CLASSIFICATION OF THE NATURAL COMMUNITIES OF NORTH CAROLINA

THIRD APPROXIMATION

by

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CLASSIFICATION OF THE NATURAL COMMUNITIES OF NORTH CAROLINA
Third Approximation

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CLASSIFICATION OF THE NATURAL COMMUNITIES OF NORTH CAROLINA

THIRD APPROXIMATION

INTRODUCTION

This document presents a framework for the classification of natural communities in North Carolina. 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, similar to that given by Whittaker (1975), has been used for a number of state natural community classifications and is given in the Natural Heritage operations manual (The Nature Conservancy 1981).

Natural communities may be characterized by vegetation composition and physiognomy, assemblages of animals or other organisms, topography, substrate, hydrology, soil characteristics, or other abiotic factors. The natural community approach differs from the use of plant communities or plant associations in its inclusion of all these factors. This multi-dimensional approach makes dealing with natural communities potentially extremely complex, and it is the role of a classification to order this complexity.

In practice, many of the factors are correlated and do not occur in all possible combinations. Also, all factors are not of equal ecological importance. Some factors can apparently be safely excluded from consideration in some areas. Other factors or components are necessarily excluded from consideration because of lack of knowledge about them and their importance.

NATURALNESS

While the above definition of natural communities includes all assemblages that may occur, this document restricts its scope to those communities which may be considered natural in a narrower sense. We are primarily interested in communities whose characteristics and functioning are shaped by the processes of evolution and ecological interactions of long periods of time, without the overriding influence of modern human activities.

One approach to viewing naturalness is the potential natural condition, the conditions that would prevail if humanity and all its works were removed from the earth, all exotic species eliminated, and recovery processes allowed to occur without climatic or geologic changes. Another commonly used view of naturalness is as presettlement conditions, those conditions prevailing before European settlement. These two views are not strictly the same, because of the role of the American Indians and the question of whether it should be regarded as natural. Extinctions of species also create differences between presettlement and potential natural communities. Both views of naturalness are of ecological value. In practice, very rarely, if ever, do we know both the presettlement and potential natural state and know them to be different from each other. Because of our limited knowledge and our imperfect examples, the difference between the two views is seldom of major practical importance.

Because the influence of modern civilization has been so pervasive, no communities in North Carolina exist in a completely natural state, by either definition of naturalness. Direct disturbances such as logging and grazing, and indirect disturbances such as introduction of exotic species, blocking of natural fire spread, and modification of flooding and sedimentation regimes, have reached even the most remote corners of the state. However, there do exist examples of communities in which that influence has been relatively minimal, and others which, though somewhat modified, still approximate many natural characteristics and functions. Communities may therefore be regarded as relatively natural or

relatively modified. The level of alteration allowed before a community occurrence can no longer be considered natural may vary with factors such as the nature of the alteration or disturbance, the community's resilience to that type of disturbance, and the existence of other examples that are less altered. It also will depend on our ability to recognize what the natural state is.

Because communities are dynamic systems, naturalness must be judged for function as well as structure. Natural communities are not a simple fixed pattern on the landscape to which all succession will lead; they are subject to natural disturbance at differing frequencies and intensities. The natural landscape is generally believed to consist of a shifting mosaic of patches in different stages of recovery from a variety of natural disturbances. Such disturbances, even when catastrophic, do not detract from naturalness. The natural frequency of such disturbances and prevailing state of the communities must be considered. Human disturbances which resemble natural disturbances in nature, intensity, and frequency detract less from naturalness than those that do not.

Some aspects of natural dynamics can be easily altered indirectly by actions away from the site, so that freedom from disturbance at a site, or old- growth or "virgin" condition, is not a sure indication of natural condition. While old-growth forest is the typical natural state for many community types, in types that are subject to periodic natural catastrophic disturbance, old- growth may represent a relatively unnatural state. A few natural processes have been so disrupted that replacement of them by human management is the only practical way to keep communities in a relatively natural state. The most widespread examples of this are in communities dependent on frequent fire, such as those dominated by longleaf pine (Pinus palustris). The near elimination of fire by artificial firebreaks and fire suppression has created a situation in which the most natural examples of these communities are those that have been deliberately managed with fire. The more the burning schedule and methods resemble the natural fire regime, the more natural the community may be regarded.

VALUE OF NATURAL COMMUNITIES AS ELEMENTS OF NATURAL DIVERSITY

Natural communities are valuable elements of natural diversity for a variety of reasons. In natural heritage methodology, they are generally regarded as "coarse filters" for diversity of organisms. By protecting examples of all the natural community types, the majority of species can be protected without laborious individual attention. This includes both species too common and those too poorly known to warrant or receive specific attention. Species- specific action is then focused on the rare species that occur in only a fraction of the community types that are their habitat.

Natural communities are of even greater value in their own right. Like species, they have an intrinsic value as natural systems, as well as an aesthetic value to human beings. They also contain valuable scientific resources in the form of information about interactions among populations, the structures and relationships they produce, and the ecosystem functions that arise from them. While simple population interactions have been studied experimentally without reference to communities, the more complex natural interactions are less easily reproduced. It is only through the study of communities that appropriate experimental settings and questions can be constructed. Understanding of the community setting is necessary for understanding of individual species, since it is the environment in which evolution shaped them. Understanding of communities is also necessary for full understanding of the ecosystem processes on which humanity is dependent. Communities in relatively natural condition are unique resources, offering scientific and philosophical insight, providing standards against which human management can be judged, and containing the source of recovery and improved management of damaged ecosystems.

WHY WE CLASSIFY COMMUNITIES

Natural communities generally occur in continuously varying patterns. Unlike individual organisms and most species populations, there are seldom discrete breaks in the pattern of diversity. Most of the environmental factors that determine communities vary over continuous gradients. Even natural disturbances, while sometimes having discrete boundaries, have continuously varying frequencies, intensities, and effects related to other environmental gradients. Species populations tend to respond individualistically to these complex environmental gradients, producing continuous variation in composition. Any boundaries defined for community types are therefore artificial and somewhat arbitrary. Occurrences near a boundary of a

category may be more similar to some occurrences in the adjacent category than they are to members at the opposite end of their own category.

To some people, classification of natural communities may seem pedantic, arbitrary, or of only theoretical value. Despite its limitations, however, classification is useful and necessary in many practical situations. Record keeping for prioritization, study, and management is facilitated. The natural heritage methodology, which involves keeping records of occurrences of individual elements of natural diversity, is possible only with a classification of those elements. Communication about communities is improved by having commonly used names to refer to them.

Placing communities into ecologically based categories allows us to break up their tremendous complexity into more manageable units. Communities within a category should have many common ecological characteristics, and generalizations about them should be possible. It must be remembered, however, that the categories are still fairly broad and contain variation within them. Classification is not a substitute for ecological insight and judgment.

It is our hope that this classification will be of use and interest to the wide variety of individuals involved in the description and management of land in North Carolina and adjacent states -- ecologists, wildlife biologists, zoologists, soil scientists, foresters, environmental biologists, and land managers.

METHODS

This document used the Second Approximation (Schafale and Weakley 1985) as a starting point. The Second Approximation was based largely on secondary sources, including published literature, unpublished literature, field reports and site descriptions in the Natural Heritage Program files, and personal communication and reviews by other ecologists and naturalists. This information was interpreted in light of the authors' experience with the communities of North Carolina. For the most part only sources directly pertaining to North Carolina were used. The same kinds of sources have been used in the Third Approximation, but a much greater portion of the information and interpretation comes from the authors' field observations and experience, gained over the last five years of working for the North Carolina Natural Heritage Program.

The available information has been synthesized qualitatively and intuitively to determine the categories needed and to describe them. Although no overall quantitative analysis was done for the classification, we have benefitted from the ecological insights and descriptions derived from quantitative analysis of vegetation data for particular areas or types of communities. While a comprehensive quantitative analysis would be likely to yield an improved classification, sufficient data for such analysis are not yet available and are unlikely to be available in the near future. It is felt that a qualitatively- based analysis will be immediately useful in the protection and study of natural communities, while a quantitatively-based classification will be too long in coming. The format of successive approximations allows improvement of the classification as new information becomes available.

The component of natural communities most strongly emphasized in our work has been the vegetation, including dominant species, floristic composition, and structure or statures. The emphasis on vegetation stems partly from the wide-spread recognition that vegetation tends to integrate many environmental factors in a useful way, partly from the abundance of vegetation information, and partly from the authors' familiarity and experience. Other important factors considered in the classification include moisture regime, landform, geologic substrate, soil pH and fertility, and natural disturbance regime.

The attempt has been made to emphasize factors and values of factors that are the most ecologically important in a given set of communities. These factors are not necessarily the same across the state or across different environments, nor are the ranges of values that produce significant ecological differences necessarily equal. As an example, effective depth and water-holding capacity of the soil may be important factors for Piedmont upland hardwood forests and for longleaf pine-dominated communities, but relatively unimportant for high mountain forests (with their high rainfall) or for tidal marshes (with their regular water supply). As another example, an elevation change of a few centimeters may produce the change from Wet Pine Flatwoods to Pond Pine Woodland on one side and to Coastal Fringe Sandhill on the other side. In contrast, a change of several meters or more may occur before the transition of Coastal Fringe Sandhill to Xeric Sandhill

Scrub. Specialized environmental factors may separate distinctive natural community types despite wide ranges in other factors. Examples include alluvial deposition and flood disturbance in natural levees, exfoliation on granitic domes, and spray around waterfalls.

CLASSIFICATION STRUCTURE

The basic unit in the classification of natural communities is the natural community type. In a few instances subtypes have been defined within types, where an indication of close similarity was desired. The types and subtypes are the element level of the classification, the level at which information is organized by the Natural Heritage Program and priorities set. It is the level at which formal descriptions are given in this document.

As an aid in classifying variation within types and subtypes, we have instituted a new lower level of classification, called the variant. Variants are of the same nature as natural community types, in that they are determined by considering many biotic and abiotic factors. They are not formally described, but are briefly described under the natural community types. Designation of variants may serve to focus attention on variation within a community type, and may test categories that may be elevated to type or subtype status as more becomes known.

The Second Approximation contained a different kind of classification below the type and subtype level. A system of designating plant communities was adopted, based on the dominant species in all strata. The plant communities are more finely divided but are based on only one of the many dimensions that define natural community types. The plant community classification has not proved especially useful for natural heritage work for a variety of reasons. In some situations the plant communities are too finely divided, producing a large number of categories with no basis for prioritizing them. In other situations, a species with wide ecological amplitude may dominate in very different environmental situations, leading to fundamentally different sites being described as the same plant community. The plant community designation conventions also do not deal well with communities in which dominance is shared by many species. Moreover, quantitative data are often required to determine stratal dominants for plant community designation. Plant community designations are useful for classifying variation within some natural community types or subtypes, and for describing their vegetation. We have reduced the emphasis on plant communities as a classification level in the Third Approximation, but have retained and expanded the lists of them in the type descriptions.

The variable emphasis on different factors in natural communities, guided by the variable nature of the communities themselves, makes definition of hierarachical levels above the type level difficult. Only one such higher level is included -- that of the hydrological system, as defined in Cowardin, et al. (1979). Slightly different definitions of the systems are contained in the Natural Heritage Operations Manual (The Nature Conservancy 1981), but we have chosen to follow those of Cowardin, et al. (1979) because of their wider use.

To aid in organizing the natural community types, we have placed them into sixteen groups. These groups are not a true level of hierarchy because they are not formally defined or described, and are not necessarily mutually exclusive. For example, the Coastal Fringe Sandhill is both a sandy woodland and a community of the coastal fringe, but it is only placed in the latter category.

FORMAT

All of the community types or subtypes are described in the same format. This format is largely the same as that in the Second Approximation, with the addition of a few sectopms. Most of the sections have been rewritten, and some parts substantially expanded.

Sites: Describes the landscape or topographic setting of the type.

Soils: Soil series and their soil taxonomy are given whenever they are known. This information is derived primarily from the

mapping of known community occurrences on Soil Conservation Service county soil surveys. Attempts have been made to note situations in which the communities occur on an inclusion rather than on the primary series of a mapping unit, but errors may have occurred in this. Since the lists of series were made from a relatively small number of known community occurrences, they should not be regarded as exhaustive.

Hydrology: Names the hydrologic system of the type and describes other aspects of hydrology. For wetland types this includes an indication of flooding regime and, where significant, source of water. For upland sites, it is primarily an indication of soil moisture levels.

Vegetation: Describes the plant cover, listing dominant species in each stratum and giving other common or characteristic species. Taxonomy and nomenclature of vascular plants generally follow Kartesz (in press). Where this differs from Radford, Ahles, and Bell (1968), we have indicated the name used in that work parenthetically. Taxonomy and nomenclature of nonvascular plants generally follow Crum and Anderson (1981), Schuster (1966-1980), Hicks (1982), Hicks (in prep.), Egan (1987), and Hale (1979).

Dynamics: Describes various aspects of community dynamics, including tree population structure and reproduction, successional trends, natural disturbance regime, response to disturbance, and nutrient cycling. This section has been substantially expanded from the Second Approximation.

Range: Describes the range in North Carolina only.

Associations: Names other natural community types that often occur adjacent to the type and may grade into it.

Distinguishing Features: Gives suggestions of how the community type may be distinguished from other types. Because the communities are complex entities, it does not give all differences from related communities, but gives characteristics that are believed to be most useful in distinguishing the type. These vary among various vegetational and environmental features. This section is new in the Third Approximation.

Variations: Describes any variants that have been recognized. If no variants are recognized, describes the known range of variation within the type. All community types vary with the gradation to adjacent communities, and such variation is not generally described.

Comments: Gives information about commonness or rarity of the type, assessments on the state of knowledge of the type, and any other information that does not fit in the other sections.

Rare Plant Species: Lists plant species currently monitored by the Natural Heritage Program as rare or on its Watch List (a less formal list of species which appear to be rare or of conservation concern) that are known to occur within communities of the type. This is a new section in the Third Approximation, intended to aid in the search for rare plant species in conjunction with community work. Because the list of element species is continually updated, and because some species are no longer known to occur in unaltered communities, these lists do not constitute a complete list of rare plant species of North Carolina monitored by the N.C. Natural Heritage Program. The current complete list (Weakley 1990a) and Watch List (Weakley 1990b) are available from the N.C. Natural Heritage Program. These lists are revised on an at least annual basis, so future users of this document interested in rare plant and animal species associated with these communities should contact the Natural Heritage Program for up-to-date information.

Synonyms: Gives other names that have been applied to communities that fit in the type.

Examples: Gives examples where communities of the type are known to occur, along with their county of occurrence. Whenever possible, the list consists of a selection of well-known, high-quality examples and good examples in protected, publically accessible natural areas. However, for particularly rare or poorly known types, it may give the only sites known. Inclusion of a site in this section should not be taken to imply either public accessibility or designation as a "type specimen." Well-defined references pertaining directly to the example are given where they exist. The absence of a reference indicates

that the information on the occurrence comes from individual field reports in the Natural Heritage Program files or from the authors' experience or general knowledge. Such sources also exist for many of the sites with cited references, and may contain better information about the site than those references cited.

Sample Plant Communities: Lists plant communities known or believed to occur in examples of the type, named by the dominants of the strata. The lists have been expanded in the Third Approximation to make them more illustrative of the kinds of vegetation that may occur in the community type. Redundant entries were removed and new entries added to better illustrate the known range of vegetation within the natural community type. For each plant community listed, other plant communities, differing by lack of dominants in one stratum, or by combinations of listed dominants, are also possible. This list is for illustration purposes and should not be regarded as exhaustive.

References: References have been placed at the end of the document. Only published or well-defined, unpublished, "gray literature" material has been cited. Extensive use has been made of written field notes by Natural Heritage Program staff and contracted workers; because of the large number and difficulty in definition of these sources, they have not been cited.

FUTURE DIRECTIONS

The document is unlikely to be the final approximation of the natural community classification. Much remains to be learned about all of the community types in North Carolina. Continued field work by Natural Heritage Program staff and contracted workers, new academic studies, and quantitative vegetation sampling under way by the North Carolina Vegetation Survey and others are likely to lead to better understanding of communities and further refinement of categories. Several areas where current studies are likely to lead to future revision are mountain wetlands, longleaf pine-dominated woodlands, and other fire- dependent communities of the coastal plain, but some revisions are likely in most parts of the classification. The trend of finer division of types when more is known is likely to continue, and future approximations are likely to recognize more types and subtypes.

It is our hope that the currently limited scope of the classification can be broadened in the future, to include aquatic communities, and eventually to include modified as well as natural communities. We would like to expand our descriptions of the community types to include information about faunal and other components, as well as to improve information in the current sections.

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SUMMARY OF CHANGES IN CATEGORIES

NEW TYPES

Montane Oak--Hickory Forest
Basic Mesic Forest (Montane Calcareous Subtype)
Piedmont Longleaf Pine Forest
Diabase Glade
Coastal Fringe Evergreen Forest
Floodplain Pool
Low Elevation Seep
Estuarine Fringe Loblolly Pine Forest
Upper Beach

SPLITS OF TYPES

Second Approximation	Third Approximation
Northern Hardwoods Forest	Northern Hardwood Forest (Typic Subtype)
	Boulderfield Forest
Cove Forest	Rich Cove Forest
	Acidic Cove Forest
Acidic Cliff	Montane Acidic Cliff
	Piedmont/Coastal Plain Acidic Cliff
	Piedmont/Coastal Plain Heath Bluff
Basic Cliff	Montane Mafic Cliff
	Piedmont Mafic Cliff
	Montane Calcareous Cliff
	Piedmont Calcareous Cliff
Pine/Scrub Oak Sandhill	Coastal Fringe Sandhill
	Pine/Scrub Oak Sandhill
Semipermanent Impoundment	Coastal Plain Semipermanent Impoundment
	Piedmont/Mountain Semipermanent Impoundment
Piedmont/Mountain Alluvial Forest	Piedmont/Low Mountain Alluvial Forest
	Montane Alluvial Forest
Swamp Forest-Bog Complex	(Southern Subtype)
	(Spruce Subtype)
Southern Appalachian Bog	(Northern Subtype)
	(Southern Subtype)
Pine Flatwoods	Wet Pine Flatwoods
	Dry Pine Flatwoods
Maritime Swamp Forest	Maritime Swamp Forest

\---------- Maritime Shrub Swamp

COMBINATIONS OF TYPES

Red Spruce--Fraser Fir Forest ----------\
Red Spruce Forest ----------Red Spruce--Fraser Fir Forest

Marsh-Bog Complex ----------\
Southern Appalachian Bog---------- Southern Appalachian Bog
(Northern and Southern Subtype)

MAJOR CHANGES OF CONCEPT

Seepage Pocosin ---------- Sandhill Seep
Wind Forest ----------Northern Hardwood Forest (Beech Gap Subtype)

SIMPLE NAME CHANGES

Chestnut Oak--Scarlet Oak Forest----------> Piedmont Monadnock Forest
Montmorillonite Forest ----------> Xeric Hardpan Forest
Mafic Bedrock Glade ----------> High Elevation Mafic Glade
Maritime Forest ----------> Maritime Evergreen Forest
Maritime Mesophytic Forest ----------> Maritime Deciduous Forest
Piedmont Hardpan Bog ----------> Upland Pool

FRASER FIR FOREST

Sites: Highest mountain areas, generally above 6000 feet, but may extend lower in some exposed sites or mesic coves. These sites have the most boreal-like climate in the state.

Soils: Rocky, usually shallow soils with a thick organic layer. Most would probably be the Burton series (Typic Haplumbrept).

Hydrology: Mesic to wet due to high rainfall and fog deposition and low temperatures.

Vegetation: Canopy strongly dominated by Abies fraseri (greater than 67%). May have lesser amounts of Picea rubens, Sorbus americana, Betula alleghaniensis, Prunus pensylvanica, and Acer spicatum. Shrubs are sparse to dense. Typical species include Sambucus racemosa var. pubens, Rhododendron catawbiense, Viburnum lantanoides (alnifolium), Vaccinium erythrocarpum, Menziesia pilosa, Rubus alleghaniensis, and Rubus idaeus spp. sachalinensis. Herbs are generally dense except under heavy shrub cover. Oxalis montana (acetosella), Athyrium filix- femina var. asplenioides, or Dryopteris campyloptera usually dominate. Other common herbs include Aster acuminatus, Aster divaricatus, Clintonia borealis, Solidago glomerata, Cacalia (Senecio) rugelia, Ageratina altissima var. roanensis (Eupatorium rugosum), Chelone lyonii, Circaea alpina, Streptopus roseus, Viola macloskeyi ssp. pallens, and Huperzia (Lycopodium) lucidula. There is usually a very high bryophyte cover, with many characteristic species, such as Hylocomium splendens and Ptilium crista-castrensis.

Dynamics: It is unclear how much of what is known about the dynamics of spruce- fir forests in general applies to these highest elevation forests. As in Red Spruce--Fraser Fir Forests, gap regeneration is probably important (Busing 1985; White, MacKenzie, and Busing 1985), but larger natural disturbances such as wind, ice, and extreme cold are probably more important than in the lower forests. As in Red Spruce--Fraser Fir Forests, fire is not a significant factor (White, MacKenzie, and Busing 1985).

Busing (1985) found, in mixed spruce and fir forests, that fir was more likely than spruce to capture gaps, and that spruce dominated or codominated by virtue of its much greater longevity. The dominance of fir in the highest elevation sites may be a result of more frequent disturbances and reduced life span of spruce.

Fraser Fir Forests were damaged less than Red Spruce--Fraser Fir Forests by early logging, because the fir lumber was of less value. Where intense slash fires burned into them, however, the effect was similar. Trees, seedlings, and often the organic surface of the soil was consumed, rendering the site unsuitable for conifer regeneration. In addition, Fraser Fir Forests have proved very susceptible to large blowdowns that start at the edge of clearings. Expansion of blowdowns over a period of years has disturbed large areas of otherwise undisturbed Fraser Fir Forest (Pyle and Schafale 1985, 1988). While blowdowns probably occurred naturally, logging and clearing has greatly increased their effect.

All Fraser Fir Forests have been disturbed in recent years by the Balsam Woolly Adelgid, an introduced insect pest. The adelgid kills essentially all adult firs. Degree of disturbance depends on the amount of Abies fraseri initially present. Changes resulting from fir death include an increase in Rubus alleghaniensis, Rubus idaeus spp. sachaniensis, and various shrubs, and a decrease in moss and forest herbs (Boner 1979; DeSelm and Boner 1984). Boner (1979) found that seedlings of fir increased with time since adelgid attack, and Witter and Ragenovich (1986) believed that fir seedlings present at the time of attack would be able to mature and reproduce before succumbing to the adelgid. If this fails to occur, 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.

There has been widespread concern about declines in growth rates and the unhealthy condition of trees in Southern Appalachian spruce-fir forests. 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. However, because the damage by the Balsam Woolly Adelgid has been so severe and widespread, hypothesized damage by other environmental factors may be impossible to detect in Fraser Fir Forests.

Range: Limited to the highest Blue Ridge peaks. The southern limit is Richland Balsam and Clingman's Dome, the northern limit Mt. Rogers in Virginia.

Associations: Grades to Red Spruce--Fraser Fir Forest at lower elevations. May grade to or sharply border Heath Bald, Grassy Bald, or High Elevation Rocky Summit.

Distinguishing Features: Fraser Fir Forests are distinguished from all other high elevation forests by having a canopy with greater than 67% Abies fraseri and occurring at the highest elevations. Some Red Spruce--Fraser Fir Forests may become dominated by fir after logging and will be difficult to distinguish, but will generally be at lower elevation.

Variation: Although there are floristic and vegetational differences among spruce- and fir-dominated forests in different mountain ranges (Pittillo 1984; Schwartzkopf 1974), the variation is less than in many mountain community types. The extreme environment limits the number of species that typically occur. Generally fir increases in importance with elevation, and may or may not be present in lower sites. Crandall (1958) described five undergrowth types in spruce-fir forests in the Smokies:

Oxalis-Hylacomium, on steep, high, north-facing slopes.
Oxalis-Dryopteris, on the highest peaks.
Viburnum-Vaccinium-Dryopteris, on steep slopes at slightly lower elevations.
Senecio, with heavy cover of Cacalia (Senecio) rugelia, on southwest and northwest slopes in the Smokies only.
Rhododendron, on rocky spurs and steep ridges, transitional to Heath Bald.

Other than the Oxalis-Dryopteris type, it is unclear how many of these variants occur in Fraser Fir Forests in addition to Red Spruce-Fraser Fir Forests. Other variants undoubtedly also exist. Because of the severe disturbance by Balsam Woolly Adelgid, it is impossible to tell what long term variations among sites will be.

Comments: Most of the scientific literature considers all spruce and fir- dominated forest together. The Abies fraseri-dominated forests of the highest peaks appear distinct, however, and are kept as a separate type here. It is unclear how much of the information on spruce-fir forests in general applies to them. This is a rare and extremely endangered community type. Its potential sites are extremely limited. Although most or all are in protected ownership, the Balsam Woolly Adelgid makes it uncertain whether any of the sites are viable. None remain in good condition.

Rare Plant Species: Vascular -- Abies fraseri, Alnus viridis ssp. crispa, Betula papyrifera var. cordifolia, Cacalia rugelia, Cardamine clematitis, Carex trisperma, Dryopteris carthusiana, Glyceria nubigena, Phegopteris connectilis, Poa palustris, Rhododendron vaseyi, Stachys clingmanii, Streptopus amplexifolius, Streptopus roseus var. roseus; nonvascular -- Bazzania nudicaulis, Brachydontium trichodes, Frullania oakesiana, Harpanthus drummondii, Leptodontium excelsum, Leptoscyphus cuneifolius, Lophozia attenuata, Metzgeria temperata, Nardia scalaris, Plagiochila corniculata, Sphenolobopsis pearsonii.

Synonyms:
SAF 34: Red Spruce-Fraser Fir (in part).
Spruce-fir forest (general usage, in part).

Examples:
Great Smoky Mountains, Swain and Haywood counties (Whittaker 1956, Crandall 1958).
Black Mountains, including Mt. Mitchell State Park and Pisgah National Forest, Yancey County (Davis 1930, McLeod 1988).
Richland Balsam, Blue Ridge Parkway, Haywood County.

References: Boner (1979), Brown (1941), Busing (1985), Crandall (1958), Davis (1930), DeSelm and Boner (1984), Eagar (1984), Pittillo (1984), Pyle (1984), Pyle and Schafale (1985), Pyle and Schafale (1988), Saunders (1979), Schwartzkopf (1974), White, MacKenzie, and Busing (1985), Whittaker (1956), Witter and Ragenovich (1986).

Sample Plant Communities:
Abies fraseri.
A. fraseri/Sorbus americana/Aster acuminatus.
A. fraseri/Rhododendron catawbiense/Oxalis montana (acetosella)/Moss spp.
A. fraseri/Rhododendron catawbiense-Viburnum lantanoides (alnifolium).

A. fraseri/Rubus sp./Ageratina altissima var. roanensis (Eupatorium rugosum).
A. fraseri/Vaccinium fuscatum (atrococcum).
A. fraseri/Vaccinium erythrocarpum/Hylocomium sp.
A. fraseri/Mixed herbs.
A. fraseri/Mixed heaths.
A. fraseri/Aster acuminatus.
A. fraseri/Aster acuminatus/Moss spp.
A. fraseri/Aster divaricatus.
A. fraseri/Carex debilis-Carex intumescens.
A. fraseri/Dryopteris campyloptera-Athyrium filix-femina var. asplenioides.
A. fraseri/Oxalis montana/Moss spp.
A. fraseri/Cacalia (Senecio) rugelia.
A. fraseri/Solidago glomerata.
A. fraseri/Mixed graminoids.
A. fraseri/Mixed tall herbs
A. fraseri/Mixed mosses.
Sorbus americana.
Rubus alleghaniensis.
Rubus alleghaniensis-Rubus idaeus ssp. sacchalinensis.

RED SPRUCE--FRASER FIR FOREST

Sites: High mountain areas, in all topographic positions. Generally above 5500 feet elevation (though locally lower in suitable sites) and extending to the tops of all but the highest peaks.

Soils: Highly variable, from deep mineral soils to well-developed boulderfields. The soil often has a thick organic layer. Most would probably be included in the Burton series (Typic Haplumbrept).

Hydrology: Mesic to wet due to high rainfall, fog deposition, low temperatures, shading by the tree canopy, and high water-holding capacity of the soil. Although not considered wetlands, many sites may be saturated for long periods.

Vegetation: Forest dominated by Picea rubens, with or without Abies fraseri, and lesser amounts of Betula alleghaniensis (lutea), Acer spicatum, Sorbus americana, Betula papyrifera var. cordifolia, or various northern hardwoods. Shrubs are generally fairly sparse but may be dense. Typical species include Viburnum lantanoides (alnifolium), Vaccinium erythrocarpum, Vaccinium constablaei, Sambucus racemosa var. pubens, Rubus alleghaniensis, Ilex montana, and Rubus canadensis. In exposed sites a dense layer of Rhododendron catawbiense may dominate. Herbs are often dense, dominated by Oxalis montana (acetosella), Athyrium filix-femina var. asplenioides, Dryopteris campyloptera, or, in the Smokies, Cacalia (Senecio) rugelia. Other common herbs include Aster acuminatus, Aster divaricatus, Clintonia borealis, Solidago glomerata, Cacalia (Senecio) rugelia, Chelone lyonii, Circaea alpina, Streptopus roseus, Viola macloskeyi ssp. pallens, Carex pensylvanica, Maianthemum canadense, and Huperzia (Lycopodium) lucidula. Bryophyte cover is usually high, with many characteristic species, such as Hylocomium splendens and Ptilium crista-castrensis.

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. Recent observations suggest that ice and wind storms are significant factors creating gaps.

Both spruce and fir produce abundant seedlings which may persist in a suppressed condition under a closed canopy until a gap is produced. 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.

Spruce-fir forests are especially vulnerable to human-caused disturbances such as logging and associated fire, as was widespread in the early part of this century. When the canopy was removed, the soil organic layer was able to dry and carry fire. Logging slash fires often consumed not only the bank of seedlings but much of the soil itself. The dominant trees, particularly spruce, are often unable to reestablish in cleared and burned areas (Korstian 1937, Saunders 1979, Pyle and Schafale 1985, 1988), and most areas logged and burned in the early part of the century show no sign of returning to conifer dominance. However, Brown (1941) noted that they were able to invade Grassy Balds and Heath Balds on Roan Mountain. Areas logged but not burned, as on Roan Mountain, sometimes become dominated by fir.

All Red Spruce--Fraser Fir Forests which escaped logging have been disturbed in recent years by the Balsam Woolly Adelgid, an introduced insect pest. The adelgid kills essentially all adult firs. Degree of disturbance depends on the amount of Abies fraseri initially present. Changes resulting from fir death include an increase in Rubus alleghaniensis and various shrubs, and a decrease in moss and forest herbs (Boner 1979; DeSelm and Boner 1984). Boner (1979) found that seedlings of fir increased with time since adelgid attack, and Witter and Ragenovich (1986) believed that fir seedlings present at the time of attack would be able to mature and reproduce before succumbing to the adelgid. If this fails to occur, 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.

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. 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 has been 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 remains about potential effects of air pollutants.

Range: Limited to the highest Blue Ridge ranges and anomalously absent from some mountains within its elevational range. The southern limit is Richland Balsam and the central Smoky Mountains, the northern limit Mt. Rogers in Virginia.

Associations: Grades to Fraser Fir Forest at the highest elevations. Grades to Heath Bald on sharp exposed ridges. May grade into or sharply border Grassy Bald or Northern Hardwood Forest (Beech Gap Subtype). Grades to Northern Hardwood Forest (Typic Subtype) at lower elevations.

Distinguishing Features: Red Spruce--Fraser Fir Forests are distinguished from all other high elevation forests by having a canopy dominated by Picea rubens or an even mix of Picea rubens and Abies fraseri under natural conditions. Fraser Fir Forest has greater than 67% fir in the canopy and occurs at the highest elevations. Some Red Spruce--Fraser Fir Forests may become dominated by fir after logging and will be difficult to distinguish. The transition to Northern Hardwood Forest (Typic Subtype) often consists of a broad zone of spruce-yellow birch forest. The boundary is placed where predominance shifts from hardwood species to conifers.

The Spruce Subtype of the Swamp Forest--Bog Complex community type is also dominated by Picea rubens, but occurs in flat, valley bottoms, wetland sites below the normal elevational range of spruce.

Variation: Although there are floristic and vegetational differences among Red Spruce--Fraser Fir Forest in different mountain ranges (Pittillo 1984; Schwartzkopf 1974), the variation is less than in many mountain community types. However, the wide range of topography and soil conditions allows significant differentiation within a mountain range. Generally fir increases in importance with elevation, and may or may not be present in lower sites. Crandall (1958) described five undergrowth types in spruce-fir forests in the Smokies:

Oxalis-Hylacomium, on steep, high, north-facing slopes.
Viburnum-Vaccinium-Dryopteris, on steep slopes at slightly lower elevations,
Senecio, with heavy cover of Cacalia (Senecio) rugelia, on southwest and northwest slopes in the Smokies only.
Rhododendron, on rocky spurs and steep ridges, transitional to Heath Bald.

Her fifth type, Oxalis-Dryopteris, occurred only on the highest peaks, in Fraser Fir Forest. The other four may be treated as variants. Other variants probably exist in other mountain ranges.

Comments: The Second Approximation included separate Red Spruce Forest and Red Spruce--Fraser Fir Forest types, based on descriptions by Whittaker (1956) and others. They are combined here because, in subsequent field observations, the pure spruce zone appears to be only irregularly present and not to be significantly different from the mixed spruce-fir zone. The Fraser Fir Forest of the highest peaks appears more distinct and is kept as a separate type.

Most of the scientific literature considers all spruce and fir-dominated forests together. Most such studies apply to this type; it is unclear how much of this information also applies to Fraser Fir Forest.

Rare Plant Species: Vascular -- Abies fraseri, Alnus viridis ssp. crispa, Betula papyrifera var. cordifolia, Botrychium oneidense, Cacalia rugelia, Calamagrostis canadensis, Cardamine clematitis, Carex projecta, Cinna latifolia, Geum geniculatum, Glyceria nubigena, Phegopteris connectilis, Poa palustris, Rhododendron vaseyi, Stachys clingmanii, Streptopus amplexifolius, Streptopus roseus var. roseus; nonvascular -- Bazzania nudicaulis, Brachydontium trichodes, Frullania oakesiana, Harpanthus drummondii, Leptodontium excelsum, Leptoscyphus cuneifolius, Lophozia attenuata, Metzgeria temperata, Nardia scalaris, Plagiochila corniculata, Sphenolobopsis pearsonii.

Synonyms:
SAF 34: Red Spruce-Fraser Fir (in part).
Red Spruce Forest, Red Spruce--Fraser Fir Forest (Second Approximation).
Spruce-fir forest (general usage, in part).

