Beaches are sparsely vegetated areas between the unvegetated intertidal beach and the foredunes, where regular tidal flooding does not occur but where salt spray is intense but saltwater flooding and disturbance by waves occurs frequently during storms. The Southern Subtype covers more southerly examples, from Cape Hatteras southward, where *Cakile harperi* (*Cakile edentula* ssp. *harperi*) is characteristic.

Distinguishing Features: Upper Beaches are distinguished from Sand Flats by occurrence in higher energy environments, on the ocean beach, generally between the shoreline and a line of dunes that focuses wave energy. They are distinguished from adjacent Dune Grass by the absence of significant cover of *Uniola paniculata* or *Calamagrostis* (*Ammophila*) *breviligulata*. The seaward edge is the portion of the beach where all vascular plants are absent because of more regular tidal flooding and wave disturbance. The Southern Subtype is distinguished by the dominance by *Cakile harperi* rather than *Cakile edentula* in its narrower sense.

Crosswalks: *Cakile edentula* ssp. *harperi* Sparse Beach Vegetation (CEGL004401).
G661 South Atlantic & Gulf Coastal Beach Group.
Southern Atlantic Coastal Plain Southern Beach Ecological System (CES203.535).

Sites: Upper Beach communities occur on barrier islands in the sparsely vegetated zone below the foredunes. They may also occur on a few back-barrier islands that are exposed to high wave energy and salt water.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Upper beaches are above normal tide levels but are reached by saltwater and waves during storms and possibly at the highest tides. They are subject to heavy salt spray. The sand is excessively drained and presumably xeric when not flooded.

Vegetation: Upper Beach communities are sparsely vegetated, and short-lived plants are characteristic. *Cakile harperi* is the most frequent species of the Southern Subtype. Other species that may occur include *Cakile edentula, Euphorbia (Chamaecyse) polygonifolia, Amaranthus pumilus, Polygonum glaucum, Salsola kali, Atriplex arenaria, Sesuvium maritimum*, *Sesuvium portulacastrum*, *Chenopodium album*, and *Ipomoea imperati*. Small numbers of species of Dune Grass may be present, including *Uniola paniculata, Calamagrostis* (*Ammophila*) *breviligulata, Panicum amarum, Triplasis purpurea*, and *Hydrocotyle bonariensis*.

Range and Abundance: Ranked G3. In North Carolina, this community potentially occurs along the coast from Cape Hatteras southward, though it may be degraded in portions by vehicle and foot traffic. The equivalent NVC association ranges southward through Georgia, with a disjunct area of occurrence in Florida.

Associations and Patterns: Upper Beach is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. They usually occur adjacent to Dune Grass communities. Seaward is an unvegetated intertidal beach.

Variation: Little is known about natural variation. Because plants are short-lived, composition and population sizes can vary substantially from year to year in response to natural disturbance.

Dynamics: Upper Beach communities are probably the community most subject to heavy natural disturbance in all of North Carolina. The frequent saltwater flooding comes with surf focused on this zone rather than dissipated by overwash. Moslow and Heron (1994) noted that waves are the most important coastal process on the Outer Banks, from a geological perspective, and that this area has the highest wave height of anywhere on the east coast. However, overall wave energy varies with location. Coastlines with northeastern exposure, such as Core Banks, have the highest energy, while those with more southern exposure, such as Ocracoke, Shackleford Banks, and Bogue Banks, have less. The effect of this variation on Upper Beach communities should be investigated. The NVC's description of this community emphasizes its occurrence in the microtidal region of North Carolina to Georgia, and of barrier island geomorphology being dominated more by overwash rather than tidal energy. However, tidal energy is less important than wave energy in Upper Beach communities. Storm flooding is believed to be more important in both subtypes.

Besides wave disturbance, Upper Beaches occur at the wrack line, where there is regular deposition of floating material. While mats are not generally heavy as they are in marshes, they are more likely to include driftwood and other large objects that may cause local disturbance.

Beach renourishment projects and enhancement of dunes to make them more continuous are human processes that may alter the dynamics of this community, though the effect of this alteration is somewhat unclear. Many beaches have vehicle traffic that further disturbs part of the Upper Beach.

Comments: This community is often not mentioned in site descriptions and is represented by almost no plots. The two subtypes are recognized provisionally. It represents a low-diversity community with an enormous range of geographic regions and climate, which calls for some division even if there is not a strong floristic break. The subtypes follow a distinction recognized in NVC, one that is believed to correlate well with biogeography. However, the ranges of the two species of *Cakile* that mark it appear to overlap substantially in North Carolina. It is not clear how the two subtypes interact in the range of overlap. This needs further investigation.

The communities covered by the Sand Flat type were included in this type in earlier drafts of the 4th approximation, as well as in the 3rd approximation, but are now recognized as separate.

Rare species:
Vascular plants – *Amaranthus pumilus, Chenopodium berlandieri* var. *boscianum, Euphorbia bombensis, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum,* and *Sesuvium portulacastrum*.

Vertebrate animals – *Calidris canutus rufa, Caretta caretta, Charadrius melodus circumcinctus, Charadrius melodus melodus, Charadrius wilsonia, Chelone mydas, Dermochelys coriacea, Haematopus palliatus, Himantopus mexicanus, Hydroprogne caspia, Lepidochelys kempii,* and *Rynchops niger*.