Examples:
Great Smoky Mountains, Swain and Haywood counties (Whittaker 1956; Crandall 1958) (Contains the bulk of remaining examples, including extensive unlogged forests).

Black Mountains, including Mt. Mitchell State Park and Pisgah National Forest, Yancey County (Davis 1930; McLeod 1988).
Roan Mountain, Mitchell County (Brown 1941).
Grandfather Mountain, Avery, Watauga, and Caldwell counties.

References: Boner (1979), Brown (1941), Busing (1985), Cain 1931, Crandall (1958), Davis (1930), DeSelm and Boner (1984), Dull, et al. (1988), Eagar (1984), Fox (1977), Korstian (1937), Pittillo (1984), Pyle (1984), Pyle and Schafale (1985), Pyle and Schafale (1988), Saunders (1979), Schofield (1960), Schwartzkopf (1974), Weaver (1972), White, MacKenzie, and Busing (1985), Whittaker (1956), Witter and Ragenovich (1986).

Sample Plant Communities:
Picea rubens-Abies fraseri.
P. rubens-A. fraseri/P. rubens/Dryopteris intermedia-Mixed herbs.
P. rubens-A. fraseri/Sorbus americana/Aster acuminatus.
P. rubens-A. fraseri/Rhododendron catawbiense/Mixed mosses.
P. rubens-A. fraseri/Rhododendron catawbiense-Viburnum lantanoides (alnifolium).
P. rubens-A. fraseri/Rubus sp./Ageratina altissima var. roanensis (Eupatorium rugosum).
P. rubens-A. fraseri/Vaccinium fuscatum (atrococcum).
P. rubens-A. fraseri/Vaccinium erythrocarpum.
P. rubens-A. fraseri/Viburnum cassinoides/Rubus hispidus/Polytrichum sp.
P. rubens-A. fraseri/Aster divaricatus.
P. rubens-A. fraseri/Carex debilis-Carex intumescens.
P. rubens-A. fraseri/Dryopteris campyloptera-Athyrium filix-femina var. asplenioides.
P. rubens-A. fraseri/Mixed tall herbs.
P. rubens-A. fraseri/Oxalis montana (acetosella).
P. rubens-A. fraseri/Oxalis montana/Mixed mosses.
P. rubens-A. fraseri/Solidago glomerata.
P. rubens-A. fraseri/Cacalia (Senecio) rugelia.
P. rubens-A. fraseri/Mixed tall ferns.
P. rubens-A. fraseri/Mixed graminoids.
P. rubens-A. fraseri/Mixed tall herbs.
P. rubens-A. fraseri/Mixed sedges.
P. rubens-A. fraseri/Mixed mosses.
Picea rubens.
P. rubens/Sorbus americana/Aster acuminatus.
P. rubens/Rhododendron catawbiense/Mixed mosses.
P. rubens/Rhododendron catawbiense-Viburnum lantanoides.
P. rubens/Rubus sp./Ageratina altissima var. roanensis.
P. rubens/Vaccinium fuscatum.
P. rubens/Vaccinium erythrocarpum.
P. rubens/Aster divaricatus.
P. rubens/Carex debilis-Carex intumescens.
P. rubens/Dryopteris campyloptera-Athyrium filix-femina var. asplenioides.
P. rubens/Mixed tall herbs.
P. rubens/Ageratina altissima var. roanensis (Eupatorium rugosum).
P. rubens/Oxalis montana/Mixed mosses.
P. rubens/Solidago glomerata.
P. rubens/Cacalia (Senecio) rugelia.
P. rubens/Mixed tall ferns.
P. rubens/Mixed graminoids.
P. rubens/Mixed tall herbs.
P. rubens/Mixed sedges.

P. rubens/Mixed mosses.

GRASSY BALD

Sites: Slopes, ridgetops, and domes of high mountains, usually on gentle slopes.

Soils: Probably generally of the Burton series (Typic Haplumbrept). Cain (1931) found that Grassy Bald soils in the Smokies were less acidic than other soils at similar elevations.

Hydrology: Terrestrial. Probably mesic due to high rainfall, frequent fog, and low temperatures, but exposed to high winds.

Vegetation: Dominated by herbaceous species with patches of shrubs and small trees. The most characteristic dominant is Danthonia compressa. Other frequent dominants are Sibbaldiopsis (Potentilla) tridentata, Potentilla canadensis, Carex debilis, Carex brunnescens, Carex pensylvanica, Agrostis perennans, Polytrichum commune, and Deschampsia flexuosa. Phleum pratense and other exotic species may dominate areas once heavily grazed. Other common species include Angelica triquinata, Fragaria virginiana, Prenanthes roanensis, Houstonia serpyllifolia, Rudbeckia laciniata, Hieracium scabrum, Rumex acetosella, Danthonia spicata, Dennstaedtia punctilobula, Senecio schweinitzianus, Viola spp., Schizachyrium (Andropogon) scoparium, Helenium autumnale, and Senecio aureus. Balds have been invaded by varying amounts of shrubs and small trees, such as Rubus allegheniensis, Rhododendron catawbiense, R. calendulaceum, Vaccinium constablaei, Kalmia latifolia, Menziesia pilosa, Fagus grandifolia, Aesculus flava (octandra), Picea rubens, Crataegus spp., and Quercus rubra. On Roan Mountain, Alnus viridis spp. crispa is an important invading shrub.

Dynamics: The factors that produced and maintained Grassy Balds have been the subject of intense scientific debate over the years, and much has been written about them, but consensus has not been reached (see summary by Peterson 1980, Smathers 1980, and most other references below). Hypotheses of origin include human action such as clearing and grazing of cattle by early settlers; presettlement clearing, trampling, and burning by Indians; natural disturbance such as fire, windthrow, or insects; changing climatic conditions; as well as combinations of these factors. Some areas called balds are known to have been created within historical times. Others appear to have already existed when settlers arrived and are considered natural balds, though this is debated. The existence of open-country species, such as Senecio schweinitzianus, that do not occur in surrounding communities (or even on the thin soils and rock outcrops within grassy balds) provides evidence of the naturalness of the balds of the Roan Mountain Massif. Most species found on balds, however, are also characteristic of either High Elevation Rocky Summits or of surrounding high elevation forest types.

Natural Grassy Balds usually occur in a particular type of topographic environment, but only a fraction of such sites contain Grassy Balds. Most authors agree that Grassy Balds are not being created at present, and that fire and clearing produce nonpersistent successional vegetation different from Grassy Balds. However, McLeod (1988) believed that grazing or trampling of fire- produced openings had led to Grassy Bald vegetation in the Black Mountains.

Grassy Balds do not appear to be naturally maintaining themselves at present. While usually less agressive colonizers than in recently cleared or burned areas, shrubs and trees are invading essentially all unmaintained Grassy Balds. Until recently, grazing by cattle occurred on all balds and prevented woody plant invasion, which generally began soon after grazing ceased. While some balds became dominated by exotic pasture weeds under heavy grazing, the extent to which grazing has modified the natural vegetation of other, more natural, balds is unknown.

If Grassy Balds existed prior to pasturing, some process or factor had to prevent succession. Hypotheses for bald maintenance include environmental factors such as wind, dryness, cold, and frost heaving; competition with established vegetation; natural disturbances such as fire or grazing by herds of native large mammals; and prehistoric human activities. Climatic factors alone are not sufficient, since balds are not presently being maintained, but are a contributing factor. The other hypotheses are difficult to evaluate and their importance may have to be inferred by experiment.

Range: Scattered throughout the high mountains, primarily from the Great Smoky Mountains northward.

Associations: Transitions to surrounding communities may be either sharp or gradual. Surrounding communities are generally Heath Bald, Red Spruce--Fraser Fir Forest, or Northern Hardwoods (Typic or Beech Gap Subtype). Balds may contain High Elevation Seeps or Rocky Summits.

Distinguishing Features: Grassy Balds are distinguished from all other communities by the dominance of herbaceous

vegetation in high mountain locations. High Elevation Rocky Summits and High Elevation Granitic Domes may contain patches of herbaceous vegetation similar to Grassy Balds, but it will occupy only small areas in a complex of bare rock and vegetation of mixed physiognomy. Herbaceous vegetation should be considered Grassy Bald only if it covers a substantial area or extends far from the rock outcrop. Areas of former grassy vegetation which have been occupied by Rubus alleghaniensis are included in the Grassy Bald type. Areas of heaths or other shrubs are considered part of the Grassy Bald unless they have become dense enough and persisted long enough that the herbaceous flora has been eliminated.

Variation: Balds vary widely in dominant plants from site to site and within sites. Sites vary with grazing history, exposure, and unknown factors.

Comments: This 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 their origin is not known, 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 Plant Species: Vascular: Agrostis mertensii, Alnus viridis ssp. crispa, Botrychium multifidum, Calamagrostis canadensis, Carex aenea, Carex cristatella, Carex misera, Delphinium exaltatum, Gentiana austromontana, Geum geniculatum, Houstonia purpurea var. montana, Huperzia selago, Hypericum buckleyi, Lilium grayi, Lilium philadelphicum, Lycopodium dendroideum, Lycopodium hickeyi, Minuartia groenlandica, Monarda media, Phlox subulata, Platanthera grandiflora, Poa palustris, Prenanthes roanensis, Rhododendron cumberlandense, Rhododendron vaseyi, Senecio schweinitzianus, Spiranthes ochroleuca, Trisetum spicatum.

Synonyms: Meadow, field (common usage).

Examples:
Roan Mountain Massif, including Round Bald, Jane Bald, Engine Bald, Little Hump, and Big Hump, Pisgah and Cherokee National Forest, Avery and Mitchell counties and Tennessee (Brown 1941, Roan Mountain Challenge Grant Research Team 1988).
Big Yellow Mountain Preserve, Avery County (Weakley 1980b).
Big Bald Natural Area, Pisgah National Forest, Yancey County, N.C. and Unicoi County, Tenn. (Gaddy 1981a).

References: Billings and Mark (1957), Bratton and White (1980), Brown (1941), Cain (1931), Gaddy (1981a), Gersmehl (1973), Lindsay and Bratton (1976a), Lindsay and Bratton (1976a), Lindsay and Bratton (1980), McLeod (1988), Mark (1958), Peterson (1980), Roan Mountain Challenge Grant Research Team (1988), Smathers (1980), Stratton and White (1982), Weakley (1980b), Wells (1937), Wells (1956), Whittaker (1956).

Sample Plant Communities:
Agrostis perennans.
Angelica triquinata/Carex spp.
Carex brunnescens-Carex pensylvanica.
Carex brunnescens-Rumex acetosella.
Carex spp.-Sibbaldiopsis (Potentilla) tridentata.
Danthonia compressa.
Deschampsia flexuosa.
Mixed sedges.
Danthonia compressa/Sibbaldiopsis (Potentilla) tridentata.
Senecio schweinitzianus.
Senecio schwiniitzianus-Carex pensylvanica.
Polytrichum sp. Helenium autumnale/Senecio aureus.
Baeomyces fungoides.

Fragaria virginiana.
Helenium autumnale.
Potentilla canadensis.
Sibbaldiopsis tridentata.
Prenanthes roanensis.
Prenanthes roanensis/Carex spp.
Rumex acetosella.
Mixed composites.
Mixed graminoids.
Mixed herbs.
Phleum pratense.
Mixed pasture weeds.

HEATH BALD

Sites: Extremely exposed high elevation sites -- peaks, sharp ridges, and steep slopes.

Soils: Thin and rocky soils, often with a thick organic layer. Most are probably Lithic Dystrochrepts, but some may be Histosols.

Hydrology: Terrestrial. Dry because of rapid drainage, thin soil, and exposure to wind and sun, despite low temperatures and high rainfall.

Vegetation: Dominated by shrubs, usually dense but occasionally more open. Kalmia latifolia, Rhododendron maximum, or Rhododendron carolinianum usually dominate at lower elevations and R. catawbiense at higher elevations. Other important shrubs, which may sometimes dominate, include Aronia (Sorbus) melanocarpa, Clethra acuminata, Vaccinium constablaei, Gaylussacia baccata, Leiophyllum buxifolium, Menziesia pilosa, Pieris floribunda, Diervilla sessilifolia, Robinia hispida, and Alnus viridis ssp. crispa. Herbs are generally sparse, consisting primarily of species such as Gaultheria procumbens, Melampyrum lineare, Galax urceolata (aphylla), Pteridium aquilinum, Listera smallii, and Trillium undulatum.

Dynamics: The dynamics of Heath Balds have been the subject of much discussion. Cain (1930) found that all of the Heath Balds he sampled in the Smokies 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. Cain (1931) found that Heath Bald soils were more acidic than soils in other communities at the same elevations. Whittaker (1956) suggested that Heath Balds were successional in part, but that they seemed to be able to maintain themselves under present conditions. However, some open Heath Balds on Roan Mountain and the Craggy Mountains are being invaded by trees (Brown 1941). McLeod (1988) regarded Heath Balds as secondary successional communities after disturbances in extreme sites.

It seems likely that all viewpoints are true about at least some Heath Balds. Some are clearly primary successional communities, occurring on landslide scars and the edges of rock outcrops. Others are clearly secondary successions, resulting from logging and severe burns in spruce-fir forests in historical times. Others have resulted from invasion of Grassy Balds by shrubs. Others appear to have existed since prehistoric times on sites not associated with rock outcrops. Some Heath Balds are being invaded by trees, some would have been invaded if periodic fires had not kept trees out, and many will probably remain shrub dominated indefinitely even without further disturbance.

Range: Scattered throughout the higher parts of the Mountain region.

Associations: May grade to Fraser Fir, Red Spruce--Fraser Fir, Red Spruce, High Elevation Red Oak, Montane White Oak, Chestnut Oak Forest, or Pine--Oak/Heath.

Distinguishing Features: Heath Balds may be distinguished from forested communities and Pine--Oak/Heaths by the absence or near absence of trees. Any trees that are present are stunted and not significantly taller than the shrubs. Heath Balds are distinguished from Grassy Balds by the dominance of shrubs. Patches of Rubus alleghaniensis, low Vaccinium, or Gaylussacia species associated with herb-dominated vegetation or in formerly grassy areas, are considered part of the Grassy Bald. The area on Roan Mountain dominated by Alnus viridis ssp. crispa is considered Heath Bald, even though the shrubs are not in the heath family. The same is true of other areas with non-heath shrubs that occur in similar environments.

Heath Balds are distinguished from High Elevation Rocky Summits by the dominance of shrubs and the subordinate importance of bare rock. Because High Elevation Rocky Summits can contain shrub-dominated patches at their edges, some judgment may be required. Shrubby areas should be considered Heath Balds only if they cover substantial area or extend far from the rock outcrop.

Variation: Whittaker (1956) describes differences between the high elevation Rhododendron catawbiense and lower elevation Kalmia latifolia and Rhododendron maximum types. A variety of other dominance types also exist. McLeod (1988) emphasized the occurrence of both dense thickets and open "garden" Heath Balds.

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 Plant Species: Vascular -- Geum radiatum, Rhododendron vaseyi, Zigadenus leimanthoides.

Synonyms:
Shrub bald, heath slick (general usage).

Examples:
Great Smoky Mountains National Park, Haywood and Swain counties (Whittaker 1956, Cain 1930, Cain 1931).
Grandfather Mountain, Avery and Watauga counties.
Craggy Mountains, Buncombe County (McLeod 1988, Horton and Hotaling 1981, Heiman and Smith in prep.).
Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981, McLeod 1988).
Roan Mountain, Mitchell and Avery counties (Brown 1941).
Table Rock Mountain, Linville Gorge, Pisgah National Forest, Burke County.

References: Brown (1941), Cain (1930), Cain (1931), Davis (1930), Gant (1978), Govus (1985), Heiman and Smith (In prep), Horton and Hotaling (1981), McLeod (1981), McLeod (1988), Whittaker (1956).

Sample Plant Communities:
Gaylussacia baccata.
Kalmia latifolia.
Leiophyllum buxifolium.
Rhododendron catawbiense.
R. catawbiense/Polytrichum spp.
Rhododendron carolinianum.
Vaccinium constablaei.
Mixed deciduous and evergreen heaths.
Mixed evergreen heaths.
Mixed heaths.
Mixed heaths-Mixed shrubs/Mixed herbs.

HIGH ELEVATION RED OAK FOREST

Sites: Dry-mesic slopes and ridgetops at mid to high elevations (around 3500- 5000 feet, higher in south).

Soils: Various upland soils.

Hydrology: Dry-mesic. Generally more exposed than Northern Hardwoods sites, less exposed than Heath Bald, Grassy Bald, or other oak-dominated forests.

Vegetation: Closed to somewhat open canopy dominated by Quercus rubra var. ambigua (var. borealis), often with Quercus montana (prinus), Acer rubrum, Liriodendron tulipifera, or minor amounts of Q. alba, Carya spp., Q. coccinea, Robinia pseudo-acacia, Betula alleghaniensis (lutea), Tsuga canadensis, and various northern hardwood species. Castanea dentata once dominated or codominated these forests, and sprouts are frequently still an important understory component. Other important understory species include Amelanchier arborea, Acer pensylvanicum, A. rubrum, A. spicatum, Crataegus spp., and Ilex montana. Important shrubs include Rhododendron calendulaceum, Vaccinium constablaei, Vaccinium erythrocarpum, Viburnum lantanoides (alnifolium), Gaylussacia ursina, Hamamelis virginiana, Cornus alternifolia, Rhododendron maximum, and Kalmia latifolia. Herbs generally have moderate to high cover but are less diverse than in Northern Hardwood Forest. Typical species include Thelypteris noveboracensis, Athyrium filix-femina var. asplenioides, Lysimachia quadrifolia, Galax urceolata (aphylla), Conopholis americana, Dioscorea villosa, Aralia nudicaulis, Ageratina altissima var. roanensis (Eupatorium rugosum), Carex pensylvanica, other Carex spp., Dryopteris spp., Aster macrophyllus, Aster acuminatus, Convallaria montana, and Clintonia umbellulata.

Dynamics: These forests are naturally uneven-aged climax forests with reproduction occurring in canopy gaps. Like the Cove Forests and Canada Hemlock Forests, they undoubtedly have peaks of recruitment associated with disturbances that provide a greater number of gaps than usual. They probably never or only extremely rarely had the entire canopy removed at once by disturbance. Their drier, more exposed position may make them more susceptible than more mesic forests to widespread disturbance by fire, wind, or ice storm. The natural fire regime is not known, but fires were probably uncommon events in high elevation sites. Ice storms appear to be a significant disturbance factor in these communities.

All of these forests are in a state of transition since the loss of chestnut in the canopy. In most stands it appears that existing canopy and understory trees have replaced the chestnut initially, along with trees characteristic of disturbed areas, but it is not yet known what the eventual composition of these forests will be. Most of these forests have also been logged, and in combination with the chestnut blight, will show the effects of disturbance in varying amounts of opportunistic trees such as Robinia pseudoacacia, Liriodendron tulipifera, Betula alleghaniensis (lutea), and Pinus spp. The dense evergreen heath layers in some forests may also be the result of past disturbance (Monk, McGinty, and Day 1985).

Range: Throughout the higher parts of the Blue Ridge.

Associations: Grades to Northern Hardwood Forest (Typic Subtype) in more mesic or sheltered high elevation sites. Grades to Heath Bald, High Elevation Rocky Summit, or Grassy Bald on exposed peaks and ridges. Grades to Red Spruce Forest at higher elevations. May grade to Pine--Oak Heath, Montane Oak--Hickory Forest, Montane White Oak Forest or Chestnut Oak Forest on lower elevation ridges and slopes.

Distinguishing Features: High Elevation Red Oak Forests may be distinguished from all other high elevation forests by the dominance of Quercus rubra. They are distinguished from Montane Oak--Hickory Forests, which may have significant Quercus rubra, by lacking or having only minor amounts of Q. alba and Carya spp.

Variation: This is a broad category with much variation. Whittaker (1956) described differences between higher and lower elevations. Higher elevation examples had less Castanea dentata originally and therefore less disturbance from the chestnut blight. Tree species typical of Cove Forests form a larger portion, though still a minority, of the canopy. The high elevation sites have less shrub cover and are often open, grassy "orchard forests". The greater amount of shrubs and different trees in lower sites may be a result of the greater canopy opening caused by the loss of the chestnuts.

DeLapp (1978) described several undergrowth phases, varying with exposure, slope, and aspect:

1. Kalmia latifolia, on narrow well-drained ridges and steep southerly slopes. This is apparently transitional to Heath Bald or Pine-Oak/Heath.
2. Rhododendron catawbiense, a rare phase similar to the above.
3. Rhododendron maximum, on intermediate exposures and moderately deep soils at generally lower elevations.
4. Deciduous heath, on exposed, high elevation ridges and less exposed lower sites.
5. Mixed fern, with Thelypteris noveboracensis or Dennstaedtia punctilobula, on gentle slopes and in cove heads.
6. Tall herb, with Rubus canadensis, Ageratina altissima var. roanensis, and a high diversity of herbs, in steep, rocky cove heads with seepage. This appears transitional to Cove Forest.
7. Corylus cornuta, on broad ridgetops, gaps, and seepage areas.

These are tentatively recognized as variants. An additional orchard forest variant, with gnarled or stunted trees and a grass- or sedge-dominated herb layer, occurring on high, exposed ridges, is also recognized.

Comments: High Elevation Red Oak Forests occupy a very broad range of topographic positions and elevations. In the southern part of the state, beyond the range of spruce and fir, they often extend to the highest peaks. Elsewhere they occupy the middle of the exposure and elevation gradients.

In addition to elevation and topographic position, soil factors may be important in determining occurrence of this community type in some areas. Rohrer (1983) noted that substrate (metabasalt vs. arkose) shifted the boundary between this type and Northern hardwoods. This may be an effect either of nutrient status or of soil texture modifying the moisture regime.

Rare Plant Species: Vascular -- Botrychium lanceolatum var. angustisegmentum, Calamagrostis porteri, Calystegia catesbiana ssp. sericata, Clematis occidentalis, Euphorbia purpurea, Helianthemum bicknellii, Helianthemum propinquum, Lonicera dioica, Prenanthes roanensis, Prunus virginiana, Pyrola americana, Rhododendron prinophyllum, Rhododendron vaseyi, Silene ovata, Vaccinium hirsutum; nonvascular -- Schlotheimia lancifolia.

Synonyms:
Red Oak-Chestnut Forest (Whittaker 1956).
SAF 55: Northern Red Oak.

Examples:
Great Smoky Mountains National Park, Swain and Haywood counties (Whittaker 1956, Pyle 1988) (Extensive tracts of virgin forest of this type).
Middle Creek Research Natural Area and other parts of the Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981, McLeod 1988, Valentine 1983).
Hanging Rock Mountain, Avery and Watauga counties (Rohrer 1983).
Bluff Mountain Preserve, Ashe County (Whigham 1969, Weakley, Mehrhoff, and Mansberg 1979).
Big Yellow Mountain, Avery County (Weakley 1980b).
Mount Jefferson State Park, Ashe County.
Flat Rock Natural Area, Blue Ridge Parkway, Avery County.
Mount Pisgah, Blue Ridge Parkway and Pisgah National Forest, Haywood and Buncombe counties.
Southern Nantahala Wilderness, Nantahala National Forest, Macon and Clay counties (Govus 1985).
White Oak Stamp Natural Area, Nantahala National Forest, Clay County (Govus 1985).

References: Abel (1934), Day and Monk (1974), DeLapp and Wentworth (1977), Govus (1985), Keever (1953), Lacey (1979), Mansberg (1981b), McLeod (1981), McLeod (1988), Monk, McGinty, and Day (1985), Pyle (1984), Rohrer (1983), Valentine (1983), Weakley (1980b), Weakley, Mehrhoff, and Mansberg (1979), Whigham (1969), Whittaker (1956).

Sample Plant Communities:
Q. rubra var. ambigua (var. borealis)/Mixed oak and hardwood transgressives/Rhododendron catawbiense-Mixed shrubs and small trees/Mixed trees.

Q. rubra var. ambigua/Corylus cornuta/Ageratina altissima var. roanensis (Eupatorium rugosum)-Mixed herbs.
Q. rubra var. ambigua/Corylus cornuta-Mixed deciduous heaths/Mixed herbs.
Q. rubra var. ambigua/Gaylussacia baccata.
Q. rubra var. ambigua/Gaylussacia ursina.
Q. rubra var. ambigua/Kalmia latifolia/Galax urceolata (aphylla).
Q. rubra var. ambigua/Kalmia latifolia-Rhododendron calendulaceum.
Q. rubra var. ambigua/Menziesia pilosa-Mixed shrubs/Dennstaedtia punctilobula-Mixed herbs.
Q. rubra var. ambigua/Rhododendron calendulaceum/Thelypteris noveboracensis- Mixed herbs.
Q. rubra var. ambigua/Rhododendron catawbiense/Galax urceolata.
Q. rubra var. ambigua/Rhododendron maximum.
Q. rubra var. ambigua/Rhododendron maximum/Dennstaedtia punctilobula-Thelypteris noveboracensis.
Q. rubra var. ambigua/Rhododendron maximum/Mixed herbs.
Q. rubra var. ambigua/Rhododendron maximum-Kalmia latifolia.
Q. rubra var. ambigua/Rhododendron maximum-Vaccinium constablaei/Dennstaedtia punctilobula-Mixed herbs.
Q. rubra var. ambigua/Rhododendron viscosum-Corylus cornuta/Ageratina altissima var. roanensis-Mixed herbs.
Q. rubra var. ambigua/Rubus canadensis/Athyrium filix-femina var. asplenioides- Mixed herbs.
Q. rubra var. ambigua/Rubus canadensis/Dennstaedtia punctilobula-Mixed herbs.
Q. rubra var. ambigua/Rubus canadensis/Thelypteris noveboracensis-Mixed herbs.
Q. rubra var. ambigua/Vaccinium constablaei/Dennstaedtia punctilobula-Mixed herbs.
Q. rubra var. ambigua/V. constablaei/Thelypteris noveboracensis-Mixed herbs.
Q. rubra var. ambigua/Mixed deciduous heaths/Thelpypteris noveboracensis-Mixed herbs.
Q. rubra var. ambigua/Mixed heaths.
Q. rubra var. ambigua/Mixed shrubs.
Q. rubra var. ambigua/Mixed shrubs/Carex pensylvanica-Mixed herbs.
Q. rubra var. ambigua/Thelypteris noveboracensis-Mixed herbs.
Q. rubra var. ambigua/Carex pensylvanica-Mixed ferns.
Q. rubra var. ambigua-Acer saccharum/Mixed deciduous heaths/Thelypteris noveboracensis-Mixed herbs.
Q. rubra var. ambigua-Acer saccharum/Mixed herbs.
Q. rubra var. ambigua-Fraxinus americana.
Q. rubra var. ambigua-Quercus montana (prinus)/Kalmia latifolia.
Q. rubra var. ambigua-Quercus montana/Rhododendron calendulaceum/Mixed herbs.
Q. rubra var. ambigua-Quercus montana/Vaccinium constablaei-Rhododendron calendulaceum/Galax urceolata-Mixed herbs.
Q. rubra var. ambigua-Mixed hardwoods/Mixed heaths/Thelypteris noveboracensis-Galax urceolata.

MONTANE WHITE OAK FOREST

Sites: Generally exposed but not extremely rocky slopes, broad ridges, and flats, at moderate or high elevations (above 3500 feet).

Soils: Unknown. May be circumneutral.

Hydrology: Terrestrial, fairly dry.

Vegetation: Closed to somewhat open canopy dominated by Quercus alba, with small amounts of associated species such as Quercus rubra, Q. montana (prinus), Q. velutina, Q. coccinea, and Carya glabra. Castanea dentata was once very important in these communities and sprouts are still frequently a major understory component. Other understory species may include Acer rubrum, Oxydendrum arboreum, Castanea pumila, Robinia pseudoacacia, and Nyssa sylvatica. The shrub layer is generally fairly dense, with species such as Gaylussacia ursina, Kalmia latifolia, Rhododendron calendulaceum, and Vaccinium constablaei typical. The herb layer is variable, from sparse, with species such as Pteridium aquilinum, Thelypteris noveboracensis, Athyrium filix-femina var. asplenioides, Solidago caesia var. curtisii, and various grasses, to much denser and more diverse over mafic rocks.

Dynamics: All of these forests are in a state of transition after the loss of chestnut in the canopy. It is not yet known what the eventual makeup of these forests will be.

Range: Scattered throughout the Blue Ridge.

Associations: Grades to High Elevation Red Oak Forest, Chestnut Oak Forest, Northern Hardwood Forest, or Cove Forest in more sheltered sites. Grades to Pine--Oak Heath, White Pine Forest, or Heath Bald in more exposed sites.

Distinguishing Features: Montane White Oak Forests are distinguished from all other mountain communities by the strong dominance of Quercus alba in exposed, medium to high elevation sites. White oak-dominated forests on lower alluvial flats are considered part of the Montane Oak--Hickory Forest, although they may need reclassification. The boundary with the Montane Oak--Hickory Forest type is poorly known and difficult to determine.

Variation: Varies with gradation to adjacent communities. Shrub and herb layers vary from site to site and with changing moisture, soil, and slope conditions.

Comments: Whittaker (1956) describes a distinct separation between white oak forests of high and low elevations in the Smokies. Baranski (1975) however, reports that this bimodality occurs only on the Tennessee side of the Smokies, where Whittaker worked. It appears to be caused by a lack of suitable sites at mid elevations there. On the North Carolina side of the Smokies and in other North Carolina mountains white oak is more common and occurs at all elevations.

The relationship between this type and the Montane Oak--Hickory Forest type is poorly understood. It is unclear if the two are distinct enough to warrant separate categories, althoug they are rather different in some cases. A number of known occurrences are associated with mafic rocks, and high pH or clayey soil may be an important environmental factor for these communities.

Rare Plant Species: Vascular -- Euphorbia purpurea, Silene ovata.

Synonyms:
White Oak-Chestnut Forest (Whittaker 1956).
SAF 53: White Oak (in part).

Examples:
Phoenix Mountain, Ashe County (Lacey 1979).
Van Hook Wayside, Nantahala National Forest, Macon County (Boufford and Wood 1975).

Great Smoky Mountains National Park, Swain and Haywood counties (Baranski 1975).
Bluff Mountain Preserve, Ashe County (Weakley 1979).
Chunky Gal Mountain, Nantahala National Forest, Clay County (Govus 1985).
Blackrock Mountain, Nantahala National Forest, Macon and Jackson counties.
Satulah Mountain, Macon County.

References: Baranski (1975), Boufford and Wood (1975), Govus (1985), Lacey (1979), Weakley (1979), Whittaker (1956).

Sample Plant Communities:
Quercus alba/Acer rubrum-Acer saccharum/Mixed heaths.
Q. alba/Tall, deciduous heaths.
Q. alba/Mixed ferns-Carex spp.
Q. alba-Mixed xeric oaks and hickories/Gaylussacia ursina.
Q. alba/Euphorbia purpurea.
Q. alba/Mixed herbs.

NORTHERN HARDWOOD FOREST (Typic Subtype)

Sites: Medium to fairly high elevation coves, flats, and slopes, particularly on north-facing slopes.

Soils: Various upland soils. Series include Porters (Umbric Dystrochrept) and Burton (Typic Haplumbrept).

Hydrology: Terrestrial, mesic, due to low temperature and high rainfall, despite good drainage.

Vegetation: Canopy dominated by combinations of mesophytic tree species, primarily Fagus grandifolia, Betula alleghaniensis (lutea), and Aesculus flava (octandra). Additional species in some sites include Tilia americana var. heterophylla, Acer saccharum, Fraxinus americana, Prunus serotina, and Picea rubens. Understory species include Acer pensylvanicum, Magnolia acuminata, Ostrya virginiana, Acer spicatum, Sorbus americana, and Amelanchier laevis. The shrub layer ranges from fairly sparse to moderately dense. Species include Viburnum lantanoides (alnifolium), Rhododendron catawbiense, Hydrangea arborescens, Cornus alternifolia, and Ribes spp. The herb layer is generally dense and may be fairly diverse. Typical species include Ageratina altissima var. roanensis (Eupatorium rugosum), Laportea canadensis, Aster divaricatus, Aster cordifolius, Carex pensylvanica, Carex debilis, Viola canadensis, Impatiens pallida, Monarda didyma, Cardamine concatenata, Stellaria pubera, Claytonia caroliniana, Erythronium umbilicatum ssp. monostolum, Hydrophyllum canadense, Hydrophyllum virginianum, Phacelia bipinnatifida, Arisaema triphyllum, Maianthemum (Smilacina) racemosum, Cimicifuga americana, Rudbeckia laciniata, Caulophyllum thalictroides, Dryopteris marginalis, D. intermedia, D. goldiana, Athyrium felix-femina var. asplenioides, Actaea pachypoda, Collinsonia canadensis, Cacalia muhlenbergii, Geum spp., Osmorhiza claytonii, and Sanicula spp.

Dynamics: These forests are naturally uneven-aged climax forests with reproduction occurring in canopy gaps. Like the Cove and Canada Hemlock Forests, they are subject to periodic widespread disturbances that provide canopy openings and increased recruitment but probably seldom or never removed the whole canopy at once. Fire is probably a fairly rare event in the moist sites of these communities. Because most of the component trees have thin bark, rare fires might produce significant disturbance. Recent experience suggests that ice storms are an important natural disturbance factor, damaging trees over large areas and killing some.

Sites recently distured by ice storms have a dense proliferation of Rubus alleghaniensis. It is not clear how long recovery will take. Sites that were logged or severely burned in the past have increased numbers of Betula alleghaniensis, Prunus pensylvanica, or Robinia pseudoacacia, which presumably will be replaced over time with the more typical canopy. Some forests of Northern Hardwood composition have replaced Red Spruce Forests or Red Spruce-Fraser Fir Forest on sites that were severely logged and burned. Most of these sites show no sign of spruce or fir returning after 50 years.

Range: Common in high mountain areas, especially those in the northern part of the state. This type is limited to the southern Appalachians and does not include forests called Northern Hardwoods in the northern United States.

Associations: Generally grades to High Elevation Red Oak Forest on less mesic slopes. Grades downward to Cove Forest in lower mesic sites, and to Chestnut Oak Forest in more exposed sites. May grade to Red Spruce Forest, Grassy Bald, High Elevation Rocky Summit, or Heath Bald at higher elevations. May contain patches of Boulderfield Forest.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak, Red Spruce, and Red Spruce--Fraser Fir Forests by the predominance of the mesophytic tree species listed above over Quercus rubra, Picea rubens, or Abies fraseri. They are distinguished from Boulderfield Forests by occurring on soil rather than loose boulders, having most plants rooted in soil, by higher diversity, and by differences in species composition.

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 Cornus florida. Northern Hardwood species uncommon in Rich Cove Forests are fewer, but include Viburnum lantanoides (alnifolium), Rhododendron catawbiense, and Picea rubens.

The Beech Gap Subtype may be distinguished from the Typic Subtype by its high elevation, within the range of spruce-fir forests (generally above 5500 feet), and by its distinctive dwarfed canopy, lack of shrubs, and grassy herb layer.

Variation: This is a very broad category, with much variation in species composition, structure, and overall diversity. Several variants different from the typical can be recognized:

1. Spruce-fir transition variant, on high elevation open slopes, dominated mainly by Betula alleghaniensis and Picea rubens, with an herb layer containing many typical spruce-fir forest species.

2. Ridge variant, on high, exposed ridgetops, dominated mainly by Fagus grandifolia with a sedge-dominated herb layer. This variant is transitional to the Beech Gap Subtype, but has a full stature canopy.

3. High cove variant, in somewhat sheltered, high coves and concave slopes, with a more diverse canopy and herb layer transitional to Rich Cove Forest.

Additional variants may also occur.

Comments: Both Whittaker (1956) and McLeod (1988) did not clearly distinguish this type from their cove forests. However, although they share many species and the boundary is difficult to place, the tremendous diversity of mesophytic forests requires such a split. The shift in flora and expansion of mesic dominants onto more open slopes at high elevations justifies separating it. The Northern Hardwood type remains a broad category and may warrant further splitting.

In the southern part of the mountains, beyond the geographic range of spruce and fir, Northern Hardwood Forests may occupy large areas on high peaks. In addition to elevation and topographic position, soil factors may be important in determining occurrence of Northern Hardwoods in some areas. Rohrer (1983) noted that substrate (metabasalt vs. arkose) shifted the boundary between this type and High Elevation Red Oak Forest. This may be an effect either of nutrient status or of soil texture modifying the moisture regime.

The name "northern hardwood forest", traditionally given to these communities, implies a similarity to hardwood forests of the northern Appalachians. Many tree, herb, and shrub species are shared; however, our Northern Hardwood Forest has evolved under different climatic regimes, with a different phytogeographic history, and has many plant and animal species endemic to the southern Appalachians. It is clearly not the same natural community type as the forests of the northern United States.

Rare Plant Species: Vascular -- Abies fraseri, Acer saccharum var. viride, Aconitum reclinatum, Agastache scrophulariifolia, Botrychium oneidense, Bromus ciliatus, Cardamine clematitis, Carex woodii, Chrysosplenium americanum, Cinna latifolia, Corallorhiza maculata, Dirca palustris, Disporum maculatum, Gentiana austromontana, Geum geniculatum, Glyceria nubigena, Ilex collina, Lilium grayi, Lycopodium dendroideum, Panax trifolius, Prenanthes roanensis, Prunus virginiana, Pyrola elliptica, Rhododendron vaseyi, Saxifraga caroliniana, Scutellaria saxatilis, Spiranthes ochroleuca, Stachys clingmanii, Stellaria corei, Streptopus roseus var. roseus; nonvascular -- Plagiochila austinii.

Synonyms:
SAF 25, 26, 27, and 24: Sugar Maple-Beech-Yellow Birch, Sugar Maple-Basswood, Sugar Maple, Hemlock-Yellow Birch (in part).
Upper Cove Forest (Whittaker 1956, Dickson 1980, McLeod 1988).
Beech-maple forest (Brown 1941).

Examples:
Great Smoky Mountain National Park, Swain and Haywood counties (Whittaker 1956, Pyle (1984). (Extensive virgin forests).
Middle Creek Research Natural Area and other sites in the Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981, McLeod 1988, Valentine (1983) (Reportedly virgin forests).
Roan Mountain Massif, Pisgah and Cherokee National Forests, Avery and Mitchell counties, N.C. and Carter County, Tenn.
Craggy Mountains, Pisgah National Forest and Blue Ridge Parkway, Buncombe County (Heiman and Smith in prep.).

Grandfather Mountain, Avery and Watauga counties.

References: Abel (1934), Boufford and Wood (1975), Brown (1941), Davis (1930), Dickson (1980), Govus (1985), Heiman and Smith (In prep.), McLeod (1981), McLeod (1988), Rohrer (1983), Stamper (1976), Whigham (1969), Whittaker (1956).

Sample Plant Communities:
Acer saccharum/Acer saccharum/Prunus virginiana/Impatiens pallida-Mixed tall mesic forbs.
A. saccharum/Impatiens pallida-Mixed tall mesic forbs.
A. saccharum-Acer rubrum/A. saccharum transgressives/Dennstaedtia punctilobula-Mixed herbs.
A. saccharum-Mixed oaks and northern hardwoods/Mixed tall mesic forbs.
A. saccharum/Mixed herbs.
Aesculus flava (octandra)/Monarda didyma.
Aesculus flava/Mixed tall mesic herbs.
Betula lenta/Rudbeckia laciniata.
B. lenta/Mixed herbs.
Betula alleghaniensis (lutea).
Betula alleghaniensis/A. spicatum/Dryopteris campyloptera-Impatiens pallida.
Betula alleghaniensis/Amelanchier arborea.
Betula alleghaniensis/Mixed tall herbs.
Betula alleghaniensis/Ageratina altissima var. roanensis (Eupatorium rugosum).
Betula alleghaniensis/Impatiens pallida.
Betula alleghaniensis/Oxalis montana (acetosella)/Mixed mosses.
Betula alleghaniensis/Thelypteris noveboracensis.
Betula alleghaniensis/Mixed graminoids.
Betula alleghaniensis/Mixed ferns.
Betula alleghaniensis/Mixed tall herbs.
Betula alleghaniensis-Mixed northern hardwoods/Mixed tall mesic herbs.
Fagus grandifolia.
F. grandifolia/Aster sp.-Mixed herbs.
F. grandifolia/Vaccinium erythrocarpum.
F. grandifolia/Viburnum lantanoides (alnifolium).
F. grandifolia/Claytonia caroliniana.
F. grandifolia/Ageratina altissima var. roanensis-Rudbeckia laciniata.
F. grandifolia/Mixed tall ferns.
F. grandifolia/Mixed tall herbs.
F. grandifolia-Aesculus flava/Mixed herbs.
F. grandifolia-Betula alleghaniensis/Rhododendron calendulaceum.
Mixed northern hardwoods/Acer pensylvanicum.
Mixed northern hardwoods/Acer spicatum.
Mixed northern hardwoods/Mixed small trees and shrubs/Mixed tall mesic herbs.
Mixed northern hardwoods/Rhododendron maximum.
Mixed northern hardwoods/Ribes glandulosum.
Mixed northern hardwoods/Mixed tall ferns.
Mixed northern hardwoods/Mixed tall herbs.

NORTHERN HARDWOOD FOREST (Beech Gap Subtype)

Sites: High elevations, within the elevational range of spruce-fir forests. Primarily in south-facing gaps, but may occur on exposed ridgetops in areas lacking spruce and fir or adjacent to Grassy Balds.

Soils: Probably generally the Burton series (Typic Haplumbrept).

Hydrology: Terrestrial, mesic due to low temperatures and high rainfall.

Vegetation: Open or closed canopy of stunted trees, generally with a dense herb layer and little understory or shrub layer development. Fagus grandifolia is the most typical canopy species, though Aesculus flava (octandra) or Betula alleghaniensis (lutea) sometimes occur. Typical herbs include Carex pensylvanica, Carex aestivalis, C. debilis, C. intumescens, C. artitecta, Ageratina altissima var. roanensis (Eupatorium rugosum), Poa alsodes, Impatiens pallida, Laportea canadensis, Trillium erectum, Erythronium umbilicatum ssp. monostolum, Dryopteris campyloptera, Prenanthes altissima, Arisaema triphyllum, Anemone quinquefolia, Prenanthes roanensis, and Epifagus virginiana.

Dynamics: These communities are apparently stable climaxes under current climatic conditions. Trees may be quite old, although small. The forest may be periodically damaged by severe wind or ice storms. These sites are marginal 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.

Range: Scattered throughout the high mountains.

Associations: Grades into Northern Hardwood Forest (Typic Subtype), High Elevation Red Oak Forest, Red Spruce, Red Spruce--Fraser Fir Forest, or Grassy Bald.

Distinguishing Features: Northern Hardwood Forests may be distinguished from High Elevation Red Oak, and Red Spruce--Fraser Fir Forests by the predominance of the mesophytic tree species listed above over Quercus rubra, Picea rubens, or Abies fraseri. They are distinguished from Boulderfield Forests by occurring on soil rather than loose boulders, having most plants rooted in soil, and by differences in species composition.

The Beech Gap Subtype is distinguished by the dwarfed or stunted canopy trees, depauperate species composition, and high elevation. It grades to the ridge phase of the Typic Subtype, which, however, has normal tree stature, is somewhat more diverse, and occupies lower, less exposed sites. It may be difficult precisely to define the amount of dwarfing necessary to consider a community a Beech Gap. Well developed Beech Gaps are striking with their distinctive structure and appearance, indicative of an unusual environment.

Variation: Size of canopy and its density vary. In the most extreme cases the tree canopy may be reduced to shrub size. Aesculus octandra tends to occur where seepage is present.

Comments: This subtype represents a subset of the Wind Forest category of the Second Approximation. The rest of what was included in Wind Forest is combined with High Elevation Red Oak Forest or Northern Hardwood Forest (Typic Subtype).

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 and high winds were responsible for the occurrence of Beech Gaps. Fuller (1977) suggested several other factors, including allelopathic effects of beech litter on spruce and seed predation under beech litter.

Rare Plant Species: Vascular -- Lilium grayi, Platanthera grandiflora, Spiranthes ochroleuca, Streptopus roseus var. roseus.

Synonyms:
Beech Gap (Russell 1953).

Bald (local usage and some maps).
Wind Forest (Second Approximation, in part).

Examples:
Great Smoky Mountains National Park, Swain and Haywood counties (Whittaker 1956, Pavlovic 1981, Russell 1953, Fuller 1977) (extensive areas in virgin condition).
Craggy Mountains, Buncombe County.
Balsam Mountains, Transylvania and Haywood counties (Boufford and Wood 1975).

References: Boufford and Wood (1975), Fuller (1977), Pavlovic (1981), Russell (1953), Whittaker (1956).

Sample Plant Communities:
Fagus grandifolia/Carex pensylvanica.
F. grandifolia/Mixed Carex spp.
F. grandifolia-Aesculus flava (octandra)/Mixed herbs.
F. grandifolia/Epifagus virginiana
F. grandifolia-Betula alleghaniensis (lutea)/Mixed Carex spp.

BOULDERFIELD FOREST

Sites: Boulderfields at medium to high elevation. Relict periglacial boulder fields tend to occur in high, steep, north-facing coves, which have a cool microclimate.

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

Hydrology: Generally mesic due to cool microclimate, but varies widely with microsite. Seepage water flows under the rocks in some areas, producing wet sites. Microhabitats on bare rock without seepage are dry.

Vegetation: Closed to somewhat open canopy, usually strongly dominated by Betula alleghaniensis (lutea), sometimes with Aesculus flava (octandra) or Tilia americana var. heterophylla. Small numbers of other typical northern hardwoods or Picea rubens may occur. The shrub Ribes glandulosum is characteristic of these communities. Other common shrubs are Ribes rotundifolium, Ribes cynosbati, Viburnum lantanoides (alnifolium), and Acer spicatum. In general the rocks are densely covered with moss, and herbs such as Polypodium virginianum, Cystopteris protrusa, and Oxalis montana (acetosella) are sparse. Where water is present among the rocks, lush beds of herbs such as Chelone lyonii, Circaea alpina, Rudbeckia laciniata, Impatiens pallida, Monarda didyma, and Diphylleia cymosa occur.

Dynamics: The Southern Appalachian boulderfields are apparently relict, created by periglacial action in the Pleistocene. Weathering and soil accumulation might be expected to eventually turn these communities into Northern Hardwoods (Typic Subtype), but their persistence since the Pleistocene suggests that they are essentially stable over long periods of time. Soil development is either very slow or is inhibited. The rapid drainage of water through the boulders would be expected to prevent rapid weathering, and may carry away accumulating mineral and organic material.

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 alleghaniensis to germinate and establish on top of logs and rocks allows it to dominate in this unique environment.

Range: Scattered throughout the high mountains, but fairly uncommon.

Associations: Grades to Northern Hardwood Forest (Typic Subtype), High Elevation Red Oak Forest, Red Spruce--Fraser Fir Forest, or other high elevation communities, occasionally to Rich or Acidic Cove Forest.

Distinguishing Features: Boulderfield Forests are distinguished from all other communities by their distinctive environment, structure, and vegetation. Their flora is a small subset of the species of the Northern Hardwood Forest which are adapted to this unique environment. At the highest elevations, boulderfields occur which are dominated by Picea rubens and Abies fraseri. These are considered part of the Red Spruce--Fraser Fir Forest type, since their species composition is so similar to other examples of that type.

Variation: Varies with amount of water seeping or flowing among the rocks, and with gradation to adjacent communities. Two distinct variants, with and without significant seepage, are recognized.

Comments: Boulderfield Forests were included under Northern Hardwoods Forest in the Second Approximation. They appear, however, to be distinctive enough to be a separate type. When well developed, the aspect of large trees and moss-covered boulders and the distinctive species composition are striking.

Rare Plant Species: Vascular -- Aconitum reclinatum, Cardamine clematitis, Conioselinum chinense, Disporum maculatum, Geum geniculatum, Meehania cordata, Stellaria corei.

Synonyms:
boulder field, talus slope Northern Hardwoods Forest (Second Approximation--in part).

Examples:

Steestachee and Wesner Balds, Balsam Mountains, Blue Ridge Parkway, Haywood County.
Grandfather Mountain, Watauga and Avery counties.
Great Smoky Mountains National Park, Swain and Haywood counties.
Shining Rock Wilderness, Haywood County.
Big Butt Mountain, Brush Fence Ridge, Pisgah National Forest, Buncombe County (Heiman and Smith, in prep.).
Long Hope Falls, Ashe County.
Bluff Mountain, Ashe County.

References: Boufford and Wood (1975), Chafin and Jones (1989), Govus (1985), Heiman and Smith (In prep.), Whittaker (1956).

Sample Plant Communities:
Aesculus flava (octandra)/Monarda didyma.
Betula alleghaniensis (lutea).
Betula alleghaniensis/Ribes glandulosum.
Betula alleghaniensis/Oxalis montana (acetosella)/Mixed mosses.
Betula alleghaniensis/Mixed mosses.

RICH COVE FOREST

Sites: Sheltered, mesic, low to moderate elevation sites, primarily broad coves and lower slopes.

Soils: Rich, generally circumneutral. May be quite rocky but generally deep. Series mapped include Ashe (Typic Dystrochrept), Porters (Umbric Dystrochrept), and Tusquitee (Humic Hapludult).

Hydrology: Terrestrial, mesic.

Vegetation: Dense forest canopy with a diverse mixture of mesophytic trees, including Liriodendron tulipifera, Tilia americana var. heterophylla, Acer saccharum, Aesculus flava (octandra), Betula lenta, Magnolia acuminata, Prunus serotina, Tsuga canadensis, Fraxinus americana, Fagus grandifolia, and Halesia tetraptera (carolina). The open understory includes Cornus florida, Carpinus caroliniana, Magnolia tripetala, M. fraseri, Ostrya virginiana, Acer spicatum, A. pensylvanicum, and Asimina triloba. The open to sparse shrub layer may include Hydrangea arborescens, Lindera benzoin, Calycanthus floridus, and Cornus alternifolia. The herb layer is lush and very diverse. A partial list of typical species includes Cimicifuga racemosa, Trillium erectum, Caulophyllum thalictroides, Impatiens pallida, I. capensis, Laportea canadensis, Adiantum pedatum, Polystichum acrostichoides, Ageratina altissima var. roanensis (Eupatorium rugosum), Hepatica acutiloba, Asarum canadense, Viola spp., Stellaria pubera, Tiarella cordifolia var. cordifolia, Galium triflorum, Actaea pachypoda, Podophyllum peltatum, Clintonia umbellulata, Sedum ternatum, Mitella diphylla, Osmorhiza claytonii, Dryopteris intermedia, Arisaema triphyllum, Cystopteris protrusa, Trillium grandiflorum, Viola canadensis, Dicentra canadensis, Dicentra cucullaria, Hydrophyllum canadense, Hydrophyllum virginianum, and Carex spp.

Dynamics: These communities are naturally relatively stable, uneven-aged climax forests, with trees up to several centuries old. Tree reproduction occurs in canopy gaps. Production of gaps is continuous but variable, with more trees established following disturbances that kill a number of canopy trees. Lorimer (1980), working in virgin cove and hemlock forests at Joyce Kilmer Memorial Forest, estimated that the average canopy mortality in a decade was 5.5%, with 3.8% in non-disturbance decades and up to 14% in decades with major disturbances. 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. He noted that many of these gaps were large enough to allow shade-intolerant trees such as Liriodendron and Betula alleghaniensis to reproduce. Wind is the most likely natural disturbance to produce gaps. Fire seems unlikely in these moist sites, but could occur at rare intervals and contribute to natural disturbances.

With heavy logging, shade intolerant species, particularly Liriodendron and Robinia pseudoacacia, increase. Logging may lead to proliferation of shrubs and reduction in the herb layer, causing this type to resemble an Acidic Cove Forest. 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.

Range: Fairly widespread throughout the Mountain region and foothills.

Associations: Grades upward into Chestnut Oak, High Elevation Red Oak, Montane Oak--Hickory, or Montane White Oak Forests on open slopes. May grade into Canada Hemlock Forest or Acidic Cove Forest within mesic sites. Grades upward to Northern Hardwood Forest in higher elevation mesic sites. May grade to Montane Alluvial Forest along rivers. May be associated with Montane Acidic, Mafic, or Calcareous Cliff communities.

Distinguishing Features: Rich Cove Forests are recognized by the dominance of a diversity of mesophytic trees, including those of rich sites, and the lush, diverse herb layer. The Acidic Cove Forest, which may occur in apparently similar sites, is dominated by the more acid-tolerant subset of the rich cove species, and has undergrowth dominated by ericaceous shrubs rather than herbs. The Canada Hemlock Forest is dominated by Tsuga canadensis. Rich Cove Forests are distinguished from the wetter Montane Alluvial Forests by their higher diversity, prominence of the herb layer, and the absence of alluvial species such as sycamore and river birch.

Both Whittaker (1956) and McLeod (1988) placed great emphasis on the broad transition between cove forests and drier

oak forest communities. This transition zone is the most diverse forest in the mountain, in terms of number of plant species. It is not made a separate type here. The boundary between Rich Cove Forest and adjacent oak communities is placed where the oaks begin to predominate over the mesophytic trees.

The boundary between the Rich Cove Forest and Northern Hardwoods types is one of the most difficult to define. Many species in all strata may be shared, and the transition is particularly gradual. It 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 elevation. Typical cove species not expected in Northern Hardwoods Forest include Liriodendron tulipifera, Magnolia fraseri, M. acuminata, Ostrya virginiana, and Cornus florida. Northern Hardwood Forest species uncommon in Rich Cove Forest are fewer, but include Viburnum lantanoides (alnifolium), Rhododendron catawbiense, and Picea rubens.

Variation: The large number of species makes possible many segregates of the codominant species and total flora in response to differences in environment, geographic location, and history. While the variations have not been well studied, several situations which possibly support distinctive Cove Forest variants are: low elevation areas in the Blue Ridge escarpment and foothills; gorges in the high-rainfall southern escarpment gorges; sites with calcareous substrates such as marble or amphibolite; particularly rocky and seepy sites; and high elevation sites transitional to Northern Hardwoods. Much variation may be expected in the transition to other community types.

Comments: This community type is one of the most well-known and recognized in the Mountains. It is characterized by the dominance of a diversity of mesophytic trees and by the lush, diverse herb layer. The high diversity in all strata makes it of great interest to botanists and ecologists.

The Rich Cove and Acidic Cove forests were included in a single Cove Forest type in the Second Approximation. The distinction between the two has not generally been made in the literature, but has been recognized in field work by the authors and others. Often, researchers have sought out Rich Cove Forests and have ignored Acidic Cove Forests if Rich Cove Forests were present. The relationship between the two types is not well understood. Some Rich Cove Forests occur on mafic or calcareous rock substrates, but many occur on the same rock types as Acidic Cove Forest. Where the two types occur together, either may be up or downslope from the other. It appears that Acidic Cove Forests are more likely to occur on convex slopes, whether they are on low ridges or in narrow ravines. This may be significant for the internal drainage of nutrient- rich soil water into these sites. Although heavy human disturbance may cause a Rich Cove Forest to become depauperate and to resemble an Acidic Cove Forest, many Acidic Cove Forests are known in inaccessible places that are unlikely to have had such disturbance.

Rare Plant Species: Vascular -- Acer saccharum var. viride, Aconitum reclinatum, Adlumia fungosa, Agastache scrophulariifolia, Allium burdickii, Arabis glabra, Botrychium jenmanii, Botrychium lanceolatum var. angustisegmentum, Botrychium matricariifolium, Botrychium oneidense, Calystegia catesbiana ssp. sericata, Cardamine dissecta, Carex albursina, Carex austrocaroliniana, Carex baileyi, Carex leptonervia, Carex manhartii, Carex pedunculata, Carex projecta, Carex sparganioides, Carex umbellata, Carex woodii, Caulophyllum giganteum, Chrysosplenium americanum, Coeloglossum viride var. virescens, Collinsonia verticillata, Corallorhiza maculata, Corallorhiza wisteriana, Coreopsis latifolia, Delphinium exaltatum, Diplazium pycnocarpon, Disporum maculatum, Dryopteris goldiana, Elymus riparius, Euphorbia purpurea, Evonymus atropurpurea, Frasera caroliniensis, Galium lanceolatum, Geum geniculatum, Helianthus glaucophyllus, Heuchera longiflora, Hexastylis rhombiformis, Hybanthus concolor, Hydrastis canadensis, Isotria medeoloides, Jeffersonia diphylla, Juglans cinerea, Liparis loeselii, Lysimachia fraseri, Meehania cordata, Pachysandra procumbens, Panax quinquefolius, Panax trifolius, Penstemon smallii, Phlox divaricata var. divaricata, Platanthera orbiculata, Polemonium reptans, Prunus virginiana, Ruercus imbricaria, Ranunculus allegheniensis, Silene ovata, Smilax biltmoreana, Stellaria corei, Synandra hispidula, Tilia americana var. americana, Trillium discolor, Trillium flexipes, Trillium pusillum var. 1, Trillium recurvatum, Trillium simile; nonvascular -- Entodon sullivantii, Hygrohypnum closteri, Plagiochila austinii.

Synonyms:
Mixed Mesophytic Forest (various usage).
SAF 25, 26, 27, 57, and 60: Sugar Maple-Beech-Yellow Birch, Sugar Maple-Basswood, Sugar Maple, Yellow Poplar, Beech-Sugar Maple (in part).
Examples:

Great Smoky Mountains National Park, Swain and Haywood County (Whittaker 1956).
Joyce Kilmer Memorial Forest, Nantahala National Forest, Graham County (Greenlee 1974; Tucker 1973; Lorimer 1980).
Middle Creek Research Natural Area, Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981, 1988, Valentine 1983).
Walker Cove Research Natural Area, Pisgah National Forest, Buncombe County (Dickson 1980).
Grandfather Mountain north slope, Avery and Watauga counties.
Redbank Cove, Blue Ridge Parkway, Haywood County (Pittillo and Govus 1978).
Whitewater Falls, Nantahala National Forest, Transylvania County.
Upper Bowlens Creek, Black Mountains, Pisgah National Forest, Yancey County.
Bluff Mountain, Ashe County (Weakley, Mehrhoff, and Mansberg 1979)
Joe Bryson Branch Natural Area, Nantahala National Forest, Macon County (Lee 1978).

References: Bratton (1978), Buckner and McCracken (1978), Cooper and Hardin (1970), Dickson (1980), Feil (1988), Greenlee (1974), Lee (1978), Lorimer (1980, McLeod (1981), McLeod (1988), Pittillo and Govus (1978), Runkle and Yetter (1987), Valentine (1983), Weakley, Mehrhoff, and Mansberg (1979), Whittaker (1956).

Sample Plant Communities:
Acer saccharum/Mixed rich spring herbs.
A. saccharum-Aesculus flava (octandra)/Dicentra canadensis-Dicentra cucullaria.
Aesculus flava/Halesia tetraptera (carolina).
Aesculus flava/Ageratina altissima var. roanensis (Eupatorium rugosum).
B. lenta/Mixed herbs.
F. grandifolia/Mixed tall herbs.
Liriodendron tulipifera/Acer saccharum/Mixed herbs.
L. tulipifera/Lindera benzoin.
L. tulipifera/Mixed rich herbs.
L. tulipifera-Acer rubrum/Acer rubrum/Mixed herbs.
Mixed cove hardwoods.
Mixed cove hardwoods/Mixed cove hardwoods/Acer saccharum/Mixed herbs//Aristolochia macrophylla.
Mixed cove hardwoods/Mixed subcanopy trees/Mixed herbs.
Mixed cove hardwoods/Mixed rich spring herbs.
Tilia americana var. heterophylla/Mixed tall herbs.
Tilia americana var. heterophylla-Fraxinus americana/Mixed herbs.
Prunus serotina-Fraxinus americana/Mixed herbs.
Halesia tetraptera-Liriodendron tulipifera/Mixed herbs.

ACIDIC COVE FOREST

Sites: Sheltered low and moderate elevation sites, primarily narrow, rocky gorges, steep ravines, and low gentle ridges within coves.

Soils: Rocky, acidic. Series include Tusquitee (Humic Hapludult) and Ashe (Typic Dystrochrept).

Hydrology: Terrestrial, mesic.

Vegetation: Generally dense forest canopy with a fairly limited number of mesophytic tree species, primarily Liriodendron tulipifera, Betula lenta, Betula alleghaniensis (lutea), Tsuga canadensis, Acer rubrum, and Quercus rubra. The open understory may include Magnolia fraseri, Halesia tetraptera (carolina), and canopy species. The shrub layer is well developed, often forming a dense thicket. Rhododendron maximum and Leucothoe fontanesiana (axillaris var. editorum) are the most typical species. The herb layer is generally not well developed and consists of a few acid-loving species such as Galax urceolata (aphylla), Polystichum acrostichoides, Mitchella repens, Epigaea repens, Thelypteris noveboracensis, Arisaema triphyllum, Viola spp., Medeola virginiana, Maianthemum (Smilacina) racemosum, and Carex spp. Occasional individuals of typically Rich Cove Forest herbs may occur.

Dynamics: Less is known about these communities than about the Rich Cove Forests. They are probably generally a stable climax type, with treefall gaps being the typical natural disturbance regime. The discussion of the dynamics of Rich Cove Forests probably applies here too. Some Acidic Cove Forests may be the result of disturbance in Rich Cove Forests and may be successional to that type. The rocky, apparently acidic soil probably serves to prevent or slow invasion of most mesophytic tree species.

These communities often occur in narrow, steep gorges, the lower parts of which may occasionally be disturbed by floods. Such sites may be more sheltered from lightning than more open coves and slopes.

The importance of Liriodendron, a shade-intolerant species, in many of these communities may suggest some form of large scale disturbance, but Buckner and McCracken (1978) made a good argument for the ability of Liriodendron to regenerate in old growth forests where the falling of large trees creates very large gaps.

Range: Fairly widespread throughout the Mountain region and foothills.

Associations: May grade into Canada Hemlock Forest, Rich Cove Forest, or Montane Alluvial Forest. Grades uphill into Chestnut Oak, High Elevation Red Oak, Montane Oak--Hickory Forest, or Montane White Oak Forest on open slopes. May grade into Hemlock Forest. May grade upward to Northern Hardwoods Forest in high mesic sites.

Distinguishing Features: Acidic Cove Forests are distinguished from Rich Cove Forests by being dominated by the more acid-tolerant subset of the mesophytic species. The species listed above tend to dominate, and species such as Tilia americana var. heterophylla, Aesculus flava (octandra), Acer saccharum, Magnolia acuminata, Magnolia tripetala, and Asimina triloba are absent or rare. The dominance of a dense heath shrub layer and poorly developed herb layer is also a distinguishing feature. Similar criteria distinguish Acidic Cove Forests from Northern Hardwood Forests. Canada Hemlock Forests and various oak forests are distinguished by the canopy dominants. Canada Hemlock Forests have more than 67% of the canopy composed of Tsuga canadensis.

Acidic Cove Forests are distinguished from Montane Alluvial Forests and Swamp Forest-Bog Complexes, which may be dominated by some of the same species, by occurring on well-drained, non-flooded sites and lacking both alluvial species such as Platanus occidentalis and Carpinus caroliniana, and boggy openings and species such as Sphagnum. They are distinguished from Montane Acidic Cliffs and Granitic Domes by the presence of a potentially closed or nearly closed canopy.

Variation: Variation is not well known. Much variation may be expected in the transition to other community types.

Comments: This type was considered part of a single Cove Forest type in the Second Approximation. The distinction between Rich Cove and Acidic Cove Forest has not generally been made in the literature, though McLeod (1988) distin-

guished cove forests with hemlock and oaks from those without. The primary distinction is the lower diversity, with canopy dominants a small subset of the rich cove dominants. The ericaceous shrub layer and small group of acid-loving herb species is characteristic.

The topographic relationship between the two types is unclear. Acidic Cove Forest often tends to occur lower on steep slopes near streams in some sites, but in other places it occurs on gorge walls above Rich Cove Forest. It may also occur on alluvial flats. McLeod found that (rich) cove forest sites tended to have circumneutral soils even over typically acidic substrates. A topographic configuration such as a concave slope that collects runoff and soil water with bases leached from above may be the cause of the raised pH. Acidic Cove Forests, which more often occur on convex slopes and well-drained rocky sites, may not accumulate water flow from above.

The Acidic Cove Forest type is closely related to Canada Hemlock Forest and Montane Alluvial Forest, both of which also have relatively species-poor composition and often prominent shrub layers.

Rare Plant Species: Vascular -- Calystegia catesbiana ssp. sericata, Cardamine rotundifolia, Carex woodii, Chrysosplenium americanum, Coeloglossum viride var. virescens, Corallorhixa maculata, Geum geniculatum, Hexastylis contracta, Hexastylis rhombiformis, Isotria medeoloides, Liparis loeselii, Listera australis, Lygodium palmatum, Lysimachia fraseri, Meehania cordata, Panax quinquefolius, Panax trifolius, Platanthera orbiculata, Shortia galacifolia, Stewartia ovata, Trichomanes petersii, Trientalis borealis; nonvascular -- Brachymenium andersonii, Brachymenium systylium, Brachythecium rotaeanum, Bryocrumia vivicolor, Bryoxiphium norvegicum, Ditrichum ambiguum, Drepanolejeunea appalachiana, Entodon sullivantii, Lophocolea muricata, Macrocoma sullivantii, Mnium carolinianum, Nardia lescurii, Plagiochila austinii, Plagiochila caduciloba, Plagiochila echinata, Radula sullivantii, Schlotheimia lancifolia.

Synonyms:
Mixed Mesophytic Forest.
SAF 57 and 58: Yellow Poplar and Yellow Poplar-Eastern Hemlock.

Examples:
Corbin Creek area, Whitewater Gorge, Nantahala National Forest, Transylvania County.
Great Smoky Mountains National Park, Swain and Haywood County.
Dismal Falls Natural Area, Pisgah National Forest, Transylvania County.
Garden Creek Natural Area, Stone Mountain State Park, Wilkes County.
Wolf Creek Biology Preserve, Jackson County.

References: Buckner and McCracken (1978), Cooper and Hardin (1970), Day and Monk (1974), McLeod (1988), Rodgers and Shake (1965), Tucker (1973), Whittaker (1956).

Sample Plant Communities:
A. rubrum-B. alleghaniensis (lutea)/Mixed herbs.
Betula lenta/Hamamelis virginiana/Rhododendron maximum.
B. lenta/Rhododendron maximum.
B. lenta-Liriodendron tulipifera/Tsuga canadensis/Shortia galacifolia.
B. lenta-L. tulipifera/Rhododendron maximum.
Betula alleghaniensis.
F. grandifolia/Rhododendron maximum.
F. grandifolia/R. maximum/Leucothoe fontanesiana (axillaris var. editorum).
F. grandifolia/Mixed tall ferns.
Liriodendron tulipifera/Acer saccharum/Mixed herbs.
L. tulipifera/R. maximum.
L. tulipifera-Acer rubrum/Acer rubrum/Mixed herbs.
Mixed cove hardwoods/Rhododendron maximum.
Mixed cove hardwoods and conifers/Mixed cove hardwoods/Rhododendron maximum/Shortia galacifolia.

CANADA HEMLOCK FOREST

Sites: Sites slightly less mesic than Cove Forest sites, including open valley flats, slopes above Cove Forests, sheltered low ridges, narrow ravines, and open north-facing slopes at fairly high elevations.

Soils: Very acidic, usually rocky, upland soils. Series include Ashe (Typic Dystrochrept), Edneyville (Typic Dystrochrept), and Porters (Umbric Dystrochrept).

Hydrology: Terrestrial, mesic.

Vegetation: Dense forest dominated by Tsuga canadensis, with small amounts of other Cove Forest trees. Rarely may be dominated by Tsuga caroliniana or a mixture. Undergrowth is generally a dense thicket of Rhododendron maximum, alone or with Kalmia latifolia or Leucothoe fontanesiana (axillaris var. editorum). Herbs are few. Sometimes the shrub layer is more open, with species such as Hamamelis virginiana, Evonymus americana, Vaccinium stamineum, Viburnum lantanoides (alnifolium), Stewartia ovata, and other low shrubs. Typical herb species include Mitchella repens, Viola rotundifolia, Tiarella cordifolia, Aster cordifolius, Medeola virginica, Cimicifuga racemosa, Thalictrum clavatum, Polystichum acrostichoides, Dryopteris intermedia, Thelypteris noveboracensis, Dennstaedtia punctilobula, and Uvularia sessilifolia.

Dynamics: These communities are naturally relatively stable, uneven-aged climax forests, with trees up to several centuries old. Tree reproduction occurs in canopy gaps. Production of gaps is continuous but variable, with more trees established following disturbances that kill a number of canopy trees. Lorimer (1980), working in virgin cove and hemlock forests at Joyce Kilmer Memorial Forest, estimated that the average canopy mortality in a decade was 5.5%, with 3.8% in non-disturbance decades and up to 14% in decades with major disturbances. 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. He noted that many of these gaps were large enough to allow shade-intolerant trees such as Liriodendron and Betula alleghaniensis (lutea) to reproduce. Wind is the most likely natural disturbance to produce gaps. Fire seems unlikely in these moist sites, but could occur at rare intervals and contribute to natural disturbances.

Range: Throughout the Blue Ridge and on north-facing river bluffs in the upper Piedmont as far east as Stokes County.