SAND FLAT

Concept: Sand Flats are sparsely vegetated areas on extensive low-lying sand flats, generally on the accreting ends of barrier islands.

Distinguishing Features: Sand Flat communities are distinguished by occurrence on accreting sand flats and by sparse vegetation containing *Sesuvium*, *Atriplex*, and *Suaeda*. Incipient dunes dominated by *Uniola paniculata* or *Calamagrostis* (*Ammophila*) *breviligulata* may be present, but substantial areas of these plants should be regarded as inclusions of Dune Grass. Upper Beach communities may share some of the few plant species, but are more subject to wave action and salt spray and are characterized by *Cakile* spp.

Crosswalks: *Sesuvium portulacastrum - Atriplex* spp. - *Suaeda* spp. Sparse Beach Vegetation (CEGL004406).
G661 South Atlantic & Gulf Coastal Beach Group.
Central Atlantic Coastal Plain Sandy Beach Ecological System (CES203.064).
Southern Atlantic Coastal Plain Southern Beach Ecological System (CES203.535).

Sites: Sand Flats are barrier island areas with little or no topography, subject to overwash during storms but not exposed to high wave energy as beaches are. They generally are newly deposited sand spits on ends of barrier islands, formed as inlets migrate. Tidal deltas or large overwash deposits could potentially also form them. The surfaces are generally too young to have developed dunes but incipient dunes may be present.

Soils: Sand Flats consist of newly deposited sand, potentially with a high shell content, with little or no soil development.

Hydrology: The substrate of Sand Flats is porous, but they occur near enough to sea level that lower levels presumably are saturated with salt water. Conditions are salty but salt is not concentrated by evaporation, and salt presumably is leached by rainfall between overwash events. They are not flooded by the highest regular tides but are frequently overwashed by seawater during storms.

Vegetation: Sand Flats are sparsely vegetated overall. Plant cover consists of mats which may be locally dense but are often widely scattered. Mats are typically dominated by *Sesuvium portulacastrum, Sesuvium maritimum*, or *Suaeda linearis*. Other species may include *Spartina patens, Panicum amarum, Vigna luteola, Ipomoea imperati, Ipomoea sagittata, Sporobolus virginicus*, *Amaranthus pumilus*, and *Cyperus* sp. *Uniola paniculata* may be present in small amounts.

Range and Abundance: Ranked G3. Only a handful of well-developed examples in good condition occur in North Carolina. The association ranges from Delaware and Maryland southward to Florida.

Associations and Patterns: Sand Flats are large patch communities. They may cover areas of many acres but are not a regularly repeating part of most barrier island landscapes. They may contain patches of Dune Grass on developing dunes and may border Salt Marsh, Salt Shrub, or other Estuarine Communities.

Variation: Sand Flats probably vary mostly with age and stability or time since disturbance.

Dynamics: Sand Flats are young communities that are subject to frequent natural disturbance in the form of overwash. They often are short lived at any given place, because of the dynamic nature of inlets, and may appear or disappear in a few years. A dramatic example occurs at Hatteras Inlet, where 1.5 miles of predominantly Sand Flat has disappeared at the end of Hatteras Island since 1998. A relatively new inlet through Core Banks has migrated 1.2 miles in the same period, producing new Sand Flat habitat as dunes and overwash flats were destroyed on the other side of the inlet. Where sand spits last longer, dunes begin to form, and different barrier island communities develop. This may happen over decades or just a few years.

The dynamics of spit formation and migration may vary both with weather cycles over periods of years and with the configuration of the coast in different places. Their dynamics depend on the energy of tidal currents and the amount of sand moving in the longshore drift. Moslow and Heron (1994) note that tidal currents depend on the size of the tidal wedge as well as the tidal amplitude, and currents can be substantial even with the very limited tidal range on the Outer Banks. The authors also note that there have been 30 inlets in the Outer Banks over the last 400 years even though there are only around ten at present, indicating substantial turnover.

Comments: Besides the sparse vegetation, Sand Flats are often crucial places for animals. A number of birds nest on them, including a remarkable number of rare species. On accessible barrier islands, Sand Flats are often popular places for driving and often are disturbed by vehicle traffic. Both vehicle and foot traffic are a threat to rare birds nesting in this habitat, who readily abandon their nests if disturbed.

The inclusion of Sand Flat in the Estuarine Communities theme is marginal. They could potentially fit within Maritime Grasslands because they are not usually wet. However, the more frequent flooding with salt water, while not as frequent as in the tidal marshes, is similar to that in Salt Shrub.

Rare species:
Vascular plants – *Amaranthus pumilus, Chenopodium berlandieri* var. *boscianum, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum,* and *Sesuvium portulacastrum*.

Vertebrate animals – *Calidris canutus rufa, Charadrius melodus circumcinctus, Charadrius melodus melodus, Charadrius wilsonia, Gelochelidon nilotica, Haematopus palliatus, Himantopus mexicanus, Hydroprogne caspia, Rynchops niger, Sterna dougallii dougallii, Sternula antillarum,* and *Sterna hirundo*.

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