Associations: Grades to Acidic Cove Forest, Northern Hardwood Forest, Montane Oak--Hickory Forest, Chestnut Oak Forest, High Elevation Red Oak Forest, or Red Spruce Forest, often fairly sharply. It appears that the change in environment caused by hemlock dominance, especially when associated with Rhododendron, excludes or suppresses many other species, thus sharpening the boundary.

Distinguishing Features: Canada Hemlock Forests are distiguished from Rich Cove Forests, Acidic Cove Forests, Northern Hardwood Forests, and other upland forests by the dominance of Tsuga canadensis. They are distinguished from Montane Alluvial Forests and Swamp Forest-Bog Complexes, which may be dominated by hemlock, by occurring on well-drained, non-flooded sites and lacking both alluvial species such as Platanus occidentalis and Carpinus caroliniana, and boggy openings and species such as Sphagnum. The rare stands of Tsuga caroliniana on mesic valley sites are also included in this type.

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. The mesic valley Carolina hemlock forest, which are tentatively included in this type, are also clearly a distinct variant.

Comments: Canada Hemlock Forests are generally low in species diversity, especially in the herb layer. McLeod (1988) reported an average species richness of 28.9/0.1 ha in the Black Mountains and noted that about half of the species present were woody. Oosting and Billings (1939) suggest that the marked acidity of the soil caused by the hemlocks may exclude other species. Whittaker (1956) notes that many species populations have a break or a dip in their normally continuous distribution patterns corresponding to the hemlock forest, from which they are partially or completely excluded.

These communities are widespread in the mountains. Because many occur in steep, inaccessible gorges, a number of virgin or old-growth examples remain. Most, however, are small.
Whittaker described the hemlock forests of the Smokies as merging with cove forests below 2500 feet and becoming mixed with hardwoods. This may refer to the mixed forests that are now classified as Acidic Cove Forests.

While Tsuga caroliniana usually occurs higher on slopes than T. canadensis, occasional stands are known in valley bottoms in the South Toe River drainage. McLeod's (1988) analysis of vegetation data found that valley Carolina hemlock stands were distinct from those on bluffs and slopes, and in various ways more resembled Canada Hemlock Forests. They are therefore tentatively included in this type.

Rare Plant Species: Vascular -- Hexastylis contracta, Hexastylis rhombiformis, Meehania cordata.

Synonyms:
SAF 23: Eastern Hemlock (in part).
Eastern Hemlock Forest (Whittaker 1956, McLeod 1988).

Examples:
Great Smoky Mountains National Park, Swain and Haywood counties (Whittaker 1956, Pyle 1985) (Extensive examples in virgin and old-growth condition occur in the park, especially in the Cataloochee area).
Joyce Kilmer Memorial Forest, Nantahala National Forest, Graham County (Oosting and Bordeau 1955, Tucker 1973, Lorimer 1980) (virgin forest).
Middle Creek Research Natural Area and other sites in the Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981, McLeod 1988).
Douglas Falls, Craggy Mountains, Pisgah National Forest, Buncombe County.
Henry Wright Preserve, Macon County(virgin forest).
Linville Falls and Gorge, Blue Ridge Parkway and Pisgah National Forest, Burke County.
Santeetlah Creek Bluffs proposed Research Natural Area, Nantahala National Forest, Graham County.
Piney Knob Fork Natural Area, Nantahala National Forest, Macon County.

References: DeLapp and Wentworth (1977), Feil (1988), Govus (1985), McLeod (1981), McLeod (1988), Oosting and Billings (1939), Oosting and Bordeau (1955), Pyle (1984), Runkle (1982), Tucker (1973), Valentine (1983), Weakley and Dickerson (1979), Whittaker (1956).

Sample Plant Communities:
T. canadensis/Rhododendron maximum.
T. canadensis/Rhododendron maximum/Gaylussacia ursina.
T. canadensis/Rhododendron maximum/Galax urceolata (aphylla).
T. canadensis/Rhododendron maximum/Leucothoe fontanesiana (axillaris var. editorum).
T. canadensis/Mitchella repens.
Tsuga canadensis.
T. canadensis/Gaylussacia ursina.
T. canadensis/Kalmia latifolia.
T. canadensis/Mixed tall ferns.
T. canadensis/Mixed tall forbs.
T. canadensis-Pinus strobus/Magnolia fraseri-Betula lenta/Rhododendron maximum-Leucothoe fontanesiana.
T. canadensis-Tsuga caroliniana/Rhododendron maximum/Mitchella repens.
T. canadensis-Quercus montana (prinus)/Kalmia latifolia.

MESIC MIXED HARDWOOD FOREST (Piedmont Subtype)

Sites: Lower slopes, steep north-facing slopes, ravines, and occasionally well- drained small stream bottoms, on acidic soils.

Soils: Deep, well-drained, somewhat acidic soils. Series include Cecil, Georgeville, Pacolet, Tatum, Wedowee (Typic Hapludults), Tallapoosa (Ochreptic Hapludult), and Louisburg (Ruptic-Ultic Dystrochrept).

Hydrology: Terrestrial, mesic.

Vegetation: Canopy dominated by mesophytic trees such as Fagus grandifolia, Quercus rubra, Liriodendron tulipifera, Acer rubrum, A. saccharum, and in the western Piedmont, Tsuga canadensis. Typical understory trees include Cornus florida, Ostrya virginiana, Acer rubrum, and Ilex opaca. Shrub species may include Vaccinium stamineum, Viburnum rafinesquianum, Evonymus americana, and sometimes Kalmia latifolia. The herb layer is often moderately dense and diverse, though it may be sparse under heavy shade. Herb species may include Polystichum acrostichoides, Viola spp., Dichanthelium (Panicum) spp., Galium circaezans, Hexastylis arifolia, H. minor, Desmodium nudiflorum, Erythronium umbilicatum ssp. umbilicatum, Hepatica americana, Chamaelirium luteum, Epifagus virginiana, Tiarella cordifolia var. collina, Heuchera americana, Stellaria pubera, Podophyllum peltatum, Botrychium virginianum, and Prenanthes serpentaria.

Dynamics: Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms may allow pulses of increased regeneration and allow the less shade-tolerant species to remain in the community. However, Skeen, Carter, and Ragsdale (1980) argued that even the shade-intolerant Liriodendron could reproduce enough in gaps to persist in the climax Piedmont forests.

The natural fire regime of the Piedmont is not known, but fires certainly occurred periodically. Because Mesic Mixed Hardwood Forests generally occur in moist and topographically sheltered sites, they probably burned only rarely and with low intensity.

Disturbed areas have increased amounts of pines and weedy hardwoods such as Liriodendron tulipifera and Liquidambar styraciflua. Many areas have been selectively cut many times and have increased importance of Fagus grandifolia and other noncommercial hardwoods relative to oaks.

Range: Throughout the Piedmont, possibly in lower parts of the Blue Ridge.

Associations: Grades into Piedmont/Low Mountain Alluvial Forest or Piedmont/Mountain Bottomland Forest below. Grades into various upland communities above, typically Dry-Mesic Oak--Hickory Forest. May grade into Basic Mesic Forest at geologic contacts, or to Piedmont/Coastal Plain Acidic Cliff or Heath Bluff on steeper, rockier slopes.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition. Mesic Mixed Hardwood Forests are dominated by Fagus grandifolia, Quercus rubra, Liriodendron tulipifera, and other mesophytic trees. Oaks other than Q. rubra are not generally important. Mesic Mixed Hardwood Forests are distinguished from Alluvial and Bottomland Forest by the lack of bottomland trees and the presence of flood-intolerant trees. They sometimes may occur on the better drained parts of small stream bottoms. Mesic Mixed Hardwood Forests may be distinguished from Basic Mesic Forest by more acidic soils, absence of base-loving plants, sparser herb layer, and lower floristic diversity, especially in the herb layer. Species that typically indicate Basic Mesic Forests in Piedmont sites include Hybanthus concolor, Actaea pachypoda, Dicentra cucullaria, Dirca palustris, Delphinium tricorne, Trillium cuneatum, Hydrastis canadensis, and Cystopteris protrusa. Additional species, such as Asimina triloba, Lindera benzoin, Evonymus atropurpurea, Staphylea trifolia, Nemophila microcalyx, and Corydalis flavula, suggest Basic Mesic Forest where they occur on upland slopes.

Variation: Varies locally with position on slope and nature of soil. Western Piedmont sites often have increasing importance of Tsuga canadensis, Rhododendron spp., and other species more typical of the Blue Ridge region.

Comments: While not as extensive as the Oak--Hickory forests, Mesic Mixed Hardwood Forest communities are fairly common. Their occurrence on steep sites has allowed many of them to escape, until recently, with less disturbance than most

upland communities. Examples with old forest can be found.

Rare Plant Species: Vascular -- Aster mirabilis, Cardamine douglassii, Corallorhiza wisteriana, Evonymus atropurpurea, Galium uniflorum, Isotria medeoloides, Magnolia macrophylla, Panax quinquefolius, Panax trifolius, Phacelia ranunculacea; nonvascular -- Hygrohypnum closteri.

Synonyms:
Type II (Nehmeth 1968).
Mesic mesotrophic forest (Peet and Christensen 1980).
Mixed mesophytic forest (general usage).

Examples:
W.B. Umstead State Park, Wake County.
Eno River State Park, Orange and Durham County.
Caswell Upland Hardwood Forest Natural Area, Cherokee Scout Reservation, Caswell County.
Duke Forest, H.J. Oosting Natural Area, Korstian Division, Eno Division, and Durham Division, Orange and Durham County.
Birkhead Wilderness and other parts of Uwharrie National Forest, Randolph and Montgomery counties.
Rankin Hardwood Forest, Gaston County.
Raven Rock State Park, Harnett County.
Hill Demonstration Forest (Nehmeth 1968-Lower slope and ravine slope types).

References: LeGrand and Dalton (1987), Nehmeth (1968), Oosting (1942), Peet and Christensen (1980), Skeen, Carter, and Ragsdale (1980).

Sample Plant Communities:
Fagus grandifolia.
F. grandifolia/Mixed subcanopy hardwoods/Mixed herbs.
F. grandifolia/Mixed shrubs.
F. grandifolia-Mixed mesic hardwoods/Cornus florida-Mixed subcanopy hardwoods.
F. grandifolia-Mixed upland hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
F. grandifolia-Mixed mesic hardwoods/Kalmia latifolia.
F. grandifolia-Mixed mesic oaks and hickories.
Mixed mesic hardwoods.
Mixed mesic hardwoods/Cornus florida/Mixed herbs.
Mixed mesic hardwoods/Cornus florida-Mixed subcanopy hardwoods.
Quercus rubra-Fagus grandifolia/Mixed subcanopy.
Q. rubra-F. grandifolia/Ostrya virginiana-Mixed subcanopy hardwoods/Kalmia latifolia.
Q. rubra-Mixed mesic hardwoods/Cornus florida-Mixed subcanopy hardwoods/Mixed herbs.
Q. rubra-Mixed mesic hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
Liriodendron tulipifera/Cornus florida.

MESIC MIXED HARDWOOD FOREST (Coastal Plain Subtype)

Sites: Mesic upland areas protected from fire. Primarily on north-facing river bluffs and ravine slopes, less commonly on upland flats or islands surrounded by peatland or swamp communities.

Soils: Various moist upland soils. Series include Suffolk (Typic Hapludult), Kalmia (Typic Hapludult), Wagram (Arenic Paleudult), Onslow (Spodic Paleudult), Baymeade (Arenic Hapludult), Stallings (Aeric Paleudult), Craven (Aquic Hapludult), Winton (Aquic Hapludult), and Dogue (Aquic Hapludult).

Hydrology: Terrestrial, mesic.

Vegetation: Canopy of various mixtures of mesophytic trees such as Fagus grandifolia, Liriodendron tulipifera, Acer floridanum, Quercus alba, Q. rubra, and Liquidambar styraciflua. Trees such as Quercus michauxii, Q. pagoda (falcata var. pagodaefolia), and Carya ovata, more typical of Bottomland Hardwoods or Nonriverine Wet Hardwood Forest, are sometimes abundant. Trees from drier communities, such as Quercus alba, Q. falcata, and various Carya species, are also sometimes abundant. Understory species include Cornus florida, Ilex opaca, Ostrya virginiana, Oxydendrum arboreum, Carpinus caroliniana, Acer rubrum, Stewartia malacodendron, and Persea palustris. The shrub and herb layers range from sparse to dense and fairly diverse. Common shrub species include Symplocos tinctoria, Hamamelis virginiana, Arundinaria gigantea, and Vaccinium spp. Other shrubs include Evonymus americana, Gaylussacia frondosa, Callicarpa americana, Clethra alnifolia, and Aesculus sylvatica. Herb species include Polystichum acrostichoides, Athyrium filix-femina var. asplenioides, Mitchella repens, Chasmanthium (Uniola) laxum, Carex spp., Tipularia discolor, Medeola virginiana, and Epifagus virginiana.

Dynamics: Mesic Mixed Hardwood Forests generally occur on sites that are sheltered by topography and moisture from fire. Fires were probably much less frequent and intense than in most of the Coastal Plain uplands. Fire was probably an important factor in confining mesic, fire-intolerant vegetation to these sites.

Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms or severe fires may allow pulses of increased regeneration and allow the less shade-tolerant species to remain in the community.

Disturbed areas have increased amounts of pines and weedy hardwoods such as Liriodendron tulipifera and Liquidambar styraciflua. Like floodplain forests, some of these communities are susceptible to invasion by exotic species such as Lonicera japonica when disturbed.

Range: Throughout the Coastal Plain.

Associations: Usually bordered by Coastal Plain Bottomland Hardwoods, Cypress-- Gum Swamp, or Small Stream Swamp at slope base and Dry-Mesic Oak--Hickory Forest, Dry Oak--Hickory Forest, or Pine/Scrub Oak Sandhill above. May grade to Nonriverine Wet Hardwood Forest on flats.

Distinguishing Features: Mesic Mixed Hardwood Forests are distinguished from Basic Mesic Forests by having acidic rather than circumneutral to basic soils, a less well-developed herb layer, generally lower floristic diversity, and no or very few basic indicator species. Species that typically indicate Basic Mesic Forests in the Coastal Plain include Magnolia tripetala, Dicentra cucullaria, Aquilegia canadensis, Sanguinaria canadensis, Asarum canadense, and Enemion (Isopyrum) biternatum. Additional species, such as Asimina triloba, Lindera benzoin, and Aesculus pavia suggest circumneutral or basic conditions when they occur on upland slopes.

Mesic Mixed Hardwoods are distinguished from Bottomland Hardwoods and Small Stream Swamps by having upland rather than wetland vegetation. Mesic Mixed Hardwood Forests on slopes are distinguished from Piedmont/Coastal Plain Acidic Cliff and Heath Bluff by having a closed or nearly closed tree canopy and lacking a dense evergreen heath shrub layer.

The distinction between Nonriverine Wet Hardwood Forest and Mesic Mixed Hardwood Forest on upland flats is often very difficult to make. While they are often vegetationally distinct, the characteristic dominants of each type may occur in the other. Small differences in microtopography may strongly affect species composition. In these cases, a site may have to be classified as the predominant type, with a warning that the community is truly a mixture.

A similar situation may occur with Dry-Mesic Oak--Hickory Forest. In general, dominance by Quercus alba and less mesic species indicates a Dry-Mesic Oak--Hickory Forest, while dominance by Fagus, Liriodendron, or more mesic oaks indicates Mesic Mixed Hardwoods. There may be situations where the canopy composition is ambiguous and classification may have to be based on lower strata of vegetation.

Variation: This is a very heterogeneous category because of the variety of mesic sites in the Coastal Plain. Frost, Schneider, and LeGrand (1990) recognized three categories in the northeastern corner of the state that fall within the Mesic Mixed Hardwood Forest (Coastal Plain Subtype). These are recognized as variants here:

1. Bluff/slope variant, with composition most similar to the Piedmont subtype, often containing a number of species of generally more northerly and westerly distribution.
2. Upland flat variant, transitional to Nonriverine Wet Hardwood Forest, often containing combinations of wetter and drier species as well as typical mesic species. Variation may be controlled by small microtopographic differences.
3. Swamp island variant, with somewhat lower diversity, a poorly developed herb layer, and more species of Coastal Plain and southern affinities.

Comments: Mesic forests in Virginia have been described by Ware (1978), DeWitt and Ware (1979) as related to the Southern Mixed Hardwoods Forest of Quarterman and Keever (1962) which occurred on the Coastal Plain farther south. Nesom and Treiber (1977) described the mesic forest in the North Carolina Coastal Plain as a topoedaphic climax, with floristic affinities to the Piedmont and Mountain mesic forests. It may be that with sufficient data both types of mesic forest could be distinguished among the communities in this category, and that this would be a better basis for dividing the subtypes than the current Coastal Plain/Piedmont split.

This subtype is not extremely rare, although it usually occurs in small areas. The Bluff/Slope Variant is not uncommon and slope steepness often makes it unsuitable for building, agriculture, and intensive forestry, although most or all examples have suffered some logging. Particularly high quality areas, old growth stands, and areas adjacent to other natural lands should be preserved. The swamp island variant is much rarer. The upland flat variant probably was once common in the northeastern part of the state but has been largely destroyed and is now extremely threatened.

Rare Plant Species: Vascular -- Lathyrus palustris, Listera australis, Malaxis spicata, Panax quinquefolius, Schisandra glabra, Trillium pusillum var. virginianum; nonvascular -- Brachythecium rotaeanum.

Synonyms:
Beech-Mixed Hardwoods (Nesom and Treiber 1977)
Beech bluffs, beech slopes, beech ravines (general usage, in part).
Southern Mixed Hardwood Forest (Ware 1978).
Upland Flats Mesic Hardwood Forest (mesic flat variant); Mesic Mixed Hardwood Forest, Swamp Island Subtype; Mesic Mixed Hardwood Forest, Bluff/Slope Subtype (Frost, Schneider, and LeGrand 1990).

Examples:
Bluff/Slope Variant:
Flanner Beach Natural Area, Croatan National Forest, Craven County (McDonald, Ash, and Fussell 1981).
Merchants Millpond State Park, Gates County (Frost 1982).
Camassia Slopes Preserve, Northampton County (Lynch 1981).
Cliffs of the Neuse State Park, Wayne County (Bruton 1968).
Otter Creek Natural Area, East Carolina University, Pitt County.

Swamp Island Variant:
Dismal Swamp Mesic Islands, Dismal Swamp National Wildlife Refuge, Gates County (Frost 1982).
Upper Waccamaw River Floodplain, Columbus County (Schafale, LeGrand, and Marty 1986; Marty 1988).

Upland Flat Variant:
Perquimans River Cherrybark Flats, Perquimans County (Frost, Schneider, and LeGrand 1990).
Merry Hill Mesic Hardwood Flats, Bertie County (Frost, Schneider, and LeGrand 1990).

References: Bruton (1968), DeWitt and Ware (1979), Frost (1982), Frost, Schneider, and LeGrand (1990), Hartshorn (1972), Lynch (1981), Lynch and Peacock (1982b), McDonald, Ash, and Fussell (1981), Marty (1988), Nesom and Treiber (1977), Peacock and Lynch (1982b), Quarterman and Keever (1962), Schafale, LeGrand, and Marty (1986), Ware (1978), Wells (1928).

Sample Plant Communities:
Mixed mesic hardwoods/Mixed mesic subcanopy hardwoods.
Mixed mesic Coastal Plain oaks/Mixed subcanopy/Mixed Coastal Plain shrubs.
Fagus grandifolia.
Fagus grandifolia/Ilex opaca.
Fagus grandifolia-Acer floridanum/Cornus florida-Ilex opaca/Mixed herbs.
Fagus grandifolia-mixed upland hardwoods/Kalmia latifolia.
Fagus grandifolia/Aesculus sylvatica/mixed mesic herbs.
Pinus taeda-Fagus grandifolia/Carpinus caroliniana-Mixed hardwoods.

BASIC MESIC FOREST (Piedmont Subtype)

Sites: Lower slopes, north-facing slopes, ravines, and occasionally well- drained small stream bottoms, with basic or circumneutral soils.

Soils: Deep, well-drained soils with circumneutral or higher pH. Series include Tatum (Typic Hapludult), Wilkes (Typic Hapludalf), and Louisburg (Ruptic-Ultic Hapludalf).

Hydrology: Terrestrial, mesic.

Vegetation: Canopy dominated by mesophytic trees, primarily Liriodendron tulipifera, Fagus grandifolia, Acer floridanum, and Quercus rubra. Trees typical of better drained bottomland sites, such as Quercus shumardii, Juglans nigra, and Celtis laevigata, may be present. Understory may include Cercis canadensis, Cornus florida, Ostrya virginiana, Carpinus caroliniana, Asimina triloba, and Ulmus rubra. Shrubs may include Viburnum spp., Lindera benzoin, Styrax grandifolia, Hydrangea arborescens, Evonymus atropurpurea, Staphylea trifolia, Calycanthus floridus, and Aesculus sylvatica. The herb layer is generally dense and very diverse, with species such as Polystichum acrostichoides, Asarum canadense, Actaea pachypoda, Menispermum canadense, Hepatica americana, Sanguinaria canadensis, Cimicifuga racemosa, Cypripedium pubescens (calceolus), Panax quinquefolius, Adiantum pedatum, Podophyllum peltatum, Tiarella cordifolia var. cordifolia, Viola spp., Hybanthus concolor, Dicentra cucullaria, Enemion (Isopyrum) biternatum, Delphinium tricorne, Trillium cuneatum, Lathyrus venosus, and Corydalis flavula.

Dynamics: Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms may allow pulses of increased regeneration and allow the less shade-tolerant species to remain in the community. However, Skeen, Carter, and Ragsdale (1980) argued that even the shade- intolerant Liriodendron could reproduce enough in gaps to persist in the climax Piedmont forests.

The natural fire regime of the Piedmont is not known, but fires certainly occurred periodically. Because Basic Mesic Forests generally occur in moist and topographically sheltered sites, they, like Mesic Mixed Hardwood Forests, probably burned only rarely and with low intensity.

Disturbed areas have increased amounts of pines and weedy hardwoods such as Liriodendron tulipifera and Liquidambar styraciflua. Like floodplain forests, these communities are susceptible to invasion by exotic species such as Lonicera japonica when disturbed.

Range: Scattered throughout the Piedmont, potentially in lower parts of the Blue Ridge.

Associations: Grades into Piedmont/Mountain Levee Forest, Bottomland Forest, or Alluvial Forest below. May grade into Basic Oak--Hickory Forest or Xeric Hardpan Forest above. May grade into Piedmont Mafic Cliff or Piedmont Calcareous Cliff on steeper, rockier slopes. May grade into Mesic Mixed Hardwood Forest or Dry-Mesic Oak--Hickory Forest on more acidic sites.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition. Mesic Mixed Hardwood Forests are dominated by Fagus grandifolia, Quercus rubra, Liriodendron tulipifera, and other mesophytic trees. In contrast to Oak--Hickory Forests, oaks less mesic than Q. rubra are not generally important in this community type.

The boundary with Alluvial or Bottomland Forests is more difficult to define by species composition. A number of species that are confined to bottomlands in acidic terrain, may occur on slopes on basic soils. The dominant species, however, will be upland species, and flood-intolerant species will usually be present.

Basic Mesic Forests are distinguished from cliff communities by having a naturally closed or nearly closed canopy. They are distinguished from the acidic Mesic Mixed Hardwood Forest by having circumneutral to basic soil pH, a denser herb layer, and greater floristic diversity, with base-loving plants and plants more characteristic of bottomlands. Species that typically indicate Basic Mesic Forests in Piedmont sites include Hybanthus concolor, Actaea pachypoda, Dicentra cucullaria, Dirca palustris, Delphinium tricorne, Trillium cuneatum, Hydrastis canadensis, and Cystopteris protrusa. Additional species, such as Asimina triloba, Lindera benzoin, Evonymus atropurpurea, Staphylea trifolia, Nemophila microcalyx, and Corydalis

flavula, more typical of rich alluvial sites, suggest Basic Mesic Forest where they occur on upland slopes.

Variation: Varies locally with position on slope and nature of soil. Mountain species become increasingly important in the western Piedmont. There are probably differences worthy of recognition as variants between sites on mafic rocks and those of calcareous rocks, but the latter sites are too rare in the Piedmont to have much information. Sites on metamorphosed graywacke or mudstone may be distinctive from both or may be intermediate between the two.

Comments: This type is similar to the Mesic Mixed Hardwoods community type. It differs in its occurrence over basic substrates and greater general species richness. Although basic soils and indicator vegetation are generally associated with mafic rocks, occasional examples occur on apparently acidic rocks. Likewise, many sites with mafic or intermediate rocks have communities indistinguishable from Mesic Mixed Hardwoods and should be placed in that type. The additional factors necessary to develop a Basic Mesic Forest are not known.

It should be noted that soils on lower slopes, even on acidic rocks, generally have a higher pH than those on upper slopes and ridgetops. This is possibly caused by accumulation of leached bases, and it makes the distinction between the effect of moisture status and nutrient status more difficult. Basic substrates appear to allow many lower slope and bottomland species to occur farther upslope, in apparently drier sites. Thus a Basic Mesic Forest community might extend farther upslope than the acidic equivalent, a Mesic Mixed Hardwoods Forest.

Because of the limited extent of basic rocks in the Piedmont, these communities are rare. The occurrence of these communities on steep slopes has allowed many of them to escape with less disturbance than many upland communities. The great floristic diversity of these communities makes them of particular botanical interest. They are often sites for rare and disjunct species.

Rare Plant Species: Vascular -- Aster mirabilis, Cardamine dissecta, Cardamine douglassii, Carex jamesii, Corallorhiza wisteriana, Delphinium exaltatum, Diplazium (Athyrium) pycnocarpon, Dirca palustris, Enemion (Isopyrum) biternatum, Evonymus atropurpurea, Heuchera caroliniana, Hybanthus concolor, Hydrastis canadensis, Lathyrus venosus, Philadelphus hirsutus, Philadelphus inodorus, Porteranthus (Gillenia) stipulatus, Ptelea trifoliata, Quercus muehlenbergii.

Synonyms:
Mesic Eutrophic Forest (Peet and Christensen 1980).
Postclimax (Oosting 1942) (in part).
Type II (Nehmeth 1968).

Examples:
Willie Duke's Bluff, Durham County (Sutter, Harrison, and Rettig 1988).
Sevenmile Creek Sugar Maple Bottom, Orange County (Sather and Hall 1988).
Upper Barton Creek, Lower Barton Creek, Old Still Creek natural areas, Falls Reservoir lands, Wake and Durham County.
PeeDee Gabbro Slopes, Richmond County.
Swift Creek Bluffs, Wake County (LeGrand and Dalton 1987)
Cane Creek Branch Slopes, Caswell County.
Bear Slide at Eden, Rockingham County.

References: Carter and LeGrand (1989), LeGrand (1986), LeGrand and Dalton (1987), Nehmeth (1968), Oosting (1942), Peet and Christensen (1980), Sather and Hall (1988), Skeen, Carter, and Rasdale (1980), Sutter, Harrison, and Rettig (1987), Weakley and Dickerson (1979), Wilson (1975).

Sample Plant Communities:
Acer floridanum/Mixed subcanopy/Lindera benzoin.
A. floridanum-Mixed bottomland hardwoods/Mixed subcanopy hardwoods/Mixed herbs//Lonicera japonica.
A. saccharum-Quercus rubra/Carpinus caroliniana-Asimina triloba/Mixed herbs.
Liriodendron tulipifera.
Liriodendron tulipifera/Mixed subcanopy/Lindera benzoin.
Liriodendron tulipifera-Mixed upland oaks/Mixed subcanopy hardwoods/Lindera benzoin/Caulophyllum thalictroides-Mixed

herbs.
Mixed mesic hardwoods.
Mixed mesic hardwoods/Cercis canadensis/Mixed herbs.
Mixed mesic hardwoods/Cornus florida/Mixed herbs.
Mixed mesic hardwoods/Cornus florida-Mixed subcanopy.
Mixed mesic hardwoods/Mixed subcanopy hardwoods.
Mixed mesic hardwoods/mixed subcanopy hardwoods/Mixed shrubs/Mixed herbs.
Mixed mesic hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
Mixed mesic hardwoods/Mixed shrubs.
Mixed mesic hardwoods/Mixed herbs.

BASIC MESIC FOREST (Coastal Plain Subtype)

Sites: Mesic upland areas, primarily north-facing slopes, with basic or circumneutral soil produced by outcrops of marl or deposits of basic alluvium.

Soils: Series mapped include Autryville (Arenic Paleudult), Craven (Aquic Hapludult), and Marvyn (Typic Hapludult), but these communities probably represent inclusions in these map units. Soils are probably Alfisols or Inceptisols.

Hydrology: Terrestrial, mesic.

Vegetation: Canopy of various mixtures of mesophytic trees including Fagus grandifolia, Acer floridanum, Liriodendron tulipifera, Carya cordiformis, Carya pallida, Quercus alba, Quercus shumardii, Ulmus americana, Juglans nigra, and Quercus michauxii. Understory trees may include Ostrya virginiana, Ilex opaca, Cornus florida, Carpinus caroliniana, Magnolia tripetala, and Asimina triloba. Shrubs include species such as Symplocos tinctoria, Lindera benzoin, Hamamelis virginiana, Evonymus americana, Asimina parviflora, and Viburnum spp. Herbs generally very diverse, with basophilic species and species typical of areas farther west in addition to more common mesophytic species such as those found in Mesic Mixed Hardwoods communities. These communities frequently contain a number of rare species.

Dynamics: Basic Mesic Forests generally occur on sites that are sheltered by topography and moisture from fire. Fires were probably much less frequent and intense than in most of the Coastal Plain uplands and were probably an important factor in controlling the extent of mesic vegetation.

Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms or severe fires may allow pulses of increased regeneration and allow the less shade-tolerant species to remain in the community.

Disturbed areas have increased amounts of pines and weedy hardwoods such as Liriodendron tulipifera and Liquidambar styraciflua. Like floodplain forests, these communities are susceptible to invasion by exotic species such as Lonicera japonica when disturbed.

Range: Scattered in the Coastal Plain, primarily in the area of marl outcrop in the eastern Coastal Plain south of the Neuse River but also on basic alluvial terraces along the Roanoke.

Associations: Often interspersed with Coastal Plain Marl Outcrop communities. Usually bordered by Bottomland Hardwoods, Cypress--Gum Swamp, or Small Stream Swamp at slope base and Dry-Mesic Oak--Hickory Forest above. May potentially grade into Mesic Mixed Hardwoods Forest with substrate change along the slope.

Distinguishing Features: Basic Mesic Forests are distinguished from the acidic Mesic Mixed Hardwoods by having circumneutral to basic soil pH, a denser herb layer, and greater floristic diversity. Species that typically indicate Basic Mesic Forests in the Coastal Plain include Magnolia tripetala, Dicentra cucullaria, Aquilegia canadensis, Sanguinaria canadensis, Asarum canadense, and Enemion (Isopyrum) biternatum. Additional species, such as Asimina triloba, Lindera benzion, and Aesculus pavia suggest circumneutral or basic conditions when they occur on upland slopes.

Basic Mesic Forests are distinguished from Coastal Plain Marl Outcrops by having a closed or potentially closed canopy of trees rooted within the community. Small Marl Outcrops may have a closed canopy above them but with its trees able to root only in rock crevices and in adjacent communities.

Basic Mesic Forests are distinguished from Dry-Mesic Oak--Hickory Forest and other drier upland communities by the dominance of mesophytic trees over drier site trees. Some species typical of bottomland Hardwoods, such as Quercus michauxii, Q. shumardii, Carpinus caroliniana, and Asimina triloba may also be present. The occurrence of bottomland species makes the boundary with floodplain communities more difficult to define. The boundary is placed where flooding ceases to be a significant environmental factor for the biota. In general, upland and flood-intolerant species will dominate in the Basic Mesic Forest.

Variation: Two distinctive variants are recognized:

1. Marl Outcrop Variant, on soils derived from or influenced by limestone.

2. Terrace Slope Variant, on slopes mantled with rich alluvial terrace material on the edges of floodplains.

Comments: The Coastal Plain subtype is generally distinct from the Piedmont subtype, and perhaps should be considered a separate type. There appears to be a geographic break between the two, and a regular difference in substrate. Most of the Piedmont sites are on mafic crystalline rocks, while most of the Coastal Plain sites are on limestone, which has a substantially different chemistry.

Both variants of this subtype are rare, because of the rarity of basic substrates on the Coastal Plain. The terrace slope variant is known from only four sites in North Carolina and appears to be limited to the Roanoke River valley.

Rare Plant Species: Vascular -- Camassia scilloides, Carex jamesii, Diplazium pycnocarpon, Enemion biternatum, Evonymus atropurpurea, Galium uniflorum, Hybanthus concolor, Phlox divaricata var. laphamii, Ptelea trifoliata, Sideroxylon (Bumelia) lycioides, Tilia americana var. caroliniana, Trillium sessile

Synonyms:
Mixed Mesophytic Forest (general usage, in part).
Terrace I Slopes (The river terrace subtype only--Lynch 1981).

Examples:
Marl Outcrop Variant
Island Creek, Jones County (Sears 1966).
New River Limestone Ravine, Onslow County.
Deep Creek Gully, Craven County (McDonald, Ash, and Fussell 1981).
Fort Barnwell, Craven County (McDonald, Ash, and Fussell 1981).

Terrace Slope Variant
Camassia Slopes, Halifax County (Lynch 1981).
Phlox Woods, Halifax County (Lynch 1981).
Larkspur Ridge, Halifax County (Lynch 1981).
Roanoke Big Oak Woods, Halifax County (Lynch 1981).

References: Lynch (1981), McDonald, Ash, and Fussell (1981), Sears (1966).

Sample Plant Communities:
Mixed mesophytic hardwoods/Mixed understory hardwoods/Mixed calciphilic herbs.

BASIC MESIC FOREST (Montane Calcareous Subtype)

Sites: Low elevation, sheltered, lower slopes on limestone, dolomite, or marble.

Soils: Presumably Alfisols or high pH Inceptisols. Soils have not been mapped in the known areas.

Hydrology: Moist but well drained.

Vegetation: Forest dominated by mesophytic trees, including calciphilic or basophilic species. Typical species are Quercus muehlenbergii, Juglans nigra, Fraxinus americana, and Acer saccharum var. saccharum, with a diversity of Cove Forest or Mesic Mixed Hardwoods Forest species potentially present. Understory species may include Celtis occidentalis, Hamamelis virginiana, and Ulmus rubra. Typical shrubs include Calycanthus floridus, Cornus alternifolia, and Hydrangea arborescens. Vines such as Toxicodendron (Rhus) radicans, Parthenocissus quinquefolia, and Aristolochia macrophylla may be prominent. Herb layer generally lush and diverse, with species such as Impatiens spp., Hybanthus concolor, Polymnia canadensis, Bromus pubescens (purgans), Laportea canadensis, Aquilegia canadensis, Adiantum pedatum, Sanguinaria canadensis, and Asarum canadense. If additional examples are discovered, this description may need revision.

Dynamics: Stable or may undergo slow succession to greater dominance by more long-lived mesophytic trees. Probably not susceptible to fire except in extraordinary circumstances. Small gap-forming disturbance processes dominate naturally.

Range: Well-developed examples are known only from the upper Catawba River area of McDowell County. Some marginal examples, of uncertain classification, are known from the Hot Springs Window of Madison County. The other primary potential area for occurrence is the Murphy Syncline (primarily Cherokee and Swain counties).

Associations: Grades into Montane Calcareous Cliff on steeper or rockier slopes, or contains small inclusions of it. May grade to Montane Alluvial Forest below. May abruptly border acidic substrate communities such as Montane Acidic Cliff or Cove Forest.

Distinguishing Features: The Basic Mesic Forest (Montane Calcareous Subtype) is distinguished from all other forested community types by the canopy composition. It is distinguished from the Montane Calcareous Cliff type by having a potentially closed or nearly closed tree canopy.

Variation: Varies locally with position on slope and nature of soil. If examples occur in other geographic areas they are likely to vary substantially.

Comments: The classification and description of this subtype is based on occurrences in only one area. The classification of these communities as a subtype of Basic Mesic Forests is somewhat tentative, and the relationship of this category to other community types is not well known. Some calcareous areas in the mountains support Rich Cove Forests not very different from those on felsic substrates, and it is unclear what is different about the sites that support this subtype. They are at low elevations, but are somewhat influenced by montane climates and biogeographic patterns. Although located on sheltered lower slopes, they may be drier than Rich or Acidic Cove Forests.

Rare Plant Species: Vascular -- Arabis patens, Heuchera longiflora, Hexalectris spicata, Hybanthus concolor, Hydrastis canadensis, Hydrophyllum macrophyllum, Lathyrus venosus, Penstemon smallii, Philadelphus hirsutus, Philadelphus inodorus, Polymnia canadensis, Ptelea trifoliata, Quercus muehlenbergii, Stachys nuttallii, Thaspium pinnatifidum, Zigadenus elegans ssp. glaucus. Most of these species are known only from Hot Springs Window sites of uncertain classification.

Synonyms: None known.

Examples:
Linville Caverns, McDowell County.
Catawba River Dolomite Area, Pisgah National Forest, McDowell County.

Hot Springs Window area, Madison County.

References: none.

Sample Plant Communities:
Quercus muehlenbergii-Juglans nigra/mixed calciphilic herbs
Quercus muehlenbergii-mixed mesophytic hardwoods/Impatiens capensis-Laportea canadensis.

CAROLINA HEMLOCK BLUFF

Sites: Generally steep, rocky, exposed upper slopes, bluffs, and gorge walls, sometimes extending onto adjacent flatter areas.

Soils: Rocky, strongly acid soils, even over mafic rocks.

Hydrology: Terrestrial, dry or dry-mesic.

Vegetation: The canopy is generally well developed, though not always closed, owing to extreme rockiness and steepness. Tsuga caroliniana is the dominant trees; species such as Quercus montana (prinus), Pinus rigida, Pinus pungens, Quercus rubra, or Tsuga canadensis often occur. Undergrowth is generally a dense layer of heaths, especially Kalmia latifolia, Rhododendron catawbiense, Gaylussacia spp., and Vaccinium spp. The herb layer is very sparse below the dense shrub growth. Species may include Gaultheria procumbens, Mitchella repens, Chimaphila maculata, Galax urceolata (aphylla), Xerophyllum asphodeloides, and Trillium undulatum. Bryophytes (Dicranum spp., Leucobryum albidum, and L. glaucum) and lichens (Cladonia spp. and Cladina spp.) are sometimes prominent.

Dynamics: Carolina hemlock has a stress tolerant strategy, consisting of tolerance of low nutrients and dryness, tolerance of shade, and slow growth (Humphrey 1989). The occurrence of Carolina hemlock communities on dry exposed sites often associated with Pine--Oak/Heath suggests fire may be an important factor in these communities. However, Humphrey (1989) found that, at Bluff Mountain, Carolina hemlock had expanded from well-established stands on the steepest bluff, replacing undisturbed oak forests on the flatter areas above, and suggested reduction in fire occurrence had allowed the expansion. It may be that the hemlock is not fire tolerant and is naturally confined to limited rocky bluff areas that are sheltered, while Pine--Oak/Heath communities occur in fire prone sites.

Range: Scattered throughout the Blue Ridge, but uncommon. A few sites occur in the upper Piedmont on steep north-facing river bluffs.

Associations: Frequently grades uphill to Pine--Oak/Heath, sometimes to Low Elevation Rocky Summit. Grades to various cliff and upland forest types. Often grades downslope in ravines to Canada Hemlock Forest in the moister soils below.

Distinguishing Features: Carolina Hemlock Bluffs are distinguished from Pine-- Oak/Heath by the predominance of Tsuga caroliniana over pines and oaks. They are distinguished from the occasional cliffs or rocky summits with Tsuga caroliniana on them by having a substantial, if not fully closed, tree canopy. The rare stands of Tsuga caroliniana on mesic valley sites are included in the Canada Hemlock Forest type.

Variation: Considerable, but unstudied. Important factors are likely to be elevation, exposure, soil characteristics, fire history.

Comments: Little is known about these communities. They appear to share characteristics with both Canada Hemlock Forests and Pine-Oak/Heaths. Like the former, they generally occur on high, exposed, rocky sites, though they may grade at the lower edge to the latter. Like Canada hemlock, Carolina hemlock appears to exclude other species, although it more frequently shares dominance.

While Tsuga caroliniana usually occurs higher on slopes than T. canadensis, occasional stands are known in valley bottoms in the South Toe River drainage. McLeod's (1988) analysis of vegetation data found Carolina hemlock stands on bluffs were most similar to heath balds, while valley bottom stands were separate. The valley stands had taller trees and in other ways more resembled Canada Hemlock Forest communities. These stands are tentatively included in the Canada Hemlock forests type rather than the Carolina Hemlock Bluff. Individual Carolina hemlock trees or small groves may also occur in Pine-Oak/Heath, Chestnut Oak Forest, or Montane Oak--Hickory Forest.

Rare Plant Species: None known.

Synonyms:

Apparently SAF 23: Eastern Hemlock, in part, presumably, although Carolina Hemlock is not mentioned.

Examples:
Kelsey Tract, Nantahala National Forest, Macon County.
Bluff Mountain, Ashe County (Weakley, Mehrhoff, and Mansberg 1979).
Linville Falls., Burke County.
Beartree Ridge, Pisgah National Forest, McDowell County.
Lower Cascade Falls, Hanging Rock State Park, Stokes County (Weakley and Dickerson 1979).

References: Heiman and Smith (in prep.), Humphrey (1989), McLeod (1988), Weakley and Dickerson (1979), Weakley, Mehrhoff, and Mansberg (1979)

Sample Plant Communities:
Tsuga caroliniana.
T. caroliniana/Kalmia latifolia.
T. caroliniana/Rhododendron catawbiense.
T. caroliniana/Rhododendron catawbiense-R. maximum.
T. caroliniana/Rhododendron minus.
T. caroliniana/Mixed heaths.
T. canadensis-T. caroliniana/Rhododendron maximum/Mitchella repens.
T. caroliniana/Rhododendron maximum.
T. caroliniana-Pinus virginiana-P. rigida.

WHITE PINE FOREST

Sites: Walls of gorges and other steep exposed slopes.

Soils: Sandy or rocky, very acidic. Series not known.

Hydrology: Probably dry-mesic.

Vegetation: Canopy dominated by Pinus strobus, with or without associated trees such as Tsuga canadensis or Quercus montana (prinus). The shrub layer is often dense. Shrubs include Vaccinium spp., Rhododendron spp., and Gaylussacia spp.

Dynamics: Pinus strobus appears to respond readily to disturbance and is often a successional tree. Most white pine-dominated stands in the mountains are the result of clearing and are not considered part of this natural community type.

The dynamics of natural White Pine Forests are not known. They may in the long term be successional to some other community, or they may be maintained by poor site conditions and possibly fire.

Range: Scattered in the Mountain Region, possibly in the upper Piedmont.

Associations: May be associated with High Elevation Granitic Dome, Chestnut Oak Forest, Montane Oak--Hickory Forest, Montane White Oak Forest, or other upland forest communities.

Distinguishing Features: White Pine Forests are distinguished by having a well- developed Pinus strobus-dominated canopy which is not the result of human disturbance of another community type. They can generally be recognized only on steep, inaccessible sites.

Variation: Not known.

Comments: This is one of the most poorly known community types. The category is tentatively included here, but may need to be modified when more is learned. Successional white pine stands are common but natural White Pine Forests appear to be rare. Their long term persistence is not known. Fire may be involved in regenerating or maintaining stands. Otte (pers. comm. 1985) suggested that White Pine Forests were associated with sandy soils. Examples are also known from shallow soils over granitic rock.

Rare Plant Species: None known.

Synonyms:
SAF 21: Eastern White Pine (in part).
SAF 22 and 51: White Pine-Hemlock and White Pine-Chestnut Oak (in part).

Examples:
Linville Gorge, Pisgah National Forest, Burke County.
Blackrock Mountain, Nantahala National Forest, Macon County.
Toxaway River Gorge, Transylvania County.

References: none known.

Sample Plant Communities:
Pinus strobus.
Pinus strobus/Rhododendron minus-Kalmia latifolia.

PINE--OAK/HEATH

Sites: Exposed sharp ridges, knobs, low elevation peaks, and steep south slopes.

Soils: Generally thin and rocky, extremely acidic soils. Most are probably Porters (Umbric Dystrochrept) or Cleveland (Lithic Dystrochrept).

Hydrology: Terrestrial, xeric because of shallow soil and rapid drainage.

Vegetation: Open to nearly closed, often stunted and gnarled canopy dominated by combinations of Pinus virginiana, P. pungens, P. rigida, or Quercus coccinea. Other trees may include Quercus montana (prinus), Castanea pumila, Castanea dentata, Sassafras albidum, Nyssa sylvatica, Acer rubrum, Tsuga caroliniana, and Oxydendrum arboreum. The shrub layer is generally very dense, dominated by ericaceous species, most commonly Kalmia latifolia, Gaylussacia baccata, Vaccinium pallidum (vacillans), and Gaylussacia ursina. Other common shrubs include Vaccinium stamineum, Rhododendron catawbiense, Rhododendron maximum, Symplocos tinctoria, Comptonia peregrina, and Leucothoe recurva. Smilax glauca and Smilax rotundifolia are sometimes abundant. Characteristic herb species include Epigaea repens, Chimaphila maculata, Galax urceolata (aphylla), Schizachyrium (Andropogon) scoparium, Melampyrum lineare, Coreopsis major, Pteridium aquilinum, Tephrosia virginiana, Uvularia pudica, Gaultheria procumbens, and Xerophyllum asphodeloides.

Dynamics: Pine-Oak/Heaths are believed to depend on periodic severe fires, which open seedbeds for shade-intolerant species, such as pines, to regenerate (Harmon, Bratton, and White 1984). Whittaker (1956) noted that pine communities often had bimodal size structures plus a few older trees. He attributed this to establishment of the stand after a severe fire, with a second generation being produced when the first matured. Although he believed the pine stand could reproduce and maintain itself indefinitely without further fire, others have disagreed. In the long absence of fire, they might become shrub dominated on the death of the pines, or succeed to oak or Carolina hemlock dominance.

The natural fire regime needed to maintain these communities is not known. The sites characteristic of Pine--Oak/Heath appear to be unusually prone to fire. They are among the most exposed to lightning and the driest in the landscape. Even relatively low-intensity surface fires spreading from adjacent communities may increase in intensity when they reach the dense vegetation, thick dry litter, and openness to wind of Pine--Oak/Heath sites.

Castanea dentata was a major component in many of these communities. Its death has undoubtedly made some communities more open-canopied and heath- dominated than they were originally. Some Quercus montana-dominated Pine--Oak/Heaths may have originally been chestnut oak-chestnut forests.

Range: Throughout the Mountain Region; in the Piedmont confined to high ridges and monadnocks in the upper Piedmont, especially on quartzite.

Associations: Grades to Chestnut Oak Forest, Montane Oak--Hickory Forest, or Carolina Hemlock Bluff in somewhat less dry and exposed sites. Grades to High Elevation Red Oak Forest, Montane White Oak Forest, or Heath Bald at high elevations. Often borders High or Low Elevation Granitic Domes and Rocky Summits.

Distinguishing Features: Pine--Oak/Heaths are distinguished from upland hardwood forest communities by their structure and composition, with a dense shrub layer and an open canopy composed of yellow pines or xerophytic oaks. Some examples may have a closed pine canopy and a less dense shrub layer. The gradations to Chestnut Oak Forest, Montane White Oak Forest, and Montane Oak-- Hickory Forest with abundant heath shrubs may be gradual, particularly if large numbers of chestnut trees were once present so that their loss has left the forest canopy open.

Carolina Hemlock bluffs, which are often associated with Pine--Oak/Heaths, are distinguished by the dominance of Tsuga caroliniana and by their generally better developed canopy. Pine--Oak/Heaths are distinguished from Heath Balds by lower elevation, occurrence of some trees among the dense shrubs, and generally more xerophytic species composition. Whittaker (1956) placed the upper boundary of these communities around 4500 feet elevation in the Smokies, but examples are known up to 4800 feet, particularly in the southern part of the state. Most examples, however, are below 4000 feet.

Low and High Elevation Granitic Domes usually have Pine--Oak/Heath-like vegetation in the shallow soil surrounding the open rock. In general, these should be considered merely zones of the dome community unless they cover a substantial

area or extend far from the rock outcrop. The same is true of Low Elevation Rocky Summits, which may contain patches of shrub-dominated areas.

Variation: This is a heterogeneous type, with a variety of potential tree dominants. Whittaker (1956) and Racine (1966) have described a general pattern of Pinus virginiana dominating at the lowest elevations, P. rigida at intermediate, and P. pungens at the highest elevations. Oak may dominate in somewhat less exposed situations, or its occurrence may be related to fire history. However, some of the low elevation sites on upper Piedmont monadnocks, have some or all of these species mixed, some well below their normal elevational range. These different canopy compositions may be regarded as variants.

Comments: Much remains to be learned about the role of fire in these communities and its interaction with site factors in determining vegetation.

Rare Plant Species: Vascular -- Amorpha glabra, Fothergilla major, Hudsonia montana, Liatris turgida, Polygala paucifolia, Quercus ilicifolia, Thermopsis mollis var. fraxinifolia, Thermopsis mollis var. mollis.

Synonyms:
Virginia pine forest, pitch pine heath, table mountain pine heath (Whittaker 1956).
SAF 45: Pitch Pine.

Examples:
Great Smoky Mountain National Park, Swain and Haywood counties (Whittaker 1956).
Doughton Park, Blue Ridge Parkway, Alleghany County (Pittillo and Govus 1978).
Bear Tree Ridge, Pisgah National Forest, McDowell County.
Woods Mountain and Singecat Ridge, Pisgah National Forest, McDowell County.
Saddle Mountain Nature Conservancy Preserve, Surry County.
Stone Mountain State Park, Wilkes and Alleghany counties.
Looking Glass Rock, Pisgah National Forest, Transylvania County.
Hawksbill Mountain and other sites on the east rim of Linville Gorge, Burke County.
Hanging Rock State Park, Stokes County (McCurdy 1975).
Pilot Mountain State Park, Surry County (Williams and Oosting 1944).
Crowders Mountain State Park, Gaston County.

References:
Cooper and Hardin (1970), Dumond (1969), Feil (1988), Harmon, Bratton, and White (1984), McCurdy (1975), Pittillo and Govus (1978), Racine (1966), Sather (1982), Whittaker (1956), Williams and Oosting (1944).

Sample Plant Communities:
Pinus pungens.
P. pungens/Leiophyllum buxifolium.
P. pungens/Tall, evergreen heaths.
P. pungens-Pinus virginiana.
P. pungens-Mixed oaks and hardwoods/Kalmia latifolia-Rhododendron maximum.
Pinus rigida.
P. rigida/Gaylussacia baccata.
P. rigida/Kalmia latifolia.
P. rigida/Menziesia pilosa.
P. rigida/Rhododendron catawbiense.
P. rigida/Rhododendron catawbiense/Gaylussacia ursina.
P. rigida/Vaccinium constablaei-Gaylussacia ursina.
P. rigida-Pinus pungens/Gaylussacia baccata.
P. rigida-P. pungens/Kalmia latifolia.
P. rigida-P. pungens/Leiophyllum buxifolium.

P. rigida-P. pungens/Rhododendron catawbiense.
P. rigida-P. pungens/Rhododendron carolinianum.
P. rigida-Pinus virginiana/Gaylussacia ursina/Vaccinium pallidum (vacillans)/Schizachyrium scoparium.
P. rigida-P. virginiana-Quercus coccinea/Gaylussacia ursina-Vaccinium stamineum.
P. rigida-P. virginiana-Quercus coccinea/Kalmia latifolia.
P. rigida-P. virginiana-Quercus montana.
P. rigida-Quercus montana (prinus)/Rhododendron catawbiense.
P. rigida-Quercus montana/Vaccinium constablaei.
P. rigida-Mixed oaks/Cladonia spp.
Pinus virginiana/Gaylussacia baccata-Vaccinium pallidum.
P. virginiana.
P. virginiana/Vaccinium pallidum.
P. virginiana/Kalmia latifolia.
P. virginiana/Kalmia latifolia-Rhododendron catawbiense.
P. virginiana/Tall evergreen heaths.
P. virginiana/Mixed heaths.
P. echinata-Quercus montana.
Quercus montana-Pinus virginiana/Mixed heaths.
Pinus pungens-Tsuga caroliniana-Populus grandidentata/Mixed shrubs.

CHESTNUT OAK FOREST

Sites: Slopes and ridgetops at low to moderate montane elevations (up to around 4000 feet).

Soils: Rocky, acidic, upland soils. Series include Ashe, Chestnut, Edneyville, and Chandler (all Typic Dystrochrepts).

Hydrology: Terrestrial, dry-mesic.

Vegetation: Canopy dense to somewhat open, dominated by Quercus montana (prinus) or Q. coccinea, with lesser amounts of Quercus rubra, Q. alba, Q. velutina, Carya spp., Tsuga caroliniana, Nyssa sylvatica, Acer rubrum, Pinus spp., Liriodendron tulipifera, and various Cove Forest species. Castanea dentata formerly dominated or codominated in the canopy and sprouts are still an important understory component. Other understory species include Oxydendrum arboreum, Acer rubrum, Sassafras albidum, and Amelanchier arborea. Shrubs range from a dense heath layer dominated by Kalmia latifolia with Rhododendron maximum or R. carolinianum, to a more open layer with species such as Gaylussacia ursina, Rhododendron calendulaceum, Clethra acuminata, Pyrularia pubera, Vaccinium stamineum, Corylus cornuta, and Vaccinium constablaei. Herbs range from very sparse to moderately sparse. Under heavy heath cover Galax urceolata (aphylla) is the primary herb, with Epigaea repens, Gaultheria procumbens, and Aureolaria laevigata. With a more open shrub layer the herbs are more diverse, with additional species such as Prenanthes trifoliolata, Pedicularis canadensis, Chimaphila maculata, Goodyera pubescens, Medeola virginiana, Maianthemum (Smilacina) racemosum, Polygonatum biflorum, and Veratrum parviflorum.

Dynamics: These forests are naturally uneven-aged climax forests, with reproduction occurring in canopy gaps. The open, fairly dry slopes are exposed to a variety of natural disturbances such as fire, winds, and ice storms. Fires were probably usually of low to moderate intensity and confined to the surface. It is unclear if community structure or composition has changed because of widespread fire suppression.

All of these forests are in a state of transition following the loss of chestnut as a canopy dominant. In most stands it appears that chestnuts have been replaced initially by existing canopy and understory species. Species that respond favorably to disturbance, such as Liriodendron tulipifera, Robinia pseudoacacia, Acer rubrum, and Pinus spp. have increased. Kalmia latifolia has also greatly increased in density (Monk, McGinty, and Day 1985). Stands that had large amounts of chestnut may now have an open canopy, with a denser shrub layer, causing them to resemble Pine-Oak/Heaths. It is not yet known what the eventual composition of these forests will be.

Range: Common throughout the Mountain Region, also locally in the upper Piedmont.

Associations: Grades to High Elevation Red Oak or Montane White Oak Forest on higher elevation slopes. Grades to Pine--Oak Heath or Carolina Hemlock Bluff on more exposed ridgetop sites. Grades to Acidic Cove Forest, Rich Cove Forest, Canada Hemlock Forest, or Montane Oak--Hickory Forest on more sheltered and mesic sites. May be associated with various Granitic Dome, Rocky Summit, or Cliff communities.

Distinguishing Features: Chestnut Oak Forests are distinguished from all other mountain forests by the dominance of Quercus montana or Q. coccinea. They are distinguished from Granitic Dome, Rocky Summit, and Cliff communities by having a potentially closed or nearly closed canopy and having little exposed rock. They are generally easily distinguished from Pine--Oak/Heaths by lack of substantial numbers of pines in the climax state, closed or nearly closed canopy, and a less dense shrub layer. However, where chestnut trees were once abundant, their death may have left an open canopy and allowed a dense heath layer to develop. Such areas should be regarded as Chestnut Oak Forests if they can be recognized as such. Logging may also make the distinction difficult.

Chestnut Oak Forests are distinguished from Piedmont Monadnock Forests, which may be dominated by the same species, by higher elevation and presence and importance of a number of typically montane (in North Carolina) species, such as Castanea dentata, Betula alleghaniensis, Pinus rigida, Pinus pungens, Rhododendron calendulaceum, and Rhododendron carolinianum. Piedmont species such as Quercus falcata and Q. stellata are generally absent. The two types are generally geographically separated, but both may occur in the upper Piedmont.

Variation: Varies with gradation to adjacent communities. More xeric sites, transitional to Pine-Oak/Heath, have a more open canopy with dense Kalmia latifolia-dominated heath and few herbs (Whittaker's chestnut oak-chestnut heath). More mesic and lower elevation sites have less dense shrub layer and more herbs. The Quercus coccinea-dominated examples may be regarded as a distinct variant.

Comments: Chestnut Oak Forests appear to be a relatively common natural community type in the Blue Ridge region. They are very rare in the Piedmont.

The relationship between this type and Montane Oak--Hickory Forest is not well understood. In some places Montane Oak--Hickory occurs between Chestnut Oak Forest and Acidic Cove Forest, but in other places one or the other is absent. Chestnut Oak Forest seems best developed in the northern escarpment region, while Montane Oak--Hickory Forest appears to be more widespread in the southern mountains.

The transition between Chestnut Oak Forest and High Elevation Red Oak Forest is also of interest. In some places it seems to be fairly sharp, but other areas have very broad transition zones. McLeod (1988) described mixed Quercus montana-Q. rubra-Liriodendron tulipifera forests covering large areas in the virgin forests of the Walker Cove Research Natural Area.

Rare Plant Species: Vascular -- Fothergilla major, Monotropsis odorata, Thermopsis mollis var. mollis.

Synonyms:
Chestnut oak-chestnut forest, Chestnut oak-chestnut heath (Whittaker 1956).
SAF 44: Chestnut Oak.
Chestnut Oak Forest, Scarlet Oak-Red Maple Forest (McLeod 1988).

Examples:
Great Smoky Mountains National Park, Swain and Haywood counties (Whittaker 1956) (extensive virgin forests).
Middle Creek Research Natural Area, Black Mountains, Pisgah National Forest, Yancey County (McLeod 1981) (virgin forests).
Linville Gorge Wilderness, Pisgah National Forest, Burke County.
Doughton Park, Blue Ridge Parkway, Wilkes County.
Whitewater, Chattooga, and other gorges on the southern escarpment, Transylvania, Jackson, and Macon counties (Dumond 1969, Cooper and Hardin 1970).
Hanging Rock State Park, Stokes County (McCurdy 1975).

References: Cooper and Hardin (1970), Day and Monk (1974), DeLapp and Wentworth (1977), Dumond (1969), Feil (1988), Keever (1953), McCurdy (1975), McLeod (1981), McLeod (1988), Monk, McGinty, and Day (1985), Rohrer (1983), Valentine (1983), Whittaker (1956).

Sample Plant Communities:
Quercus montana (prinus).
Quercus montana/Gaylussacia baccata-Vaccinium stamineum-Vaccinium pallidum (vacillans).
Quercus montana/Kalmia latifolia.
Quercus montana/Pieris floribunda.
Quercus montana/Rhododendron nudiflorum.
Quercus montana/Tall dwarf, deciduous heaths.
Quercus montana/Mixed graminoids.
Quercus montana/Mixed tall herbs.
Quercus montana-Mixed oaks and hardwoods/Kalmia latifolia-Mixed heaths.
Quercus montana-Q. rubra/Acer rubrum/Hamamelis virginiana-Rhododendron calendulaceum/Subxeric herbs.
Quercus coccinea.

PIEDMONT MONADNOCK FOREST

Sites: Monadnocks and high ridges, generally on quartzite, rhyolite, pyrophyllite or other highly resistant rocks.

Soils: Rocky, well-drained, generally very acidic soils. Series include Nason, Georgeville, Tatum (Typic Hapludults), Davidson (Rhodic Paleudult), Goldston (Ruptic-Ultic Dystrochrept), and Uwharrie (Typic Hapludult).

Hydrology: Terrestrial, dry to xeric.

Vegetation: Canopy strongly dominated by Quercus montana (prinus). Other canopy trees may include Q. alba, Q. coccinea, Q. stellata, Q. marilandica, Q. falcata, Carya glabra, Carya alba (tomentosa), Pinus virginiana, and Pinus echinata. The understory is typically strongly dominated by Oxydendrum arboreum and Acer rubrum, with some Cornus florida, Nyssa sylvatica, and other species. A patchy shrub layer consists primarily of Vaccinium pallidum (vacillans), V. stamineum, Gaylussacia baccata, Kalmia latifolia, Toxicodendron (Rhus) radicans. The herb layer is sparse, with Chimaphila maculata, Desmodium nudiflorum, Danthonia spicata, Schizachyrium (Andropogon) scoparium, Tephrosia virginiana, Hieracium venosum, Coreopsis verticillata, and Pteridium aquilinum also characteristic.

Dynamics: The exposed position of monadnocks makes these forests very susceptible to disturbance by high winds and lightning. Canopy gaps are probably larger and more frequent than in most Piedmont forests, but forests are generally uneven-aged and often contain old trees. Because of the dryness and disturbance, pines were probably a more important component of Piedmont Monadnock Forests than of other Piedmont forests.

The natural fire frequencies of the Piedmont are not known, but fires certainly occurred periodically. Monadnocks are likely sites for lightning fires to start, as well as being very susceptible to fires spreading from below. They may have burned more frequently than most Piedmont communities. Because the herb layer is sparse and the component species fire tolerant, fires may have had little effect on community composition or structure.

Range: Throughout the Piedmont. Rare in the northeastern Piedmont, more common westward and in the Uwharrie Mountains.

Associations: Grades downward to Dry or Dry-Mesic Oak--Hickory Forest. May grade into Piedmont/Coastal Plain Acidic Cliff or Heath Bluff. May rarely grade to Pine--Oak Heath on sharp high ridgetops.

Distinguishing Features: Piedmont Monadnock Forests are distinguished from Dry Oak--Hickory, Dry-Mesic Oak--Hickory, Basic Oak--Hickory, and other upland forest by the dominance of Quercus montana in the canopy. They are usually on distinct monadnocks, but may occasionally occur on lower ridges. They are distinguished from Acidic Cliffs and Heath Bluffs on which Q. montana is sometimes present, by having a closed or potentially closed tree canopy.

Piedmont Monadnock Forests are distinguished from the mountain Chestnut Oak Forest by the absence of a number of typically montane (in North Carolina) species, such as Castanea dentata, Betula alleghaniensis (lutea), Pinus rigida, P. pungens, Rhododendron calendulaceum, and Rhododendron carolinianum. Species such as Q. falcata and Q. stellata are generally absent in the mountain Chestnut Oak Forest. The geographical boundary between the two types is not known. The outlier South Mountains and the high monadnock at Hanging Rock State Park have enough of a montane component to be classified as Chestnut Oak Forest; thus, both types may occur in the upper Piedmont.

Variation: The low diversity makes for less variation than is present in many community types. Examples vary in the kinds and amounts of associated oaks, pines, and other species, apparently in response to soil factors and disturbance history.

Comments: This type was called Chestnut Oak--Scarlet Oak Forest in the Second Approximation. This name was misleading in a statewide classification, however, because scarlet oak is not always a component in these communities, and it is as often a significant component of the montane Chestnut Oak Forest. While Piedmont Monadnock Forests are dominated by chestnut oak, they are distinct from the Mountain chestnut-oak dominated forests. The new name emphasizes the dependence of these communities on unusual topographic or edaphic situations.

This community type is generally quite distinctive in the eastern Piedmont where it reaches its best development near the

summits of monadnocks. Farther west, where erosional remnants are larger, it appears to become less distinct, as Quercus montana becomes more common in the Dry Oak--Hickory Forest.

Piedmont Monadnock Forests are generally very low in plant diversity. Peet and Christensen (1980) suggest a combination of elevation, dryness, and acidic, nutrient poor soil. Because many examples stand only a few hundred feet above surrounding lands and less than 1000 feet above sea level, elevation 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 on other dry sites, suggests that other factors are important. The low soil pH, infertility, and rockiness are likely factors.

Except in the Uwharrie Mountains and Blue Ridge foothills, 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 Plant Species: Vascular -- Amorpha schwerinii, Fothergilla major, Monotropsis odorata, Smilax biltmoreana, Thermopsis mollis var. mollis.

Synonyms:
Chestnut Oak--Scarlet Oak Forest (Second Approximation).
Monadnock Forest (Peet and Christensen 1980).
Type V (Nehmeth 1968).
SAF 44: Chestnut Oak (in part).

Examples:
Uwharrie National Forest, Montgomery and Randolph counties (Wells 1974) (widespread in the forest, with varying quality).
Morrow Mountain State Park, Stanly County (Morgan 1962).
Bald Mountain and Blackwood Mountain, Blackwood Division, Duke Forest, Orange County (Gibbon 1966, Ohmann 1980).
Occoneechee Mountain, Orange County (Sather and Hall 1988).
Hill Forest, Durham County (Gibbon 1966, Nehmeth 1968).
Medoc Mountain State Park, Halifax County.
Young's Mountain, Rowan County (an unusual example, occurring on diorite).

References: Gibbon (1966), LeGrand (1986), Morgan (1962), Nehmeth (1968), Ohmann (1980), Peet and Christensen (1980), Sather and Hall (1988), Wells (1974).

Sample Plant Communities:
Quercus montana (prinus).
Quercus montana/Oxydendrum arboreum.
Quercus montana/Vaccinium pallidum (vacillans).
Quercus montana/Mixed shrubs.
Quercus montana/Acer rubrum.
Quercus montana-Q. alba/Mixed subcanopy hardwoods/Kalmia latifolia-Mixed shrubs.
Quercus montana-Q. alba/Mixed subcanopy hardwoods/Mixed shrubs.
Quercus montana-Q. coccinea.
Quercus coccinea/Vaccinium pallidum.
Pinus virginiana-Quercus montana/Oxydendrum arboreum/Mixed heaths.

MONTANE OAK--HICKORY FOREST

Sites: Dry-mesic slopes and partly sheltered ridgetops at moderate to fairly elevations (about 2500-5000 feet).

Soils: Probably generally Ultisols or Dystrochrepts. Series include Porters (Umbric Dystrochrept), Ashe (Typic Dystrochrept), Chandler, and Watauga (Typic Hapludults). McLeod (1988) reported that sites in the Black and Craggy Mountains have higher pH and base saturation than Piedmont oak-hickory forests but this may not always be true.

Hydrology: Terrestrial, dry-mesic.

Vegetation: Canopy dominated by a mixture of oaks, hickories, and other hardwoods, with Quercus alba, Q. rubra, and Q. montana (prinus) most common. Other common trees include Carya alba (tomentosa), C. glabra, Quercus velutina, Acer rubrum, Liriodendron tulipifera, and Q. coccinea. Occasional Pinus strobus and other pines occur. Castanea dentata sprouts are generally common, indicating the former importance of this species. Other typical understory species include Oxydendrum arboreum, Cornus florida, Acer rubrum, Nyssa sylvatica, and Amelanchier arborea. The shrub layer varies in density. Rhododendron maximum and Kalmia latifolia may occur, but more often species such as Rhododendron calendulaceum, Gaylussacia ursina, Vaccinium spp., Viburnum acerifolium, and Hamamelis virginiana dominate. Herbs are generally sparse but may be fairly diverse, with species such as Medeola virginica, Maianthemum (Smilacina) racemosum, Polygonatum biflorum, Thelypteris noveboracensis, Dennstaedtia punctilobula, Uvularia puberula (pudica), Prenanthes altissima, Dioscorea villosa, Conopholis americana, and Galium spp. typical.

Dynamics: These forests are naturally uneven-aged climax forests, with reproduction occurring in canopy gaps. The open, fairly dry slopes are exposed to a variety of natural disturbances such as fires, winds, and ice storms. Fires were probably usually of low to moderate intensity and confined to the surface. It is unclear if community structure or composition has changed because of widespread fire suppression.

All of these forests are in a state of transition following the loss of chestnut as a canopy dominant. In most stands it appears that chestnut has been replaced initially by existing canopy and understory species. Species that respond favorably to disturbance, such as Liriodendron tulipifera, Acer rubrum, Robinia pseudoacacia, and Pinus spp. have increased. Kalmia latifolia has also greatly increased in density (Monk, McGinty, and Day 1985). Stands that had large amounts of chestnut may now have an open canopy, with a denser shrub layer, causing them to resemble Pine--Oak/Heath. It is not yet known what the eventual composition of these forests will be.

Range: Throughout the Mountain Region, though predominantly in the southern part of the state, south of the Asheville Basin. No sites are known in the Piedmont.

Associations: May grade to Chestnut Oak Forest, High Elevation Red Oak Forest, Montane White Oak Forest, Pine-Oak/Heath, or White Pine Forest in drier sites; Rich or Acidic Cove Forest in more mesic sites.

Distinguishing Features: The appropriate boundaries for this new type are not yet well worked out. Montane Oak--Hickory Forests are distinguished from Chestnut Oak Forests and High Elevation Red Oak Forests by having a canopy not truly dominated by Quercus montana or Q. rubra respectively. While these species are usually present, they are mixed with each other or subordinate to other oaks and hickories, particularly Quercus alba, Q. velutina, and Carya species. Montane Oak--Hickory Forests are distinguished from Montane White Oak Forests by not being strongly dominated by Q. alba. Q. alba-dominated forests on low valley flats, however, are tentatively included in the Montane Oak-- Hickory Forest type, although they may represent a distinctive community type.

Montane Oak--Hickory Forests are distinguished from Acidic Cove Forests and Rich Cove Forests by the predominance of oaks and hickories over more mesophytic hardwoods and hemlock. This transition may be very gradual in places.

Montane Oak-Hickory Forests are distinguished from the Piedmont Dry and Dry-Mesic Oak--Hickory Forest types by the presence of a number of characteristically montane (in North Carolina) species, including Castanea dentata, Rhododendron calendulaceum, Betula alleghaniensis (lutea), and Pyrularia pubera. The types are largely geographically separated, but the location of the boundary and the extent of interfingering or intergradation is not known.

Variation: As a mixed canopy type, this community type has potential for much variation. Examples vary with gradation to

adjacent communities. Quercus coccinea and Q. montana increase in more exposed sites, Q. rubra in more sheltered. The amount of Liriodendron tulipifera and Pinus strobus present probably depends on amount of disturbance. The widespread logging and the death of chestnut have probably further increased variation. McLeod (1988) described three communities that appear to be related to this type: mixed oak-yellow poplar-hickory, white oak, and red oak-yellow poplar-chestnut oak. The first of these is typical for this type. The second is an unusual variant that occurs on high alluvial terraces and flats, possibly associated with higher pH soils. It is tentatively included in this type. The third is probably transitional to High Elevation Red Oak Forest.

Comments: This type was not recognized in the Second Approximation. Forests of this description were fitted uncomfortably in Dry-Mesic Oak--Hickory Forest, High Elevation Red Oak Forest, or were left unclassified. Once recognized, however, they appear to be one of the more common community types in the Mountains. This may be partly because the category is broadly defined.

The relationship between this type and Chestnut Oak Forest is not well understood. In some places Montane Oak--Hickory Forest occurs between Chestnut Oak Forest and Acidic Cove Forest, but in other places one or the other is absent. Chestnut Oak Forest seems best developed in the northern escarpment region, while Montane Oak--Hickory Forest appears to be more widespread in the southern mountains. There are similar questions about the relationship between Montane Oak--Hickory Forest and High Elevation Red Oak Forest. The relationship with the poorly known Montane White Oak Forest is particularly uncertain. It is unclear if the Montane White Oak Forests are distinct enough to warrant a separate category, or if they should be merged with the Montane Oak--Hickory Forest type.

Rare Plant Species: Vascular -- Hydrangea cinerea, Orbexilum pedunculatum var. pedunculatum, Quercus imbricaria.

Synonyms:
Mixed oak, yellow poplar, hickory forest (McLeod 1988).
White oak forest (McLeod 1988).
Mixed oak slope (Feil 1988).

Examples:
Black Mountains, Pisgah National Forest, Yancey County (McLeod 1988).
Blackrock Mountain, Nantahala National Forest, Macon and Jackson counties.
Chattooga, Whitewater, and other gorges of the southern escarpment, Transylvania, Jackson, and Macon counties (Dumond 1969, Cooper and Hardin 1970).
Scaly Mountain and Cole Mountain Natural Areas, Nantahala National Forest, Macon County.
Celo Community Natural Area, Yancey County (McLeod 1988).
Southern Nantahala Wilderness, Macon County.
White Oak Stamp Natural Area, Nantahala National Forest, Clay County (Govus 1985).
Joyce Kilmer Memorial Forest, Nantahala National Forest, Graham County (Tucker 1973).

References: Cooper and Hardin (1970), Dumond (1969), Feil (1988), Govus (1985), Heiman and Smith (in prep.), Keever (1953), McLeod (1981), McLeod (1988), Rodgers and Shake (1965), Tucker (1973).

Sample Plant Communities:
Quercus alba/Kalmia latifolia-mixed shrubs.
Quercus alba-Mixed hardwoods.
Quercus alba-Q. rubra-Q. montana (prinus)/Gaylussacia ursina.
Quercus velutina-Mixed hardwoods.
Mixed oaks/Mixed shrubs.
Quercus alba-Q. rubra-Q. velutina/Gaylussacia ursina-Rhododendron calendulaceum.
Quercus rubra-Q. alba-Acer rubrum-Carya sp./Gaylussacia ursina.
Quercus alba-Q. rubra-Carya tomentosa/Castanea dentata/Rhododendron calendulaceum.
Quercus rubra-Q. alba/Thelypteris noveboracensis.

DRY OAK--HICKORY FOREST

Sites: Ridgetops, upper slopes, steep south-facing slopes, and other relatively dry upland areas on acidic soils. Occasionally on upland flats with somewhat restricted rooting depth which makes them seasonally dry.

Soils: A variety of upland soils. Series include Cecil, Georgeville, Pacolet, Kalmia (Typic Hapludults), Goldston (Ruptic-Ultic Dystrochrept), Wagram (Arenic Paeudult), and Misenheimer (Aquic Dystrochrept).

Hydrology: Terrestrial, dry.

Vegetation: Forest dominated by dry site oaks, primarily Quercus alba, Q. falcata, or Q. stellata, along with various other oak and hickory species such as Quercus montana (prinus), Q. marilandica, Q. coccinea, Q. velutina, Carya alba (tomentosa), Carya ovalis, and Carya glabra. Pinus spp. are often an important component, and may occasionally even be dominant. Typical understory species include Oxydendrum arboreum, Acer rubrum, Nyssa sylvatica, Cornus florida, and Vaccinium arboreum. Shrubs range from sparse to dense, with Vaccinium stamineum, V. pallidum (vacillans), and other ericaceous shrubs most common. Vitis rotundifolia and Toxicodendron (Rhus) radicans are often present. Herbs are generally sparse, with Chimaphila maculata, Hexastylis arifolia, Pieptochaetium (Stipa) avenaceum, Danthonia spicata, Tephrosia virginiana, Coreopsis major, and Hieracium venosum typical.

Dynamics: Disturbed areas have increased amounts of pines and weedy hardwoods such as Acer rubrum and Liquidambar styraciflua, with the amounts depending on the degree of canopy opening. Areas that were cultivated are generally dominated by even-aged pine stands which are replaced by the climax oaks and hickories only as the pines die. Heavily logged areas may have a mixture of hardwoods and pines. Occasional areas may be naturally dominated by pines (see description of variants below).

Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms may allow pulses of increased regeneration and allow the less shade tolerant species to remain in the community. Skeen, Carter, and Ragsdale (1980) argued that even shade-intolerant species such as Liriodendron could reproduce enough in gaps to persist in the climax Piedmont forests. This would have been particularly true in old-growth forests where trees, and hence gaps, were larger.

The natural fire regime of the Piedmont is not known, but fires certainly occurred periodically. These communities, occurring in dry sties, may have been particularly subject to fire, more so than other hardwood forests. Most of the component trees are able to tolerate light surface fires with little effect. Regular fire may have created a more open forest, with gaps persising longer than at present and perhaps forming more frequently.

In sandy parts of the Coastal Plain, fires were frequent, apparently every 3-5 years. Dry Oak--Hickory Forests are confined to areas that are somewhat sheltered from fire spread. With the reduction in fire frequency in the Coastal Plain, many longleaf pine-dominated communities have been invaded by oaks and hickories.

Range: Throughout the Piedmont and Coastal Plain, possibly in the lower parts of the Blue Ridge.

Associations: Usually associated with Dry-Mesic Oak--Hickory Forest, sometimes with Piedmont Monadnock Forest, Piedmont/Coastal Plain Acidic Cliff, Piedmont/Coastal Plain Heath Bluff, Xeric Hardpan Forest, Upland Depression Swamp, or other upland communities.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition. Piedmont Monadnock Forests are dominated strongly by Quercus montana (prinus) and Q. coccinea, although most trees from the Dry Oak--Hickory Forest may be present in smaller numbers. Xeric Hardpan Forests are dominated by Quercus stellata and Q. marilandica. In contrast, Dry Oak--Hickory Forests generally have Q. alba or Q. falcata as the predominant tree. Dry-Mesic Oak-- Hickory Forests also usually have Q. alba as the predominant oak, but trees more mesophytic than Q. alba predominate over those more xeric. Dry Oak--Hickory Forest is distinguished from Piedmont/Coastal Plain Acidic Cliff and Piedmont/Coastal Plain Heath Bluff by the presence of a naturally closed or nearly closed canopy. It is distinguished from Montane Oak--Hickory Forest by the absence of species typical of the Blue Ridge in North Carolina, such as Castanea dentata and Rhododendron calendulaceum.

Variation: This type has substantial variation within it. Several distinctive variants are recognized, some of which may warrant future recognition as separate types or subtypes.

1. Piedmont Upland Variant, on well-drained soils in the Piedmont or heavier soils in the Coastal Plain, dominated by Quercus alba. This is the most typical variant, best fitting the above description.

2. Coastal Plain Sand Variant, on sandy Coastal Plain sites protected from fire. It is generally dominated by Quercus falcata and Q. stellata, with less Q. alba. Pines may be a significant component but are not dominant. Pine/Scrub Oak Sandhill communities which, after long fire suppression, have been invaded by these oaks resemble this type, but natural examples may occur in similar sites with natural fire breaks such as bluffs.

3. Piedmont Hardpan Variant, on soils with a shallow hardpan or clay layer that restricts rooting depth. This type is transitional to Xeric Hardpan Forest.

4. Dry Pine Variant, on steep, often rocky, south or west-facing slopes and sharp ridges in the Piedmont, dominated by Pinus echinata, P. virginiana, or, in at least one instance, P. palustris. Quercus stellata, Q. marilandica, and Q. falcata are often important. This variant is only very tentatively included within the Dry Oak--Hickory Forest type. It also resembles Pine--Oak/Heath, Pine/Scrub Oak Sandhill, and Piedmont/Coastal Plain Acidic Cliff, but may warrant a new type.

Comments: Dry Oak--Hickory Forests were once one of the predominant community types in the Piedmont. Their abundance in the Coastal Plain is less certain, but they were clearly widespread there as well. Most of this area is now in agriculture, urban development, or is occupied by successional pine stands after past agriculture. What was not cleared was subject to long-term selective cutting and to livestock foraging. The Piedmont Upland Variant of this type is still relatively common compared to most natural community types, but examples of significant size and good quality are extremely rare. Most protected areas in the Piedmont center around dissected lands near rivers or creeks. Dry Oak-- Hickory Forests are of relatively limited extent in such areas, and hence few are in protection. The abundance of the other variants is not well known, but they are much rarer.

Rare Plant Species: Vascular -- Amorpha schwerinii, Corallorhiza wisteriana, Hexastylis lewisii, Monotropsis odorata, Nestronia umbellula, Onosmodium virginianum, Porteranthus stipulatus, Prunus umbellata, Rhus michauxii, Thermopsis mollis var. mollis, Yucca flaccida.

Synonyms:
Oligotrophic Forest, Dry Eutrophic Forest (Peet and Christensen 1980).
White Oak, White Oak-Post Oak (Oosting 1942).
Type IV (Nehmeth 1968).
SAF 53: White Oak.

Examples:
Piedmont Upland Variant:
Duke Forest, Durham, Korstian, Blackwood Divisions, Orange and Durham counties (Oosting 1942, Ohman 1980).
Caswell Upland Hardwood Forest, Cherokee Boy Scout Camp, Caswell County.
Birkhead Wilderness and other places in the Uwharrie Mountains, Uwharrie National Forest, Randolph and Montgomery counties (Wells 1974).
Raven Rock State Park, Harnett County.
Rankin Hardwood Forest, Gaston County.
Otter Creek Natural Area, East Carolina University, Pitt County.

Coastal Plain Sand Variant:
Fort Bragg, Hoke County.

Piedmont Hardpan Variant:
Gold Hill Flatwoods, Rowan County.
Reed Gold Mine, Stanly County.

Dry Pine Variant:
Goldmine Branch Longleaf Pine Slope, Uwharrie National Forest, Montgomery County.
Shingletrap Shortleaf Pine Slope, Uwharrie National Forest, Montgomery County.

References: Ashe and Pinchot (1897), Glazier (1967), McDonald, Ash, and Fussell (1981), Nehmeth (1968), Ohmann (1980), Oosting (1942), Peet and Christensen (1980), Sechrest and Cooper (1970), Skeen, Carter, and Ragsdale (1980), Wells (1928), Wells (1942), Wells (1974).

Sample Plant Communities:
Mixed upland oaks.
Mixed upland oaks/Mixed subcanopy hardwoods/Cornus florida.
Mixed upland oaks-Mixed upland hardwoods/Mixed subcanopy hardwoods.
Mixed upland oaks-Mixed upland hickories.
Mixed upland hardwoods/Mixed subcanopy hardwoods.
Q. alba-Mixed upland hardwoods.
Q. alba/Mixed subcanopy hardwoods.
Q. alba/Vaccinium pallidum (vacillans).
Q. alba-Acer rubrum.

DRY-MESIC OAK--HICKORY FOREST

Sites: Mid slopes, low ridges, upland flats, and other dry-mesic upland areas on acidic soils.

Soils: A variety of upland soils. Series include Cecil, Pacolet, Wedowee, Georgeville, Tatum, Kalmia (Typic Hapludults), Wagram (Arenic Paleudult), Tallapoosa (Ochreptic hapludult), and Stallings (Aeric Paleudult).

Hydrology: Terrestrial, dry-mesic.

Vegetation: Forest dominated by mixtures of oaks and hickories, with Quercus alba most prevalent, along with Q. rubra, Q. velutina, Carya alba (tomentosa), C. ovalis, and C. glabra. Pinus species, Liriodendron tulipifera, and Liquidambar styraciflua may be common. Understory species include Acer rubrum, Cornus florida, Oxydendrum arborem, Ilex opaca, and Nyssa sylvatica. Shrubs include Viburnum rafinesquianum, Vaccinium stamineum, Vaccinium pallidum (vacillans), and Evonymus americana. Vitis rotundifolia and Toxicodendron (Rhus) radicans often are present. Herbs are fairly sparse, with Hexastylis spp., Goodyera pubescens, Chimaphila maculata, Desmodium nudiflorum, and Hieracium venosum common.

Dynamics: Disturbed areas have increased amounts of pines and weedy hardwoods such as Acer rubrum and Liquidambar styraciflua, with the amounts depending on the degree of canopy opening. Areas that were cultivated are generally dominated by even-aged pine stands which are replaced by the climax oaks and hickories only as the pines die. Logged areas may have a mixture of hardwoods and pines.

Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms may allow pulses of increased regeneration and allow the less shade tolerant species to remain in the community. However, Skeen, Carter, and Ragsdale (1980) argued that even the shade-intolerant Liriodendron could reproduce enough in gaps to persist in the climax Piedmont forests.

The natural fire regime of the Piedmont is not known, but fires certainly occurred periodically. Most of the component trees are able to tolerate light surface fires with little effect. Regular fire may have created a more open forest, with gaps persising longer than at present and perhaps forming more frequently.

In sandy parts of the Coastal Plain, fires were frequent, apparently every 3-5 years. Dry-Mesic Oak--Hickory Forests are confined to areas that are somewhat sheltered from fire spread. With the reduction in fire frequency in the Coastal Plain, many longleaf pine-dominated communities have been invaded by oaks and hickories, though most resemble Dry Oak--Hickory Forests rather than Dry-Mesic Oak--Hickory Forests.

Range: Throughout the Piedmont and Coastal Plain, possibly in the lower parts of the Blue Ridge.

Associations: Occurs in the topographic moisture gradient, between Dry Oak-- Hickory Forest and Mesic Mixed Hardwoods (Piedmont or Coastal Plain Subtype). May also grade into Piedmont/Coastal Plain Acidic Cliff, Piedmont/Coastal Plain Heath Bluff, Piedmont Monadnock Forest, other upland communities, or floodplain communities.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition. Both Dry Oak--Hickory Forests and Dry-Mesic Oak--Hickory Forests often have Q. alba as the predominant tree. In Dry-Mesic Oak--Hickory Forests trees more mesophytic than Q. alba predominate over those more xeric. Mesic Mixed Hardwood Forest is dominated by Q. rubra, Fagus grandifolia, Liriodendron tulipifera, or other trees more mesic than Q. alba. Dry-Mesic Oak--Hickory Forest is distinguished from Piedmont/Coastal Plain Acidic Cliff and Piedmont/Coastal Plain Heath Bluff by the presence of a naturally closed or nearly closed canopy. It is distinguished from Montane Oak--Hickory Forest by the absence of species typical of the Blue Ridge in North Carolina, such as Castanea dentata and Rhododendron calendulaceum.

Variation: This type has substantial variation within it, although less than might be expected given its wide geographic range. No variants are recognized, although the floristic and vegetational differences between examples on sandy Coastal Plain sites and those on Piedmont and clayey soils are worthy of consideration.

Comments: Dry-Mesic Oak--Hickory Forests were once one of the predominant community types in the Piedmont. Their

abundance in the Coastal Plain is less certain, but they were clearly widespread there as well. Most of this area is now in agriculture, urban development, or is occupied by successional pine stands after past agriculture. What was not cleared was subject to long-term cutting and to livestock foraging. This type is still relatively common compared to most natural community types, but examples of significant size and good quality are fairly rare. Most protected areas in the Piedmont center around dissected lands near rivers or creeks. Dry-Mesic Oak--Hickory Forests are relatively common in these areas and many good small examples are protected.

Rare Plant Species: Vascular -- Amorpha schwerinii, Helianthemum propinquum, Hexastylis lewisii, Nestronia umbellula, Orbexilum pedunculatum var. pedunculatum, Porteranthus stipulatus, Prunus alabamensis, Pyrola americana, Quercus prinoides, Smilax biltmoreana, Smilax hugeri.

Synonyms:
Mesic Mesotrophic and Dry-mesic Mesotrophic Forest (Peet and Christensen 1980).
White Oak-Red Oak-Black Oak (Oosting 1942).
Type III (Nehmeth 1968).
SAF 52: White Oak-Black Oak-Northern Red Oak.

Examples:
Duke Forest, Durham, Korstian, Blackwood, and Eno Divisons, Orange and Durham counties (Oosting 1942, Ohman 1980).
Caswell Upland Hardwood Forest, Cherokee Boy Scout Camp, Caswell County.
W.B. Umstead State Park, Wake County.
Eno River State Park, Orange and Durham counties.
Rankin Hardwood Forest, Gaston County.
Rendezvous Mountain State Forest, Wilkes County.
Otter Creek Natural Area, East Carolina University, Pitt County.
Camassia Slope--Roanoke River, Northampton County (Lynch 1981)
Flanner Beach Scarp area, Craven County (McDonald, Ash, and Fussell 1981).
Hunters Creek Upland Forest, Croatan National Forest, Jones County.

References: Glazier (1967), LeGrand and Dalton (1987), Lynch (1981), McDonald, Ash, and Fussell (1981), Nehmeth (1968), Ohmann (1980), Oosting (1942), Peet and Christensen (1980), Sechrest and Cooper (1970), Skeen, Carter, and Ragsdale (1980), Wells (1928), Wells (1942), Wells (1974).

Sample Plant Communities:
Mixed oaks/Cornus florida.
Mixed oaks/Cornus florida/Mixed herbs.
Mixed upland oaks.
Mixed upland oaks/Mixed subcanopy hardwoods/Cornus florida.
Mixed upland oaks-Mixed upland hardwoods/Mixed subcanopy hardwoods.
Mixed upland oaks-Mixed upland hickories.
Mixed upland oaks-Mixed upland hickories/Ostrya virginiana-Mixed subcanopy.
Q. alba-Mixed upland hardwoods.
Q. alba/Mixed subcanopy hardwoods.
A. alba/Cornus florida.
Q. rubra/Viburnum rafinesquianum.
Q. rubra-Q. alba/Viburnum rafinesquianum.

BASIC OAK--HICKORY FOREST

Sites: Slopes, ridges, upland flats, and other dry to dry-mesic sites on basic or circumneutral soils.

Soils: Generally Hapludalfs, developed from rocks such as diabase, gabbro, or mafic metamorphics. Series include Iredell (Typic Hapludalf), Mecklenburg (Ultic Hapludalf), Pinkston (Ruptic-Ultic Dystrochrept), and Picture (Abruptic Argiaquoll).

Hydrology: Terrestrial, dry to dry-mesic.

Vegetation: Canopy dominated by mixtures of oaks and hickories, including Quercus alba, Q. stellata, Q. velutina, Q. muehlenbergii, various other oaks, Carya carolinae-septentrionalis, C. glabra, C. alba (tomentosa), and C. ovalis. Other trees include Fraxinus americana, Liriodendron tulipifera, Juglans nigra, and Pinus spp. Understory includes species such as Cornus florida, Cercis canadensis, Chionanthus virginicus, Acer leucoderme, and Ostrya virginiana. Shrubs may include Calycanthus floridus, Aesculus sylvatica, Rhus aromatica, Symphoricarpos orbiculatus, Viburnum acerifolium, Viburnum prunifolium, and Viburnum rafinesquianum. The herb layer is usually moderately diverse, with species such as Carex artitecta, C. nigromarginata, Polygonatum biflorum, Galium circaezans, Uvularia perfoliata, Scleria oligantha, Aristolochia serpentaria, Euphorbia corollata, and in the mesic part of the range of this type, as on lower slopes, many of the herbs of the Basic Mesic Forest.

Dynamics: Disturbed areas have increased amounts of pines and weedy hardwoods such as Acer rubrum and Liquidambar styraciflua, with the amounts depending on the degree of canopy opening. Areas that were cultivated are generally dominated by even-aged pine stands which are replaced by the climax oaks and hickories only as the pines die. Selectively logged areas may have a mixture of hardwoods and pines.

Under natural conditions these forests are uneven-aged, with old trees present. Reproduction occurs primarily in canopy gaps. Rare severe natural disturbances such as wind storms may allow pulses of increased regeneration and allow the less shade tolerant species to remain in the community. However, Skeen, Carter, and Ragsdale (1980) argued that even the shade-intolerant Liriodendron could reproduce enough in gaps to persist in the climax Piedmont forests.

The natural fire regime of the Piedmont is not known, but fires certainly occurred periodically. Most of the component trees are able to tolerate light surface fires with little effect. Regular fire may have created a more open forest, with gaps persisting longer than at present and perhaps forming more frequently.

Range: Scattered in the Piedmont, very rare in the Coastal Plain and lower Blue Ridge.

Associations: Often associated with Xeric Hardpan Forest and Upland Depression Swamp Forest. Grades into Basic Mesic Forest (various subtypes) downslope or in more sheltered sites. Grades to regular (acidic) upland forest communities at geologic contacts.

Distinguishing Features: The factors distinguishing Basic Oak--Hickory Forests from Dry and Dry-Mesic Oak--Hickory Forests are not well known. Vegetational differences include a greater diversity of plant species, greater importance of hickories, and a variety of herbs generally associated with more mesic areas. Acid-loving species such as Vaccinium spp. and Oxydendrum arboreum are sparse or absent. Circumneutral or higher soil pH is a good indicator. Occurrence on mafic rock or on one of the soil series listed above suggests that a site is Basic Oak--Hickory Forest, although sites mapped as these soils sometimes give no vegetational indication of having basic soils. Basic Oak--Hickory Forests are distinguished from Basic Mesic Forest by the dominance of oaks and hickories in the canopy, and the absence or near absence of species such as Fagus grandifolia.

Basic Oak--Hickory Forests are distinguished from Xeric Hardpan Forests by canopy dominance, more mesic species composition, and closed canopy. They are distinguished from Piedmont Mafic Cliff or Piedmont Calcareous Cliff by naturally having a closed or nearly closed canopy.

Variation: Two variants are recognized:
1. Mafic Substrate Variant, on mafic igneous or metamorphic rocks.
2. Calcareous Substrate Variant, on limestone, dolomite, or calcite-cemented clastic sedimentary rocks.

There are apparently associated floristic differences which eventually may warrant separation into two subtypes or types. Some sites on metamorphosed argillite or graywacke may be intermediate. Examples also vary with moisture regime and soil pH.

Comments: This type covers a moisture range equivalent to both the Dry and Dry- Mesic Oak--Hickory Forest types. This is partly because less is known about these communities than their more common acidic counterparts and there is less basis for splitting types. It is also somewhat more difficult to tell moisture levels by the vegetation in these communities. Many species that are confined to relatively mesic areas on acidic substrates occur in apparently drier sites on higher pH soils. Many sites also probably have some clay hardpan development, though less so than in the Xeric Hardpan Forest or Upland Depression Swamp Forest. These areas may be alternately wet and dry, and often contain unusual mixtures of species.

Although mesic forests on basic rock are widely regarded as distinctive from those on acidic rock, drier basic forests are less often addressed. It may be that the greater erosion and leaching on higher areas, combined with greater water limitation on plants, makes the distinction between acidic and basic substrates less clear in dry sites. A number of species occur in these communities that are usually confined, on more acidic soils, to more mesic sites.

Rare Plant Species: Vascular -- Agastache nepetoides, Baptisia australis var. australis, Berberis canadensis, Buchnera americana, Cirsium carolinianum, Hexalectris spicata, Lathyrus venosus, Lotus purshianus var. helleri, Nestronia umbellula, Polygala senega, Porteranthus stipulatus, Ruellia purshiana, Silphium terebinthinaceum, Sisyrinchium dichotomum, Smilax biltmoreana, Smilax lasioneura, Solidago ptarmicoides.

Synonyms:
Dry Eutrophic, Dry-Mesic Eutrophic (Peet and Christensen 1980).

Examples:
Frogsboro Upland Depression Forest site, Caswell Game Land, Caswell County.
Goshen Gabbro Forest, Granville County (LeGrand 1986).
South Butner Diabase Hardwood Forest, Granville County (LeGrand 1986).
Uwharrie Mafic Rock Area, Uwharrie National Forest, Montgomery County.
Cedar Mountain, Rockingham County.
Mason Farm Southern Shagbark Hickory Forest, Orange County (Sather and Hall 1988).
Linville Caverns, Burke County.

References: Dayton (1966), Frye (1989), LeGrand (1986), Oosting (1942), Peet and Christensen (1980), Sather and Hall (1988).

Sample Plant Communities:
Carya glabra-Mixed upland oaks and hickories.
Mixed upland hickories/Cornus florida.
Mixed upland oaks.
Mixed upland oaks/Mixed subcanopy hardwoods-Cornus florida.
Mixed upland oaks-Mixed upland hardwoods/Mixed subcanopy hardwoods.
Mixed upland oaks-Mixed upland hardwoods/Mixed subcanopy hardwoods/Polystichum acrostichoides-Mixed herbs.
Mixed upland oaks-Mixed upland hickories.
Mixed upland oaks-Mixed upland hickories/Cercis canadensis-Mixed subcanopy hardwoods.
Mixed upland oaks-Mixed upland hickories/Ostrya virginiana-Mixed subcanopy hardwoods.
Quercus alba-Quercus rubra/Acer saccharum-Mixed subcanopy hardwoods/Panicum spp.-Mixed herbs.
Carya carolinae-septentrionalis-Mixed oaks/Viburnum rafinesquianum-Mixed shrubs.
Carya carolinae-septentrionalis-Mixed oaks/Acer leucoderme.

XERIC HARDPAN FOREST

Sites: Upland flats and gentle slopes with an impermeable clay subsoil but which do not pond water for extended periods. Most commonly occurs on mafic rocks.

Soils: Various Piedmont soils with a clay hardpan or shallow rock. The most typical series are Iredell (Typic Hapludalf), Misenheimer (Aquic Dystrochrept), and Picture (Abruptic Argiaquoll). Examples also are mapped as Enon (Ultic Hapludalf), Helena (Aquic Hapludult), and Wedowee (Typic Hapludult), but may occur on inclusions in these map units.

Hydrology: Terrestrial. Impermeable subsoil makes soil very dry in summer and during drought periods, but wet in rainy periods.

Vegetation: Somewhat stunted and open canopy characteristically dominated by Quercus stellata and Quercus marilandica. A variety of other species may be present, including Pinus virginiana, P. echinata, Carya carolinae-septentrionalis, Carya glabra, Fraxinus americana, Quercus alba, Q. phellos, and various other oaks. Typical understory species include Juniperus virginiana, Cercis canadensis, Diospyros virginiana, Vaccinium arboreum, Ulmus alata, and Chionanthus virginicus. Shrubs may be sparse or dense, with Viburnum rafinesquianum, V. prunifolium, Vaccinium stamineum, and V. pallidum (vacillans) typical. The most common herbs are Danthonia spicata and Schizachyrium (Andropogon) scoparium. Other herbs include Clematis ochroleuca, Aster solidagineus, Hieracium venosum, Hieracium gronovii, Hypericum hypericoides, Aster dumosus, Lespedeza spp., Oenothera fruticosa, Liatris graminifolia, and Solidago spp. A few areas, all with the canopy removed or kept open by artificial disturbance, have a very diverse herbaceous flora, with a number of species of prairie affinities.

Dynamics: The natural structure and dynamics of these communities is uncertain. Most now have a nearly closed canopy. Reproduction occurs in canopy gaps. In disturbed sites pines may dominate, but these sites appear to succeed to post oak-blackjack oak dominance. Succession is slowed by the unfavorable site conditions. Although the natural fire frequency is not known, it was certainly greater than now. With normally dry conditions and a grassy herb layer, these sites would have been susceptible to fire almost any time there was ignition. Fire of even moderate frequency would likely have combined with the dry site conditions to reduce tree reproduction and increase grass dominance, producing a more open, or even prairie-like, vegetation structure than is now seen. Fire would have had greater effects on the vegetation structure on these unfavorable sites than in adjacent, more mesic hardwood forests which would have burned with the same frequency. Historical references (Logan 1859, Brown 1953) 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. Similar prairies probably existed in the Charlotte belt and elsewhere in North Carolina, particularly on the soils that support Xeric Hardpan Forests. No remnants of this prairie are known in either state, although Diabase Glade communities probably contain many of the same species. The occurrence of a number of species associated with Xeric Hardpan Forests but occurring largely in pastures, roadsides, and other chronically disturbed areas supports the idea of a naturally more open vegetation structure.

Range: Scattered throughout the Piedmont.

Associations: Usually associated with Upland Depression Swamp Forest and Basic Oak--Hickory Forest or Dry Oak--Hickory Forest.

Distinguishing Features: This type is distinguished from Basic Oak--Hickory Forest, Dry Oak--Hickory Forest, Upland Depression Swamp, and other associated hardwood forests by the canopy dominated by Quercus stellata, with or without Q. marilandica. The canopy is usually distinctly open. Disturbed examples will usually have these species as understory associates, but distinguishing the type is more difficult. Diabase Glades are distinguished from Xeric Hardpan Forests by their more open structure, presence of solid rock near the surface, and mixed physiognomy, with herb, shrub, and woodland patches.

Variation: Sites vary in openness of the forest and diversity of the herbaceous layer, presumably with drainage, dryness, soil pH, and disturbance. There may be significant floristic differences between examples on circumneutral soils, such as Iredell,

and acidic soils, such as Misenheimer.

Comments: This community type is relatively rare. The conditions necessary for the formation of the impermeable subsoil seem to be fairly specialized and many areas of apparently suitable substrate, and even of the appropriate soil series, do not support Xeric Hardpan Forests. Oosting (1942) estimated this type comprised 1% of the mature upland hardwoods area in Duke Forest. Since few of these areas would have been farmed, it is likely that they represented a much smaller portion of the original vegetation.

Rare Plant Species: Vascular -- Echinacea laevigata, Helianthus laevigatus, Helianthus schweinitzii, Hexalectris spicata, Hexastylis lewisii, Lathyrus venosus, Liatris squarrulosa, Lithospermum canescens, Lotus purshianus var. helleri, Parthenium integrifolium var. auriculatum, Silphium terebinthinaceum; nonvascular -- Lophozia capitata.

Synonyms:
Montmorillonite Forest (Peet and Christensen 1981; Second Approximation).
Preclimax (Oosting 1942).
SAF 40: Post Oak-Blackjack Oak (in part).

Examples:
Frogsboro Upland Depression Swamp site, Caswell Game Land, Caswell County.
Goshen Gabbro Forest, Granville County (LeGrand 1986).
Uwharrie Mafic Rock Area, Uwharrie National Forest, Montgomery County.
South Butner Diabase Glade site, Granville County (LeGrand 1986).
Blackwood Division, Duke Forest, Orange County (Ohmann 1981).

References: Batson (1952), Brown (1953), Dayton (1966), Frye (1989), LeGrand (1986), Logan (1859), Ohmann (1980), Oosting (1942), Peet and Christensen (1980).

Sample Plant Communities:
Quercus stellata-Mixed upland hickories and oaks/Viburnum rafinesquianum.
Quercus marilandica-Quercus stellata.
Quercus marilandica-Quercus stellata/Juniperus virginiana.
Quercus stellata/Danthonia spicata.

PIEDMONT LONGLEAF PINE FOREST

Sites: Most examples are known from upland flats, but some are on rolling terrain or steeper slopes.

Soils: Various Hapludults. Examples are mapped as Lignum (Aquic Hapludult), Mayodan, Georgeville, and Nason (all Typic Hapludults).

Hydrology: Terrestrial, dry to mesic, or palustrine, intermittently to seasonally flooded.

Vegetation: Natural vegetation is essentially unknown for this type. A number of sites have enough stumps to suggest that Pinus palustris formed a rather dense canopy in the past. Presence of Aristida stricta, Gaylussacia dumosa, G. frondosa, Vaccinium crassifolium, and similar species suggest that some communities might have had an open canopy and flatwoods-like structure. At present, some former Pinus palustris communiies are dominated by hardwoods of the Dry Oak--Hickory or Dry-Mesic Oak--Hickory Forest types, with remnent pines present. Others are mixed stands of Pinus taeda, P. echinata, or P. serotina with some P. palustris. In wetter sites, Liquidambar styraciflua and Acer rubrum may form a subcanopy. The herb layer varies widely among the sites, but often shows at least a few species of Coastal Plain affinities.

Dynamics: Very little is known about these communities. The past dominance of Pinus palustris and the presence of various sandhill or flatwoods species suggests that fire must have been important. After long fire suppression most sites that were not cut recently are succeeding to hardwood dominance. Those that were cut more recently have become dominated by other pines.

Range: Known only from the eastern Piedmont adjacent to the Sandhills, in Moore, Montgomery, and Anson County. Ashe and Pinchot (1897) described a transitional forest of Pinus palustris with various dry oaks in Nash, Wake, Montgomery, Northampton, and Halifax Counties that might have been this type.

Associations: Known examples generally grade to Dry Oak--Hickory, Dry-Mesic Oak--Hickory, Mesic Mixed Hardwoods, or various floodplain forests.

Distinguishing Features: This type includes all sites in the Piedmont naturally dominated by Pinus palustris, with the exception of those that would fall into the Piedmont/Coastal Plain Acidic Cliff type or the Dry Pine Variant of the Dry Oak--Hickory Forest.

Variation: As constituted, this type is extremely heterogeneous, in topographic setting, soil, hydrology, and vegetation. The original vegetation undoubtedly contained several distinct types of longleaf pine-dominated communities in the Piedmont. Some may have been essentially similar to Coastal Plain communities, while others may have been unique. Further study may allow refinement of the classification of these communities, though extreme modifications resulting from fire suppression and logging make understanding of the original extent, composition, and structure of these communities very difficult.

Comments: This type is a somewhat arbitrary category established for the few remnants left of these communities whose true nature is very poorly known. The natural structure, natural disturbance regime, the role of hardwoods, and other aspects of their character are not known. Most of the information in the above description comes from Carter and LeGrand (1989) and Carter (pers. comm.).

How these communities fit into the Piedmont landscape is unclear. They may have once covered a large portion of the uplands of the lower Piedmont, as they did in the Sandhills Region, or they may have always occurred as smaller patches on specialized sites. Several of the known sites are on unusually flat, wet soils, but others are on ordinary rolling uplands. While the presence of remnant fire-adapted species suggests that fire was important, the relative roles of unusual sites, fire, and other kinds of disturbance are not known.

While further field survey may yield additional examples, which may provide more information on the type, much of the natural character of these communities may have to be inferred from the results of experimental restoration efforts such as burning and removing hardwoods.

Rare Plant Species: Unknown.

Synonyms:
Some of occurrences would have fallen into the Pine Flatwoods type of the Second Approximation.

Examples:
Pleasant Grove Mixed Pine Savanna, Uwharrie National Forest, Montgomery County.
Spies Longleaf/Wiregrass Site, Moore County (Carter and LeGrand 1989).
Dover Longleaf Stand, Moore County (Carter and LeGrand 1989).
Westmoore Longleaf Stand, Moore County (Carter and LeGrand 1989).
Cole Old-Growth Longleaf Stand, Moore County (Carter and LeGrand 1989).
Pee Dee National Wildlife Refuge, Anson County.

References: Ashe and Pinchot (1897), Carter and LeGrand (1989).

Sample Plant Communities:
Pinus palustris-Quercus falcata/mixed hardwoods.
Pinus palustris/mixed hardwoods.
Pinus palustris-Quercus stellata.
Pinus taeda-P. palustris/mixed subcanopy hardoods/Aristida stricta.
Pinus taeda-P. serotina/Acer rubrum-Liquidambar styraciflua.

HIGH ELEVATION ROCKY SUMMIT

Sites: Rugged, horizontal and vertical rock outcrops on exposed ridges, peaks, and upper slopes.

Soils: Vary from bare rock areas with no soil, to shallow soil over rock at edges, to deeper mineral or organic soil in cracks. Series are generally not mapped and have received little scientific study or classification effort since they lack agricultural or development potential.

Hydrology: Very variable spatially and temporally. The thin soils and exposed rock surfaces are often wetted by rain, fog deposition, and seepage. Seepages are frequent, and vary from nearly constant or perennial to seasonal or flowing only after heavy rains. When and where seepage is not flowing, the thin soils and bare rocks dry quickly after rain or fog deposition, providing extremes of wet and dry conditions. The cool temperatures, high rainfall, and frequent fog at high elevations make these sites moister overall than Low Elevation Rocky Summits. They tend to be moister than High Elevation Granitic Domes, because the presence of deep crevices allows greater water storage, and because most High Elevation Rocky Summits face north while most High Elevation Granitic Domes face south.

Vegetation: Generally very heterogeneous, often with individual plants occurring in distinct microsites. Crevices and soil pockets may support trees or shrubs such as Abies fraseri, Picea rubens, Betula alleghaniensis (lutea), Amelanchier arborea, Sorbus americana, Rhododendron catawbiense, Rhododendron carolinianum (minus), Leiophyllum buxifolium, Pieris floribunda, and Menziesia pilosa. These may resemble Heath Bald or Pine-Oak/Heath vegetation. Herbs occur on shallower soil and on the rock itself. Herb species include Saxifraga michauxii, Heuchera villosa, Danthonia compressa, Deschampsia flexuosa, Paronychia argyrocoma, Selaginella tortipila, Sibbaldiopsis (Potentilla) tridentata, Sedum telephioides, Asplenium montanum, Geum radiatum, Krigia montana, Minuartia (Arenaria) groenlandica, Senecio smallii (anonymus), Houstonia montana, Huperzia (Lycopodium) selago, Carex brunnescens, Carex misera, Scirpus cespitosus, and Potentilla canadensis. Nonvascular plants such as the moss Polytrichum appalachianum, the lichens Lasallia papulosa, Cladonia spp., and Umbilicaria spp., and various crustose species are important on bare rock.

Dynamics: These areas are generally in early stages of primary succession, which is slowed by resistant rock and unfavorable environment. While rock weathering and soil accumulation would theoretically allow development of a Heath Bald community, or at lower elevation, a Pine--Oak/Heath community, the resistant rock, steep topography, cold climate, and occasional sloughing of accumulated soil serve to maintain these communities indefinitely. There is little understanding of the dynamics of competition, reproduction, and establishment of plants in these communities.

Range: Throughout the higher parts of the Mountain Region, though best developed north of the Asheville Basin. Largely replaced in the vicinity of Highlands, North Carolina by High Elevation Granitic Domes.

Associations: Grades to Heath Bald, Grassy Bald, or high elevation forest communities.

Distinguishing Features: High Elevation Rocky Summits are distinguished from Heath Bald, Grassy Bald, and forest communities by lacking a closed tree or shrub canopy and having substantial areas of bare rock. Heath Bald- or Grassy Bald-like vegetation may occur within and on the edges of Rocky Summit communities. Such ares should be considered part of the Rocky Summit unless they cover a substantial area or extend far from the rock outcrop.

High Elevation Rocky Summits are distinguished from cliff communities by occurring in higher, more exposed sites, on upper slopes or summits. They are distinguished from Granitic Domes by having irregular, fractured rock rather than smooth exfoliating rock. This produces greater heterogeneity of soil and allows vascular plants rooted in crevices and soil pockets to predominate.

High Elevation Rocky Summits are distinguished from Low Elevation Rocky Summits by being higher, generally above 4000 feet. Species which occur in Low Elevation Rocky Summits but seldom in high include Dichanthelium spp., Diodia teres, and Talinum teretifolium. Species that occur in high but seldom in low include Carex misera, Sibbaldiopsis (Potentilla) tridentata, Scirpus cespitosus, Carex brunnescens, Geum radiatum, Solidago spithamaea, Liatris helleri, Houstonia montana, and Menziesia pilosa.

Variation: Very heterogeneous within and among sites, related to elevation, exposure, and physical structure and chemical nature of the rock. Three variants are tentatively defined:

1. Northern Variant, extending from the Virginia border to the Asheville Basin, has the most northern and alpine affinities. Elevations in this area are generally higher than in the other two variants. This variant has a suite of endemic species limited or nearly limited to it, and also has more northern disjunct and peripheral species. Where the substrate consists of mafic rocks such as amphibolite or metadiabase, atypical calciphilic species such as Aquilegia canadensis, Senecio plattensis, Physocarpus opulifolius, and Arabis lyrata may occur. Many of the known examples occur on mafic rocks, and the relative importances of substrate and latitude are not known.

2. Quartzite Variant, known definitely only from the rim of Linville Gorge, has more southern affinities and shows a relationship to Pine--Oak/Heath. Thin soils weathered from quartzite are sandy and very strongly acidic. Lower elevation and less frequent rainfall and fog deposition make this variant distinctly more xeric than the northern variant.

3. Southern Variant, generally occurring south of the Asheville Basin, where the substrates are generally acidic gneisses and schists. This appears to be the least distinctive variant of the three, with few good examples known.

Comments: This type represents the rocky peaks, knobs, and ridgetops which are not included in the Cliff or Granitic Dome categories. These are the most exposed sites in the high elevation zone. They result from a combination of poor soil development and exposure to extreme weather conditions. The importance of natural disturbance is uncertain.

The High Elevation Rocky Summits have a much more distinctive flora than Low Elevation Rocky Summits, including a number of rare endemic or northern disjunct species. Where Rocky Summits are accessible, they are easily damaged by trampling. Because they offer good views, they may receive heavy public use. Some examples, however, are well protected from disturbance by their remoteness and ruggedness.

Floristically, High Elevation Rocky Summits are of great interest, with a mixture of northern tundra disjuncts (such as Scirpus cespitosus, Trisetum spicatum, Huperzia selago), species sibling to northern species (Geum radiatum/Geum peckii), broad Southern Appalachian endemics (Asplenium montanum, Heuchera villosa, Saxifraga michauxii, Sedum telephioides), and narrow Southern Appalachian endemics (Liatris helleri, Solidago spithamaea, Houstonia montana, Gymnoderma lineare), and more general, widespread species (Potentilla canadensis, Danthonia compressa). Some of the endemics or near endemics are likely of recent origin, showing close relationship to Appalachian or northern siblings (Geum radiatum, Liatris helleri, Houstonia montana), while others are evidently ancient (Paronychia argyrocoma, Leiophyllum buxifolium, Gymnoderma lineare).

This community type might also be called the Southern Appalachian Alpine Zone. It differs from truer alpine zones in depending on a combination of climate and shallow soils, rather than climate alone, to maintain dominance by herbs, mosses, and lichens. North Carolina's High Elevation Rocky Summits show substantial affinities to the alpine tundra of New England and New York. They represent evolved relicts of the alpine tundra which occupied substantial acreages at high elevations in the southern Appalachians during the Pleistocene. Their components are a mixture of northern elements able to survive in the south in these specialized and extreme sites and southern elements recruited from surrounding vegetation.

Rare Plant Species: Vascular -- Agrostis mertensii, Alnus viridis ssp. crispa, Calamagrostis cainii, Carex aenea, Carex biltmoreana, Carex misera, Corydalis sempervirens, Cystopteris tenuis, Deschampsia cespitosa ssp. glauca, Geum radiatum, Gymnocarpium sp. 1, Helianthemum bicknellii, Helianthemum propinquum, Houstonia purpurea var. montana, Huperzia selago, Hypericum buckleyi, Juncus trifidus var. carolinianus, Liatris aspera, Liatris helleri, Milium effusum, Minuartia groenlandica, Populus grandidentata, Prenanthes roanensis, Rhododendron vaseyi, Scirpus cespitosus, Sedum rosea, Selaginella tortipila, Solidago spithamaea, Trisetum spicatum, Woodsia scopulina; nonvascular -- Anastrophyllum saxicola, Bazzania nudicaulis, Cephaloziella massalongi, Cephaloziella obtusilobula, Cephaloziella spinicaulis, Gymnoderma lineare, Leptodontium flexifolium, Lophozia attenuata, Lophozia barbata, Lophozia excisa, Lophozia hatcheri, Mylia taylorii, Nardia scalaris, Rhytidium rugosum.

Synonyms:
Rock outcrop, cliff (general usage).
May occasionally be called balds. If large and flat, may be called flatrock.

Examples:
Northern Variant:
Grandfather Mountain, Avery and Watauga counties (best developed and most extensive examples).
Hanging Rock Mountain, Avery County (Rohrer 1983).
Big Yellow Mountain, Avery County (Weakley 1980).
Bluff Mountain, Ashe County (Weakley 1979).
Mount Jefferson, Ashe County.
Tater Hill, Watauga County.
The Peak, Ashe County.
Phoenix Mountain, Ashe County.
Pinnacles of the Beech, Avery County.
Roan High Bluff, Eagle Cliff, Grassy Ridge and other sites in the Roan Mountain highlands, Pisgah National Forest, Mitchell and Avery counties.
The Craggies, Pisgah National Forest, Blue Ridge Parkway, and Asheville Watershed, Buncombe County (Heiman and Smith in prep.).
Horse Rock, Black Mountains, Pisgah National Forest, Yancey County.

Quartzite Variant:
Tablerock Mountain, Hawksbill Mountain, The Chimneys, and other areas on the east rim of Linville Gorge, Pisgah National Forest, Burke County.

Southern Variant:
Chestnut Bald and Silvermine Bald, Blue Ridge Parkway, Transylvania and Haywood counties.

References: Heiman and Smith (in prep.), Otte (1978), Rohrer (1983), Weakley, Mehrhoff, and Mansberg (1979), Weakley (1980).

Sample Plant Communities:
Bare rock.
Mixed crustose lichens.
Cetraria arenaria.
Paronychia argyrocoma.
Scirpus cespitosus.
Carex misera.
Selaginella tortipila.
Sibbaldiopsis (Potentilla) tridentata.
Sibbaldiopsis tridentata-Danthonia compressa.
Saxifraga michauxii.
Heuchera villosa.
Mixed rock outcrop herbs.
Leiphyllum buxifolium.
Rhododendron catawbiense.

HIGH ELEVATION GRANITIC DOME

Sites: Steep to gently sloping exposures of smooth, exfoliating granite or similar massive igneous or metamorphic rock such as granitic gneiss. Most well- developed exfoliation surfaces are south-facing.

Soils: Soils are generally absent, except for patchy mats of shallow organic or mineral matter, usually of a sandy texture. Shallow, rocky, continuous soils occur at the periphery. Deeper soils are generally absent because of the lack of crevices. Most of the areal extent is bare rock. The thin soils have received little scientific study or classification effort, since they lack agricultural or development potential.

Hydrology: Very variable spatially and temporally. The thin soils and exposed rock surfaces are often wetted by rain, fog deposition, and seepage. Seepages are frequent and vary from nearly constant or perennial to seasonal or flowing only after heavy rains. When and where seepage is not flowing, the thin soils and bare rocks dry quickly after rain or fog deposition, providing extremes of wet and dry conditions. The cool temperatures, high rainfall, and frequent fog at high elevations make these sites moister overall than Low Elevation Granitic Domes, but the lack of crevices makes them drier than High Elevation Rocky Summits. Most well-developed domes face south, and this also makes them drier.

Vegetation: Bare rock is vegetated by mats of distinctive species, zoned with soil depth and age. Important early species include Racomitrium heterostichum, Grimmia laevigata, Cladonia spp., Selaginella tortipila, Selaginella rupestris, and Polytrichum spp. Species in more developed mats include Danthonia spicata, Danthonia compressa, Carex misera, Carex debilis, Krigia montana, Schizachyrium (Andropogon) scoparium, Senecio millefolium, Bulbostylis capillaris, Hypericum buckleyi, Maianthemum canadense, and Corydalis sempervirens. Areas with deeper soil, such as old stable mats or edges, may have woody species such as Leiophyllum buxifolium, Kalmia latifolia, Rhododendron carolinianum, Pinus pungens, Quercus rubra, Sorbus americana, Tsuga caroliniana, and species from the surrounding communities. Seeps may contain Andreaea rupestris, Hedwigia ciliata, Sphagnum spp., and Carex biltmoreana.

Dynamics: The overall complex appears to be stable through time. Vegetation mats expand as pioneers establish at their edges and deepen as later stages invade the center. Most mats are destroyed by falling under their own weight or by spalling of the rock before they become very old. Windthrow of trees may destroy the mats they are rooted in. The breadth of the thicker mats at the upper edge may change over time.

Range: Marginal examples are widely scattered in the Blue Ridge, but most extensive well-developed examples are in the Highlands-Cashiers and Looking Glass Rock areas.

Associations: May grade to High Elevation Red Oak Forest, Pine--Oak/Heath, Montane Oak--Hickory Forest, Canada Hemlock Forest, Acidic Cove Forest, or other forest communities.

Distinguishing Features: High Elevation Granitic Domes are distinguished from High Elevation Rocky Summits by occurring on massive, exfoliating rock with few crevices or irregularities containing soil. Almost all of the soil consists of thin mats over solid rock. Marginal examples that appear to be relict or inactive exfoliation faces, with few crevices but with weathered and pitted surfaces, are fairly common. These areas often have vegetation that is depauperate, or that is transitional between Rocky Summit and Granitic Dome. Classification of these areas is difficult.

High Elevation Granitic Domes are distinguished from Acidic Cliffs by the smooth, exfoliating rock and by their more exposed topographic position. They are primarily on upper slopes to summits, only occasionally down the mid or lower slopes.

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, Scirpus cespitosus, Danthonia compressa, Hypericum buckleyi, Senecio millefolium, Robinia viscosa var. hartwegii, and Leiophyllum buxifolium. Species that occur in Low Elevation Granitic Domes but seldom in High Elevation include Talinum teretifolium, Lindernia monticola, Phlox nivalis ssp. hentzii, Scleria triglomerata, Baptisia tinctoria, Ulmus alata, Fraxinus americana, Carya spp., Chionanthus virginianus, and Ptelea trifoliata.

High Elevation Granitic Domes often have zones along their edges with Pine-- Oak/Heath- or Heath Bald-like vegetation. These should be considered part of the Granitic Dome community unless they cover a substantial areas or extend far from the rock outcrop.

Low and High Elevation Granitic Domes usually have Pine--Oak/Heath-like vegetation in the shallow soil surrounding the open rock. In general, these should be considered merely zones of the dome community unless they cover a substantial area or extend far from the rock outcrop.

Variation: Variation depends on age of mats, exposure, and presence or absence of seepage. Steepness appears to be important primarily in determining the stability of vegetation mats and the frequency of water-holding weathering pits. Variation also occurs with elevation differences.

Comments: The smooth surface and lack of crevices on exfoliation domes creates an environment which lacks many of the microhabitats found on outcrops of fractured rock. On the open rock face most of the vegetation is in zoned mats. The steep slopes cause frequent destruction of these mats, leaving the face dominated by young mats and bare rock. The tops of faces and domes often have small level areas which provide some of the distinctive microhabitats associated with flatrocks. These are usually minor in extent and not worth distinguishing as a separate community, but substantial areas are conceivable.

Rare Plant Species: Vascular -- Arabis lyrata, Aster avitus, Carex biltmoreana, Carex misera, Corydalis sempervirens, Helianthemum bicknellii, Hypericum buckleyi, Hypericum frondosum, Juncus georgianus, Juniperus communis var. depressa, Lonicera flava, Rhododendron vaseyi, Robinia viscosa var. hartwegii, Scirpus cespitosus, Sedum glaucophyllum, Selaginella tortipila, Senecio millefolium, Solidago uliginosa; nonvascular -- Bartramidula cernua, Campylopus atrovirens, Campylopus paradoxus, Gymnoderma lineare, Lophozia attenuata, Sphagnum pylaesii, Sphagnum tenellum.

Synonyms:
Granite outcrop, cliff, dome (general usage).

Examples:
Looking Glass Rock, Pisgah National Forest, Transylvania County.
Whiteside Mountain, Nantahala National Forest, Jackson County.
Big Green Mountain, Little Green Mtn., Goldspring Ridge, Blackrock Mtn., and other sites in Panthertown Valley, Nantahala National Forest, Jackson County.
Sheep Cliff, Jackson County.
Blackrock Mountain south of Highlands, Nantahala National Forest, Macon County.

References: Oosting and Anderson (1937).

Sample Plant Communities:
Bare rock.
Selaginella tortipila.
Cladonia spp.
Selaginella rupestris.
Hedwigia ciliata.
Polytrichum sp.
Danthonia compressa.
Danthonia spicata.
Schizachyrium (Andropogon) scoparium.
Mixed outcrop herbs.
Mixed outcrop seepage herbs.
Sphagnum spp.
Kalmia latifolia.
Rhododendron carolinianum.
Pinus pungens/Kalmia latifolia.

Tsuga caroliniana/Kalmia latifolia.

LOW ELEVATION ROCKY SUMMIT

Sites: Rugged, horizontal to vertical rock outcrop areas on low elevation ridges, peaks, and upper slopes in the Blue Ridge and upper Piedmont.

Soils: Primarily small accumulations of mineral or organic soil in pockets and crevices, interspersed with bare rock. Series are not generally mapped and have received little scientific study or classification effort since they lack agricultural or development potential.

Hydrology: Very variable spatially and temporally. Primarily xeric due to lack of soil and exposure to wind, but deep crevices and seepage zones may retain more moisture, and depressions may hold water for short periods after rains. The higher temperatures, lower rainfall, and less frequent fog make Low Elevation Rocky Summits drier than High Elevation Rocky Summits.

Vegetation: Generally very heterogeneous, often with individual plants occurring in distinct microsites. Trees and shrubs may occur in crevices. Typical species include Pinus virginiana, P. rigida, P. pungens, Quercus montana (prinus), Tsuga caroliniana, Amelanchier arborea, Quercus ilicifolia, Kalmia latifolia, Rhododendron maximum, Gaylussacia baccata, and Vaccinium pallidum (vacillans). Herbaceous species include Polypodium virginianum, Danthonia spicata, Dichanthelium spp., Schizachyrium (Andropogon) scoparium, Asplenium montanum, Dryopteris marginalis, Minuartia (Arenaria) groenlandica, Diodia teres, Hypericum gentianoides, Talinum teretifolium, Selaginella rupestris, Paronychia argyrocoma, Carex nigromarginata, Sedum telephioides, and Saxifraga michauxii. A variety of moss and lichen species are important on the bare rock.

Dynamics: These areas are generally in early stages of primary succession which is slowed by resistant rock and harsh environment. While rock weathering and soil accumulation may theoretically allow development of a Pine--Oak/Heath community in the absence of severe disturbance, most rocky summits are stable over long periods of time. Some Rocky Summit communities may be created by destruction of Pine--Oak Heath vegetation followed by erosion, or by debris avalanches.

Range: Rare in the Piedmont, where it is largely confined to the highest monadnocks; apparently rare in the Blue Ridge as well.

Associations: May grade to various upland communities, particularly Pine-- Oak/Heath and Chestnut Oak Forest.

Distinguishing Features: Low Elevation Rocky Summits are distinguished from Pine--Oak/Heath and forest communities by lacking a closed tree or shrub canopy and having substantial areas of bare rock. Pine--Oak/Heath-like vegetation may occur within and on the edges of Rocky Summit communities. They should be considered part of the Rocky Summit unless they cover a substantial area or extend far from the rock outcrop.

Low Elevation Rocky Summits are distinguished from cliff communities by occurring in higher, more exposed sites, on upper slopes or summits. They are distinguished from Low Elevation Granitic Domes by having irregular, fractured rock rather than smooth exfoliating rock. This produces greater heterogeneity of soil and allows plants rooted in crevices and soil pockets to predominate. Many mountain examples are on old, partially weatherd exfoliation surfaces that are intermediate between the Low Elevation Rocky Summit and Low Elevation Granitic Dome types. These are included in the Low Elevation Rocky Summit category.

Low Elevation Rocky Summits are distinguished from High Elevation Rocky Summits by being lower, generally below 4000 feet. Species which occur in Low Elevation Rocky Summits but seldom or never in high include Dichanthelium (Panicum) spp., Diodia teres, and Talinum teretifolium. Species that occur in high but seldom or never in low include Carex misera, Sibbaldiopsis (Potentilla) tridentata, Scirpus cespitosus, Carex brunnescens, Geum radiatum, Solidago spithamaea, Liatris helleri, Houstonia montana, and Menziesia pilosa.

Variation: Very heterogeneous within and among sites, in response to exposure, elevation, and physical and chemical structure of the rock. Examples on Piedmont quartzite monadnocks may be distinctive enough to be recognized as a variant,

as may the mountain examples on weathered exfoliation surfaces.
Comments: This type occurs in a more exposed and rocky environment than the Pine--Oak Heath type, and trees are unable to dominate the vegetation. Rocky Summits result from a combination of poor soil development due to resistant rock, dryness, exposure to extreme weather conditions, and perhaps natural disturbance. The irregular rock substrate produces different communities and probably different dynamics than the smooth rock of Granitic Domes.

This is a poorly known type. Well-developed examples are apparently rarer than High Elevation Rocky Summits, perhaps because the frost processes that produced the jagged high elevation crags have been less active at low elevation, while the chemical weathering processes that break them down have been more active.

Low Elevation Rocky Summits lack the distinctive flora of High Elevation Rocky Summits.

Rare Plant Species: Vascular -- Carex biltmoreana, Juniperus communis var. depressa, Minuartia groenlandica, Senecio millefolium, Spiraea betulifolia ssp. corymbosa, Xerophyllum asphodeloides; nonvascular -- Grimmia cribrosa.

Synonyms:
Rock outcrop, cliff.

Examples:
Doughton Park, Blue Ridge Parkway, Alleghany County (Pittillo and Govus 1978).
Haw Knob, Buncombe County.
Hanging Rock State Park, Stokes County.
Sauratown Mountain, Stokes County (Weakley and Dickerson 1979).
Pilot Mountain State Park, Surry County (Williams and Oosting 1944).

References: Pittillo and Govus (1978), Weakley and Dickerson (1979), Williams and Oosting (1944).

Sample Plant Communities:
Bare Rock.
Mixed lichens.
Mixed outcrop herbs.
Mixed shrubs.
Kalmia latifolia.
Pinus pungens-P. rigida/Kalmia latifolia.
Tsuga caroliniana.

LOW ELEVATION GRANITIC DOME

Sites: Steep to gently sloping exposures of smooth, exfoliating granite or similar massive igneous or metamorphic rock, such as granitic gneiss.

Soils: Soils are generally absent, except for patchy mats of shallow organic or mineral matter, usually of a sandy texture. Shallow, rocky, continuous soils occur at the periphery. Deeper soils are generally absent because of the lack of crevices. Most of the areal extent is bare rock. The thin soils have received little scientific study or classification effort, since they lack agricultural or development potential.

Hydrology: Very variable spatially and temporally. Primarily xeric due to lack of soil and exposure to wind, but deep crevices and seepage zones may retain more moisture, and depressions may hold water for short periods after rains. The higher temperatures, lower rainfall, and less frequent fog make Low Elevation Granitic Domes drier than High Elevation Granitic Domes.

Vegetation: Bare rock is vegetated by mats of distinctive species, zoned with soil depth and age. Early species include Racomitrium heterostichum, Hedwigia ciliata, Cladonia spp., Polytrichum juniperinum, Polytrichum commune, Grimmia laevigata, Philonotis fontana, and Selaginella rupestris. Species in more developed mats include Diamorpha (Sedum) smallii, Sedum telephioides, Talinum teretifolium, Cheilanthes lanosa, Cheilanthes tomentosa, Coreopsis pubescens, Phacelia dubia, Danthonia spicata, Coreopsis major, Dichanthelium (Panicum) spp., Allium cuthbertii, Hypericum gentianoides, Hypericum denticulatum var. acutifolium, Corydalis flavula, Senecio anonymus (smallii), Pycnanthemum sp., Paronychia fastigiata, Cunila origanoides, Anemone virginiana, Piptochaetium (Stipa) avenaceum, Phlox nivalis ssp. hentzii, Lindernia monticola, Carex spp., and Aster paternus. The edge and the few old mats may contain woody species such as Robinia hispida, Rhus copallina, Vaccinium stamineum, Ptelea trifoliata, Chionanthus virginicus, Juniperus virginiana, Rhus aromatica, Symphoricarpos orbiculatus, Quercus montana (prinus), Carya spp., and Fraxinus americana.

Dynamics: Vegetation mats expand as pioneers establish at their edges and deepen as later stages invade the center. Most mats are destroyed by falling under their own weight or by spalling of the rock before they become very old. Windthrow of trees may destroy the mats they are rooted in. The breadth of the thicker mats at the upper edge may change over time.

Range: Western Piedmont and lower parts of the Blue Ridge.

Associations: Grades to various upland forest communities.

Distinguishing Features: Low Elevation Granitic Domes are distinguished from Low Elevation Rocky Summits by occurring on massive, exfoliating rock with few crevices or irregularities containing soil. Almost all of the soil consists of thin mats over solid rock. Marginal examples that appear to be relict or inactive exfoliation faces, with few crevices but with weathered and pitted surfaces, are fairly common. These areas often have vegetation that is depauperate, or that is transitional between Rocky Summit and Granitic Dome. They are placed in the Low Elevation Rocky Summit type.

Low Elevation Granitic Domes are distinguished from Acidic Cliffs by the smooth, exfoliating rock and by their more exposed topographic position. They are primarily on upper slopes to summits, only occasionally down the mid or lower slopes.

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, Scirpus cespitosus, Danthonia compressa, Hypericum buckleyi, Senecio millefolium, Robinia viscosa var. hartwegii, and Leiophyllum buxifolium. Species that occur in Low Elevation Granitic Domes but seldom in High Elevation include Talinum teretifolium, Lindernia monticola, Phlox nivalis ssp. hentzii, Scleria triglomerata, Baptisia tinctoria, Ulmus alata, Fraxinus americana, Carya spp., Chionanthus virginianus, and Ptelea trifoliata.

Low Elevation Granitic Domes sometimes have zones along their edges with Pine-Oak/Heath-like vegetation. These areas should be considered part of the Granitic Dome community unless they cover a substantial area or extend far from the rock outcrop.

Variation: Differences in vegetation between faces with northerly and southerly aspect have been described. Faces vary locally with age of mats, steepness, and smoothness of the rock. The tops of domes may have some flatter areas resembling Granitic Flatrock communities. Two distinctive variants are recognized:

1. Basic Variant, known in several upper Piedmont sites, has floristic and vegetational composition suggesting a high pH soil, such as is usually associated with mafic or calcareous rocks. Such species include Rhus aromatica, Symphoricarpos orbiculatus, Corydalis flavula, Anemone virginiana, Anemone berlandieri, Arabis hirsuta var. adpressipilis, Senecio obovatus, Pellaea wrightiana, and Aquilegia canadensis. Acid-loving species, such as Diamorpha smallii and members of the Ericaceae, are nearly or totally absent. The edge of the open rock often supports an extensive, open, grassy, glade-like woodland dominated by Carya glabra, Fraxinus americana, and Juniperus virginiana.

2. Acidic Variant, shows the acid-loving flora and vegetation more typical of felsic rock outcrops. Oaks and pines, particularly Quercus montana and Pinus virginiana, are the dominant trees, and heaths are abundant.

Comments: The smooth surface and lack of crevices on exfoliation domes create an environment which lacks many of the microhabitats found on outcrops of fractured rock. On the open rock face most of the vegetation is in zoned mats. The steep slopes causes frequent destruction of these mats, leaving the face dominated by young mats and bare rock. The tops of faces and domes often have small level areas which provide some of the distinctive microhabitats associated with flatrocks. These are usually minor in extent and not worth distinguishing separately, but substantial areas may occur.

These communities share many species with Granitic Flatrock communities, but their steepness causes differences. Vegetation mats are slower to start and sooner destroyed by sloughing off. Few mats reach the stage of dominance by woody vegetation. Also, the distinctive pools of flatrocks are absent on steep faces.

The Basic Variant provides habitat for a number of rare species associated with calcareous sites. The reason for the presence of calciphilic species is unclear. Granitic rock typically produces sandy, acidic soils, but soils at these sites appear to be loamy and circumneutral. No mafic or calcareous veins are known in these sites, though felsic veins are typical of both variants. With the exception of the Stone Mountain complex, all of the upper Piedmont examples which have been explored are of the Basic Variant.

The Acidic Variant is less well known than the Basic Variant. The Stone Mountain Complex is the only example which clearly fits this variant. It is unclear which variant the examples in the lower elevation parts of the Blue Ridge represent, or indeed whether they are closely related to either of these variants; they may be more closely related to the High Elevation Granitic Domes (to which they are geographically closer).

Rare Plant Species: Vascular -- Allium cuthbertii, Amorpha glabra, Anemone berlandieri, Arabis hirsuta var. adpressipilis, Arabis lyrata, Corydalis micrantha ssp. australis, Hexalectris spicata, Juncus georgianus, Juncus secundus, Lindernia monticola, Pellaea wrightiana, Portulaca smallii, Ptelea trifoliata, Senecio obovatus, Spiraea betulifolia ssp. corymbosa; nonvascular -- Macrocoma sullivantii, Orthotrichum keeverae.

Synonyms:
Granite outcrop, cliffs.

Examples:
Rocky Face Mountain, Alexander County (Keever, Oosting, and Anderson 1951).
Joe and Little Joe Mountains, Alexander County (Radford and Martin 1975).
Stone Mountain and Wolf Rock, Wilkes and Alleghany counties (Taggart 1973).
Sugarloaf Mountain, Alexander County.
Little Mountain, Alexander County.

References: Keever, Oosting, and Anderson (1951), Radford and Martin (1975), Taggart (1973).

Sample Plant Communities:
Bare rock.
Grimmia laevigata.

Selaginella rupestris.
Cladonia spp.
Polytrichum juniperinum.
Danthonia spicata.
Schizachyrium (Andropogon) scoparium.
Phlox nivalis ssp. hentzii
Allium cuthbertii.
Mixed outcrop herbs.
Fraxinus americana-Carya/Mixed grasses.
Quercus montana-Carya spp./Piptochaetium (Stipa) avenaceum.

MONTANE ACIDIC CLIFF

Sites: Very steep to vertical slopes on acidic rock or saprolite, on lower to mid slopes, in the Blue Ridge and foothills region; steep, rocky, or dry enough to prevent formation of a closed tree canopy.

Soils: A heterogeneous mosaic ranging from bare rock to accumulations of organic or mineral matter in pockets and crevices, to thin and rocky soils. Soil series are generally not mapped for cliffs and have received little study.

Hydrology: Ranges from xeric on bare rock and shallow soil with southern exposure, to mesic on northerly and sheltered exposures, to saturated in seepage areas. Many sites are dry throughout but others may be quite heterogeneous, with wet and dry microsites intermixed. Cliffs kept wet by spray are treated in the Spray Cliff type and are excluded here.

Vegetation: Generally very heterogeneous within a site. Most of the area is bare or moss and lichen-covered rock. Xerophytic and mesophytic species may occur in close proximity. Herbs include rock outcrop species such as Saxifraga michauxii, Sedum telephioides, Asplenium montanum, Polypodium spp.; species of open or disturbed soil such as Danthonia spicata, D. sericea, Andropogon spp., Hieracium paniculatum, Krigia montana, Houstonia purpurea; and some typical forest herbs such as Maianthemum (Smilacina) racemosum, Polygonatum biflorum, Asplenium platyneuron, and Galax urceolata (aphylla). Scattered trees and shrubs may occur in crevices or areas of deeper soil. Scattered, open-grown, fairly xerophytic trees and shrubs such as Tsuga caroliniana, Pinus pungens, P. rigida, Quercus montana (prinus), Oxydendrum arboreum, Amelanchier arborea, Kalmia latifolia, Rhododendron caroliniamum, and Rhododendron minus are typical. However, on sheltered sites, more mesic species may occur, including Tsuga canadensis, Fagus grandifolia, Quercus rubra, and Rhododendron maximum.

Dynamics: May be disturbed by erosion and mass movement, producing more bare ground or rock. With stability, primary succession may lead to greater soil development and forest cover. Population dynamics on cliffs are difficult to study, but most plant populations are probably uneven-aged, with establishment being a rare event.

Range: Fairly common throughout the Mountain region and possibly in the upper Piedmont.

Associations: Grades to Acidic or Rich Cove Forest, Canada Hemlock Forest, Chestnut Oak Forest, Pine-Oak/Heath, or other upland forests on less steep and rocky slopes. May grade to Cove Forests, Montane Alluvial Forest, Piedmont/Low Mountain Alluvial Forest, or Rocky Bar and Shore below.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an open canopy and bare substrate resulting from steepness and rockiness. Where cliffs have a small talus slope at the base, it is included with the cliff community if it lacks a closed tree canopy.

Montane Acidic Cliffs are distinguished from Rocky Summits by occurring on generally lower, more sheltered sites, at mid slope or lower. Vertical cliffs at or near exposed ridgetops or peaks are considered Rocky Summits.

Acidic Cliffs are distinguished from Mafic Cliffs and Calcareous Cliffs by having acidic substrates such as felsic or intermediate igneous or metamorphic rock. Occasional sites may have seepage water which is high in minerals such as calcium, allowing a few base-loving plant species to exist on an otherwise acidic substrate. Such communities will have to be classified by the predominant vegetation. Montane Acidic Cliffs are distinguished from Piedmont/Coastal Plain Acidic Cliffs by their geographic location and dominance by montane flora.

Montane Acidic Cliffs are distinguished from Pine--Oak/Heath communities by their structure, which lacks a closed shrub layer. The cliff communities are generally in more sheltered areas. They are distinguished from Carolina Hemlock Bluffs by species composition, with Tsuga caroliniana playing only a minor role. Carolina Hemlock Bluffs generally occur in more exposed sites, similar to those of Pine-Oak/Heath and Rocky Summit.

Variation: Great variation may occur among sites. The primary sources of variation are elevation, aspect, and seepage. Acidic Cliffs may also be highly variable within a site, varying with exposure, steepness, amount of rock, depth and stability of the soil, and amount of seepage.

Cliffs of northerly and southerly aspect are frequently recognized as different types; however, the heterogeneity within a

site is very often greater than differences between aspects. Both aspects may be a complex mixture of bare rock, wet, mesic, and xeric microhabitats.

Comments: The best developed examples of Montane Acidic Cliff are dominated by rock, with only scattered woody species. Marginal examples may be difficult to distinguish from the steeper examples of forest community types and Pine--Oak/Heath. Both steep rocky cliffs and more gently forested slopes are often called bluffs in the literature, making it difficult to positively identify these communities in secondary sources. While most Piedmont/Coastal Plain Acidic Cliffs occur adjacent to streams or rivers, many Montane Acidic Cliffs occur higher on slopes, making the distinction between them and Rocky Summit communities more difficult.

The natural openness of these communities allows the persistence of shade- intolerant species, including some species generally considered weeds.

Rare Plant Species: Vascular -- Adlumia fungosa, Amelanchier sanguinea, Amorpha glabra, Asplenium bradleyi, Asplenium monanthes, Asplenium pinnatifidum, Buckleya distichophylla, Cardamine clematitis, Carex biltmoreana, Carex misera, Chenopodium simplex, Dicentra eximia, Geum geniculatum, Heuchera parviflora, Hudsonia montana, Muhlenbergia sobolifera, Saxifraga careyana, Saxifraga caroliniana, Scirpus cespitosus, Shortia galacifolia, Trichomanes petersii, Woodsia ilvensis; nonvascular -- Bryoxiphium norvegicum, Calypogeia peruviana, Cirriphyllum piliferum, Dichodontium pellucidum, Homalia trichomanoides, Leptodontium flexifolium, Lophocolea muricata, Orthodontium pellucens, Palamocladium leskioides, Plagiochila echinata, Pterigynandrum sharpii, Rhabdoweisia crenulata.

Synonyms:
Bluffs, rock outcrops (general usage).

Examples:
Auger Fork Creek, Transylvania County.
Bonas Defeat Gorge, Tuckaseegee River, Jackson County.
Face Rock, Buncombe County (Heiman and Smith in prep.)
Linville Gorge, Burke County.
Linville Mountain Natural Area, McDowell County.
Whitewater Gorge, Jackson County.

References: Cooper and Hardin (1970), Hardin and Shaw (1975), Heiman and Smith (in prep.), Sather (1982), Wickland and Horton (1977).

Sample Plant Communities: (all strata open)
Bare rock.
Mixed outcrop herbs and mosses.
Mixed ferns/Mixed mosses.
Rhododendron maximum.
Rhododendron minus.
Rhododendron catawbiense.
Kalmia latifolia.
Liriodendron tulipifera/Rhododendron maximum.
Mixed upland oaks-Tsuga canadensis/Mixed shrubs and transgressives.
Quercus coccinea/Vaccinium pallidum (vacillans).
Quercus montana (prinus)/Rhododendron catawbiense.
Q. montana/Rhododendron maximum.
Q. montana/Kalmia latifolia-Mixed shrubs.
Q. montana-Acer rubrum.
Q. montana-Pinus virginiana/Mixed heaths.
Quercus rubra-Q. prinus-Q. coccinea/Kalmia latifolia.
Tsuga canadensis/Rhododendron maximum/Galax urceolata (aphylla).

Tsuga canadensis-Fagus grandifolia-Liriodendron tulipifera/Rhododendron maximum.
Mixed pines and hardwoods.

PIEDMONT/COASTAL PLAIN ACIDIC CLIFF

Sites: Very steep to vertical slopes on acidic substrates, on stream bluffs, lower, or mid slopes, in the Piedmont and Coastal Plain regions; steep, rocky, or dry enough to prevent formation of a closed tree or shrub canopy. Generally on hard rock, but may occur in areas of soft material exposed by undercutting by a stream.

Soils: A heterogeneous mosaic ranging from bare rock to accumulations of organic or mineral matter in pockets and crevices, to thin and rocky soils. Soil series are generally not mapped for cliffs and have received little study.

Hydrology: Ranges from xeric on bare rock and shallow soil with southern exposure, to mesic on northerly and sheltered exposures, to saturated in seepage areas. Many sites are dry throughout but others may be quite heterogeneous, with wet and dry microsites intermixed. Cliffs kept wet by spray are treated in the Spray Cliff type and are excluded here.

Vegetation: Generally very heterogeneous within sites and among sites. Most of the area is bare or moss- and lichen-covered rock. Xerophytic and mesophytic species may occur in close proximity. Typical mosses include Grimmia laevigata, Aulocomnium heterostichum, and Bartramia pomiformis. Herbs may include Epigaea repens, Andropogon virginicus, Schizachyrium (Andropogon) scoparium, Danthonia spicata, Sanicula canadensis, Hieracium venosum, Houstonia purpurea, Coreopsis major, Cheilanthes lanosa, Galax urceolata (aphylla), Saxifraga virginiana, Mitchella repens, Heuchera spp., and Polypodium virginianum. Scattered trees and shrubs may occur in crevices or areas of deeper soil. Shade-intolerant and relatively xerophytic species, such as Pinus virginiana, Pinus echinata, Juniperus virginiana, Quercus montana (prinus), Q. coccinea, Q. falcata, Oxydendrum arboreum, Vaccinium arboreum, Kalmia latifolia, Vaccinium spp., and Gaylussacia spp. are common on cliffs. However, on sheltered sites more mesic species may occur, including Fagus grandifolia, Quercus rubra, Acer rubrum, Cornus florida, and in the west, Tsuga spp. and Rhododendron maximum.

Dynamics: May be disturbed by erosion and mass movement, producing more bare ground or rock. With stability, primary succession may lead to greater soil development and forest cover. Population dynamics on cliffs are difficult to study, but most plant populations are probably uneven-aged, with establishment being a rare event.

Range: Throughout the Piedmont, scattered in the Coastal Plain.

Associations: Generally borders floodplain forests or stream channels. May grade to such communities through talus slopes at the base. May grade to Heath Bluff and to various upland communities, such as Mesic Mixed Hardwood Forest, Dry Oak--Hickory Forest, or Dry-Mesic Oak--Hickory Forest, on less steep and rocky slopes.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an absent or open canopy and bare substrate resulting from steepness and rockiness. They are distinguished from Rocky Summits by occurring on generally more sheltered sites, at mid slope or lower. Vertical cliffs at or near ridgetops are considered Rocky Summits.

Acidic Cliffs are distinguished from Mafic Cliffs and Calcareous Cliffs by having acidic substrates such as felsic or intermediate igneous or metamorphic rock, sand, or clay, and by flora. Occasional sites may have seepage water which is high in minerals such as calcium, allowing a few base-loving plant species to exist on an otherwise acidic substrate. Such communities will have to be classified by the predominant vegetation.

Piedmont/Coastal Plain Acidic Cliffs are distinguished from Montane Acidic Cliffs by their geographic location and limited montane flora. They are distinguished from Heath Bluffs by having limited shrub as well as tree cover.

Variation: Great variation may occur among sites. The primary sources of variation are elevation, aspect, and geographic location. Coastal Plain sites have substrates of partially consolidated sediments, which differ from the crystalline rocks of most of the Piedmont. Species lists contain species characteristic of the province in which the site occurs. Acidic Cliffs may also be very heterogeneous within a site, varying with exposure, steepness, amount of rock, depth, stability of the soil, and amount of seepage.

Differences between northerly and southerly aspect are frequently recognized. Ebert (1967) however, found greater vegetational differences between cliffs of the same aspect than between north and south-facing cliffs. Both aspects may be a complex mixture of bare rock, wet, mesic, and xeric microhabitats.

Comments: Cliffs are distinguished by an open canopy and bare substrate, caused by steepness or rockiness.

The best developed examples of Piedmont/Mountain Acidic Cliffs are dominated by rock, with only scattered higher plants. Marginal examples may be difficult to distinguish from Heath Bluffs and steep examples of forest community types. Both rocky cliffs and steep forested slopes are often called bluffs in the literature, making it difficult to positively identify these communities in secondary sources.

The natural openness of these communities allows the persistence of shade- intolerant species, including some species generally considered weeds.

Because the microclimate may be strongly modified by slope aspect, cliffs also often contain species more typical of other provinces. They may support disjunct, apparently relict, populations of species from a different region. For example, a north-facing cliff in Wake County (Hemlock Bluffs) contains a disjunct population of Tsuga canadensis, believed to be relict from the Pleistocene.

These communities are somewhat rare because of the relatively rapid weathering in this region, but they are better protected against destruction than most communities. They can, however, be severely damaged by climbing and scrambling in heavily used areas.

Rare Plant Species: Vascular -- Asplenium bradleyi, Asplenium pinnatifidum, Heuchera parviflora.

Synonyms:
Bluffs, rock outcrops (general usage).

Examples:
Hemlock Bluffs, Wake County (Oosting and Hess 1956).
New Hope Creek Bluffs, Duke Forest, Orange County (Ebert 1957).
Carver's Falls, Cumberland County.
Cliffs of the Neuse, Wayne County (Bruton 1968).
Dan River Cliff, Stokes County (Weakley and Dickerson 1979).
Eno River State Park, Durham and Orange counties.
Cascade Creek and Indian Creek gorges, Hanging Rock State Park, Stokes County.
Raven Rock, Harnett County.
Yadkin River Bluffs, Forsyth County.
Flanner Beach Natural Area, Croatan National Forest, Craven County.
Greenbank Bluff, Brunswick County.

References: Bruton (1968), Ebert (1957), Hood (1978), Nifong and Taggart (1981), Oosting and Hess (1956), Peet and Christensen (1980), Weakley and Dickerson (1979), Wells (1974).

Sample Plant Communities: (all strata open)
Bare rock.
Crustose lichens.
Mixed rock outcrop herbs and mosses.
Mixed ferns/Mixed mosses.
Polypodium virginianum.
Danthonia spicata-Schizachyrium (Andropogon) scoparium.
Liriodendron tulipifera/Rhododendron maximum.
Liriodendron tulipifera.
Mixed upland oaks-Mixed upland hickories.
Mixed upland oaks-Tsuga canadensis/Mixed shrubs and transgressives.
Mixed scrub pines-Mixed scrub oaks.
Pinus echinata-Quercus montana (prinus).
Pinus virginiana/Vaccinium pallidum (vacillans).
Quercus coccinea/Vaccinium pallidum.

Q. montana/Kalmia latifolia-Mixed shrubs.
Q. montana-Acer rubrum.
Quercus rubra-Q. montana (prinus)-Q. coccinea/Kalmia latifolia.
Fagus grandifolia.

PIEDMONT/COASTAL PLAIN HEATH BLUFF

Sites: Steep slopes and bluffs, generally north facing, on acidic substrates in the Piedmont and Coastal Plain. Generally in areas of hard rock, but may occur in areas of soft material exposed by undercutting by a stream.

Soils: Thin and rocky soils. Series mapped include Goldston (Ruptic-Ultic Dystrochrept), Tatum (Typic Hapludult), Wedowee (Typic Hapludult), and Wilkes (Typic Hapludalf).

Hydrology: A combination of dry conditions caused by shallow, well-drained soil and cool, moist microclimate caused by north slope, seems to be responsible for the formation of these communities. Sites may be somewhat heterogeneous, with dry microsites intermixed with wet seepage areas.

Vegetation: A dense shrub layer dominates the sites. Kalmia latifolia is the most common dominant, but Rhododendron catawbiense or Rhododendron maximum may dominate. Other shrubs may include Hamamelis virginiana, Symplocos tinctoria, and Vaccinium spp. The tree canopy is open to very sparse, with trees such as Quercus montana (prinus), Pinus virginiana, Pinus taeda, Oxydendrum arboreum, Acer rubrum, and Amelanchier arborea characteristic. A variety of trees from surrounding forests may occur. Herbs are generally sparse under the shrubs, with acid-loving species such as Galax urceolata (aphylla), Epigaea repens, Gaultheria procumbens, Chimaphila maculata, Hexastylis minor, and Mitchella repens typical. Outcrop herbs may occur on interspersed rocks.

Dynamics: The long-term dynamics of these communities are not known. The heaths and other species are generally confined to these communities as disjunct occurrences in the lower Piedmont and Coastal Plain. They are probably relict occurrences from past cooler climate, as described by Oosting and Hess (1956). This suggests long-term stability of these communities, with further succession to forest cover halted, perhaps by competition from the dense shrub layer. The cool steep slopes, generally bordering floodplains, seem unlikely to be subject to fire.

Range: Scattered throughout the Piedmont and Coastal Plain.

Associations: Generally borders a floodplain forest or a stream channel. May grade to such communities through a talus slope at the base. Above, may grade to various upland communities, such as Mesic Mixed Hardwoods Forest, Dry Oak--Hickory Forest, or Dry-Mesic Oak--Hickory Forest, on less steep and rocky slopes. May be associated with Piedmont/Coastal Plain Acidic Cliff.

Distinguishing Features: Piedmont/Coastal Plain Heath Bluffs are distinguished from forest communities by having an open tree canopy. Unlike Acidic Cliffs, they have a closed, often dense, shrub layer. There is little open substrate for rock outcrop or weedy species. While all of the species on Heath Bluffs may occur on Acidic Cliffs, particularly at the top or bottom, the shrub-dominated vegetational structure is distinctive. Except for rare occurrences of Pine-- Oak/Heath, these are the only upland shrub-dominated communities in the Piedmont.

Variation: Sites vary in the amount of rock exposed and in the amount of tree cover. The dominant species vary, with a minority of sites having Rhododendron as the dominant.

Some variation may occur among sites in the different physiographic provinces. Coastal Plain sites have substrates of partially consolidated sediments, which differ from the crystalline rocks of most of the Piedmont. Species lists contain species characteristic of the province in which the site occurs. Rhododendron catawbiense dominates only in the lower Piedmont region of Orange, Durham, Chatham, and Wake counties.

Comments: Heath Bluffs were included in the Acidic Cliff category in the Second Approximation. They are distinguished here because of their distinctive vegetation. The cause of this vegetation is apparently related to both shallow soil and cool microclimate.

The best developed examples of Heath Bluff are dominated by shrubs on soil or saprolite, and have little exposed rock. As rock becomes more prominent and the shrubs become more sparse, Heath Bluffs grade to the Piedmont/Coastal Plain Acidic Cliff type. As trees become denser and shade out the shrubs, marginal examples may be difficult to distinguish from

the steep examples of forest community types. Mesic Mixed Hardwoods Forests on steep north slopes may sometimes contain some Kalmia latifolia or Rhododendron maximum. Both steep rocky cliffs, shrubby slopes, and more gentle forested slopes are often called bluffs in the literature, making it difficult to positively identify these communities in secondary sources.

These communities are somewhat rare because of the relatively rapid weathering in this region, but they are better protected against destruction than most communities. They can, however, be severely damaged by climbing and scrambling in heavily used areas.

Rare Plant Species: Vascular -- Hexastylis naniflora, Monotropsis odorata, Nestronia umbellula; nonvascular -- Calypogeia peruviana.

Synonyms:
Bluffs, rock outcrops (general usage).

Examples:
Rocky River White Pine Stand, Chatham County.
New Hope Creek Bluffs, Duke Forest, Orange County (Ebert 1957).
Rocky Ford Creek Mountain Laurel Bluff, Sandhills Game Land, Richmond County Umstead State Park, Reedy Creek Section, Wake County.
Crabtree Creek below Ebenezer Church Road, Wake County (LeGrand and Dalton 1987).
Flora's Florist Pine Stand, Moore County (Carter and LeGrand 1989).
Flat River Slopes, Durham County (Sutter, Harrison, and Rettig 1987).
Morgan Creek Bluffs, Orange County (Sather and Hall 1988).

References: Carter and LeGrand (1989), Ebert (1957), LeGrand and Dalton (1987), Peet and Christensen (1980), Sather and Hall (1988), Sutter, Harrison, and Rettig (1987).

Sample Plant Communities:
Liriodendron tulipifera/Rhododendron maximum.
Quercus montana (prinus)/Kalmia latifolia.
Quercus montana/Rhododendron catawbiense.
Q. montana/Rhododendron maximum.
Q. montana/Mixed tall heaths.
Q. montana-Pinus virginiana/Mixed heaths.
Q. rubra-Q. montana-Q. coccinea/Kalmia latifolia.
Q. alba-Fagus grandifolia/Rhododendron catawbiense.

MONTANE MAFIC CLIFF

Sites: Very steep to vertical, rocky slopes of mafic or basic igneous or metamorphic rocks, such as amphibolite and hornblende gneiss, on bluffs or slopes in the Mountain region; steep, rocky, or dry enough to prevent formation of a closed canopy.

Soils: A heterogeneous mosaic ranging from bare rock to accumulations of organic or mineral matter in pockets and crevices, to thin and rocky soils. Soil series are generally not mapped for cliffs and have been little studied.

Hydrology: A combination of dry conditions caused by shallow, well-drained soil and cool, moist microclimate caused by north slope, seems to be responsible for the formation of these communities. Sites may be somewhat heterogeneous, with dry microsites intermixed with wet seepage areas.

Vegetation: Generally very heterogeneous within sites and among sites. Xerophytic and mesophytic species may occur in close proximity. Substantial areas of bare rock occur. Plants are largely limited to crevices, soil pockets, and margins. Most of the species of the Montane Acidic Cliff may occur, but base- loving species are also present. Herbs may include Arabis canadensis, Andropogon gerardii, Dodecatheon meadii, Coreopsis major, Danthonia spicata, Danthonia compressa, Carex spp., Helianthus spp., Sedum ternatum, Tradescantia subaspera, Senecio plattensis, Polygala senega, Euphorbia corollata, Sedum glaucophyllum, Arabis lyrata, Aquilegia canadensis, and Euphorbia commutata. Vines such as Toxicodendron (Rhus) radicans, Parthenocissus quinquefolius, and Vitis spp. may spread over open rock. Scattered trees and shrubs may include Pinus virginiana, Quercus montana, Chionanthus virginianus, Fraxinus americana, Juniperus virginianus, Ostrya virginiana, Lonicera dioica, Ptelea trifoliata, Philadelphus hirsutus, and Tsuga caroliniana.

Dynamics: Generally stable, although areas may potentially be disturbed by landslides, falling rock, or undercutting by streams. Stable areas undergo slow weathering and primary succession. Population dynamics on cliffs are difficult to study, but most plant populations are probably uneven-aged, with establishment being a rare event.

Range: Potentially scattered throughout the Mountains, but rare.

Associations: May grade into, or be sharply bordered by Montane Alluvial Forest, Piedmont/Low Montane Alluvial Forest, Rich Cove Forest, or various montane forest communities.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an open canopy and bare substrate resulting from steepness and rockiness. They are distinguished from Rocky Summits by occurring on generally more sheltered sites, at mid slope or lower. Vertical cliffs at or near exposed ridgetops and peaks are considered Rocky Summits.

Mafic Cliffs are distinguished from Acidic Cliffs and Calcareous Cliffs by having substrates of mafic igneous or metamorphic rock. Presence of base-loving flora distinguishes them from Acidic Cliffs. Floristic differences from Calcareous Cliffs are poorly known. Montane Mafic Cliffs are distinguished from Piedmont Mafic Cliffs by their geographic location and montane flora.

Variation: Variation is not well known. It is likely that great variation may occur among sites. The primary sources of variation are elevation and aspect. Cliffs may also be highly variable within a site, varying with exposure, steepness, amount of rock, depth and stability of the soil, and amount of seepage.

Comments: This type is very poorly known. It was part of the Basic Cliff type of the Second Approximation. It is distinguished here because the regional climatic differences and the sudstrate differences between calcareous and mafic rock chemistry appear to be significant to plants.

The best developed examples of Montane Mafic Cliff are dominated by rock, with only scattered woody species. It is frequently difficult to distinguish these communities in the literature. Many sites called bluffs have a closed forest not different from forests on gentler slopes. Many descriptions of "outcrops" include both open cliffs and adjacent mesic forests in the same species list. It is also often difficult to tell when a rock is mafic enough to be affecting the community, but good

examples have a vegetative composition distinctive from Acidic Cliffs. They often have a number of plant species rare in North Carolina.

Rare Plant Species: Vascular -- Amelanchier sanguinea, Amorpha glabra, Arabis lyrata, Carex biltmoreana, Deschampsia cespitosa var. glauca, Dicentra eximia, Dodecatheon meadia, Draba ramosissima, Euphorbia commutata, Euphorbia purpurea, Heuchera parviflora, Lathyrus venosus, Liatris aspera, Liatris turgida, Lonicera flava, Muhlenbergia glomerata, Parthenium integrifolium var. auriculatum, Penstemon smallii, Philadelphus hirsutus, Philadelphus inodorus, Phlox subulata, Polygala senega, Populus grandidentata, Ptelea trifoliata, Rudbeckia triloba var. pinnatiloba, Saxifraga careyana, Saxifraga caroliniana, Sedum glaucophyllum, Senecio plattensis, Solidago uliginosa, Woodsia ilvensis, Woodsia scopulina; nonvascular -- Campylopus atrovirens, Cephaloziella spinicaulis, Dichodontium pellucidum, Leptodontium flexifolium, Macrocoma sullivantii, Scopelophila ligulata, Tortula ammonsiana, Tortula fragilis.

Synonyms:
Cliff, bluff, amphibolite outcrop (general usage).

Examples:
Bluff Mountain, Ashe County.
Grove Stone Quarry, Buncombe County (Heiman and Smith in prep.).
Cove Ministries Natural Area, Buncombe County (Heiman and Smith in prep.).
Long Hope Falls, Ashe County.
Cedar Cliff, Buncombe County (Heiman and Smith in prep.).
Chimney Rock Park, Rutherford County (Feil 1988).

References: Feil (1988), Heiman and Smith (in prep.).

Sample Plant Communities:
Bare rock.
Mixed outcrop herbs.
Mixed basophilic herbs.
Pinus virginiana-Quercus montana (prinus)-Juniperus virginiana.
Chionanthus virginicus.
Juniperus virginiana/mixed herbs.
Physocarpus opulifolius/Carex biltmoreana.

PIEDMONT MAFIC CLIFF

Sites: Very steep to vertical, rocky slopes of mafic or basic igneous or metamorphic rocks, on stream bluffs, lower, or mid slopes in the Piedmont region; steep, rocky, or dry enough to prevent formation of a closed tree or shrub canopy.

Soils: A heterogeneous mosaic ranging from bare rock to accumulations of organic and mineral matter in pockets and crevices to thin and rocky soils. Soil series are generally not mapped for cliffs and have received little study.

Hydrology: Ranges from xeric on bare rock and shallow soil with southern exposure, to mesic on northerly and sheltered exposures, to saturated in seepage areas. Sites may be dry throughout or may be heterogeneous, with wet and dry microsites intermixed. Cliffs kept wet by spray are treated in the Spray Cliff type and are excluded here.

Vegetation: Generally very heterogeneous within sites. Xerophytic and mesophytic species may occur in close proximity. Most of the species of the Piedmont/Coastal Plain Acidic Cliff type may occur, but base-loving species are also present. Herbs include calciphilic species such as Aquilegia canadensis, Arabis lyrata, Asplenium trichomanes, Anemone berlandieri, and Sedum glaucophyllum. On rock, calciphilic mosses such as Anomodon attenuatus and A. rostratus occur. Scattered trees may include Quercus muehlenbergii, Ulmus alata, and various trees from surrounding forests. Shrubs include Hydrangea arborescens and Kalmia latifolia.

Dynamics: Generally stable, although areas may potentially be disturbed by landslides, falling rock, or undercutting by streams. With stability, primary succession may lead to greater soil development and forest cover. Population dynamics on cliffs are difficult to study, but most plant populations are probably uneven-aged, with establishment being a rare event.

Range: Potentially throughout the Piedmont but extremely rare and poorly known. Mafic rocks tend to be less resistant to weathering than acidic rocks, and are thus less likely to form cliffs.

Associations: May grade into, or be sharply bordered by floodplain communities or Basic Mesic Forest (Piedmont Subtype). May grade to Piedmont/Coastal Plain Acidic Cliff, Heath Bluff, or various upland forest communities above and laterally.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an open canopy and bare substrate resulting from steepness and rockiness. They are distinguished from Rocky Summits by occurring on generally more sheltered sites, at mid slope or lower. Vertical, exposed cliffs at or near ridgetops are considered Rocky Summits.

Mafic Cliffs are distinguished from Acidic Cliffs and Calcareous Cliffs by having substrates of mafic igneous or metamorphic rock. Presence of base-loving flora distinguishes them from Acidic Cliffs. Floristic differences between this type and Piedmont Calcareous Cliffs are poorly known. Piedmont Mafic Cliffs are distinguished from Montane Mafic Cliffs by their geographic location and limited montane flora.

Variation: No information on variation. Factors affecting variation will be similar to those affecting variation in Acidic Cliff.

Comments: This type was part of the Basic Cliff type of the Second Approximation. It is distinguished here because the regional climatic difference and the substrate differences between calcareous and mafic rock chemistry appear to be significant to plants.

It is frequently difficult to distinguish these communities in the literature. Many sites called bluffs have a closed forest not different from forests on gentler slopes. Many descriptions of "outcrops" include both open cliffs and adjacent mesic forests in the same species list.

Synonyms: Cliff, bluff, rock outcrop.

Rare Plant Species: Vascular -- Amorpha schwerinii, Anemone berlandieri, Arabis missouriensis, Euphorbia commutata, Pellaea wrightiana, Polygala senega, Sedum glaucophyllum, Sideroxylon lycioides.

Synonyms: Cliff, bluff, rock outcrop (general usage).

Examples: No well developed examples are known. A small remnant example occurs at Uwharrie River Slopes,

Montgomery County, and a perhaps marginally basic example occurs at Rocky River-Morgans Bluff, Stanly County (Hood 1978).

References: Hood (1978).

Sample Plant Communities: none known.

MONTANE CALCAREOUS CLIFF

Sites: Very steep to vertical, rocky slopes of limestone, dolomite, or marble, on river bluffs or slopes.

Soils: A heterogeneous mosaic ranging from bare rock to accumulations of organic or mineral matter in pockets and crevices, to thin and rocky soils. Soil series are generally not mapped for cliffs and have received little study.

Hydrology: Ranges from xeric on bare rock and shallow soil with southern exposure, to mesic on northerly and sheltered exposures, to saturated in seepage areas. Many sites are dry throughout but others may be quite heterogeneous, with wet and dry microsites intermixed.

Vegetation: Generally very heterogeneous within sites and among sites. Flora varies widely among the few sites known. Xerophytic and mesophytic species may occur in close proximity. Most of the species of the Montane Acidic Cliff may occur, but base-loving species are also present. Substantial areas of bare rock occur. Plants are largely limited to crevices, soil pockets, and margins. Herbs include Asplenium resiliens, A. rhizophyllum, A. trichomanes, A. platyneuron, Asplenium ruta-muraria, Cystopteris bulbifera, Adiantum pedatum, Pellaea atropurpurea, Polypodium polypodioides, Sedum ternatum, Arabis lyrata, Arabis canadensis, Arabis patens, Aquilegia canadensis, Zigadenus elegans ssp. glaucus, Draba ramosissima, and Houstonia tenuifolia. Vines such as Toxicodendron (Rhus) radicans and Parthenocissus quinquefolius often spread over the rock. Scattered trees in crevices may include Quercus muehlenbergii, Acer saccharum, and various other trees from surrounding forests.

Dynamics: Generally stable, although areas may potentially be disturbed by landslides, falling rock, or undercutting by streams. Stable areas undergo slow weathering and primary succession, although presumably faster than similar sites on more resistant rocks. Population dynamics on cliffs are difficult to study, but most plant populations are probably uneven-aged, with establishment being a rare event.

Range: Known only from the rare areas of calcareous rock in the Mountains. The primary areas are the Hot Springs Window (Madison County), the Murphy Syncline (Cherokee and Swain Counties), and the Grandfather Mountain Window (McDowell County).

Associations: May grade into, or be sharply bordered by, floodplain communities or Rich Cove Forest or Basic Mesic Forest (Montane Calcareous Subtype) at its base. May grade to Montane Acidic Cliff or various acidic upland forest communities on different rock types.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an open canopy and bare substrate resulting from steepness and rockiness. They are distingished from Rocky Summits by occurring on generally more sheltered sites, at mid slope or lower. Vertical, exposed cliffs at or near ridgetops are considered Rocky Summits.

Calcareous Cliffs are distinguised from Acidic Cliffs and Mafic Cliffs by having substrates of calcareous sedimentary or metamorphic rock, such as limestone, dolomite, marble, or calcite-cemented clastic rocks. Presence of base-loving flora distinguishes Calcareous Cliffs from Acidic Cliffs. Floristic differences between Mafic and Calcareous Cliffs exist but are not as well known. Marginal examples of Calcareous Cliff may occur in which a small amount of calcareous rock is interbedded with more acidic rock. The solubility of the calcareous rock allows it to influence plants on adjacent acidic rock. Occasionally, somewhat calcareous ground water may allow calciphilic plants to exist in seeps on an otherwise acidic cliff. These sites may need to be classified by the predominant vegetation, or considered a mixture of both types.

Montane Calcareous Cliffs are distinguished from Piedmont Calcareous Cliffs by their geographic location and presence of montane (in North Carolina) flora.

Variation: Varies widely from site to site. Also very heterogeneous within sites, ranging from xeric to mesic among different microsites.

Comments: This type was part of the Basic Cliff type of the Second Approximation. It is distinguished here because the regional climatic differences and the substrate differences between calcareous and mafic rock chemistry appear to be

significant to plants.

It is frequently difficult to distinguish these communities in the literature. Many sites called bluffs have a closed forest not different from forests on gentler slopes. Many descriptions of "outcrops" include both open cliffs and adjacent mesic forests in the same species list.

Rare Plant Species: Vascular -- Adlumia fungosa, Arabis lyrata, Arabis patens, Asplenium monanthes, Asplenium resiliens, Asplenium ruta-muraria, Aster oblongifolius, Carex eburnea, Cheilanthes alabamensis, Corydalis micrantha ssp. australis, Croton monanthogynus, Cystopteris bulbifera, Cystopteris tennesseensis, Draba ramosissima, Heuchera longiflora, Lathyrus venosus, Lonicera dioica, Melica nitens, Parietaria pensylvanica, Penstemon smallii, Philadelphus hirsutus, Philadelphus inodorus, Polygala senega, Polymnia canadensis, Ptelea trifoliata, Quercus muehlenbergii, Rhamnus caroliniana, Senecio plattensis, Trichostema brachiatum, Zigadenus elegans ssp. glaucus; nonvascular -- Dichodontium pellucidum, Encalypta procera, Entodon compressus, Entodon concinnus, Eucladium verticillatum, Leptodontium flexifolium, Orthodontium pellucens, Platydictya confervoides, Scopelophila ligulata.

Synonyms:
Cliff, bluff, limestone outcrop, marble outcrop (general usage).

Examples:
Shady Dolomite Bluff, Madison County (Sather 1982).
Linville Caverns, McDowell County.
Blowing Spring, Nantahala Gorge, Swain County (?).

References: Oosting (1941), Sather (1982), Wickland and Horton (1977).

Sample Plant Communities:
Quercus muehlenbergii-Juglans nigra/Calycanthus floridus/mixed calciphilic herbs.
Mixed calciphilic herbs.

PIEDMONT CALCAREOUS CLIFF

Sites: Very steep to vertical, rocky slopes of limestone, dolomite, marble, or calcareous-cemented clastic sedimentary rock, on river bluffs or slopes.

Soils: Vary from bare rock to accumulations of organic and mineral matter in pockets and crevices. Little or no classification has been done on these soils in North Carolina.

Hydrology: Varies widely with exposure, depth of soil, and presence or absence of seepage.

Vegetation: May be very heterogeneous within sites and among sites, as in other cliff communities. Trees and shrubs may be present, but do not form a closed canopy. Substantial areas of bare substrate are present.

Only one example is known in North Carolina. It has a sparse cover of Pinus virginiana and Juniperus virginiana. Common herbs include Schizachyrium (Andropogon) scoparium, Dichanthelium (Panicum) spp., Danthonia spicata, Cheilanthes tomentosa, C. lanosa, Polypodium polypodioides, and Asplenium platyneuron.

Dynamics: Not well known. The one known site has large areas of loose, shaly fragments which appear unstable; however, this would probably not be typical of a better developed cliff site.

Range: Only one site is known, formed on Triassic calcite-cemented siltstone in Rockingham County. Potential occurrence in North Carolina is limited to similar rock in the Dan River Triassic Basin and very small occurrences of limestone or marble. More potential sites exist in Virginia.

Associations: May grade into Basic Oak--Hickory Forest, Basic Mesic Forest, floodplain communities, or to acidic-substrate communities.

Distinguishing Features: Cliff communities are distinguished from forest communities by having an open canopy and bare substrate resulting from steepness and rockiness. They are distinguished from Rocky Summits by occurring on generally more sheltered sites, at mid slope or lower. Vertical, exposed cliffs at or near ridgetops are considered Rocky Summits.

Calcareous Cliffs are distinguished from Acidic Cliffs and Mafic Cliffs by having substrates of calcareous sedimentary or metamorphic rock. In the one North Carolina example the substrate is a Triassic calcite-cemented siltstone. Floristic differences from Mafic Cliffs are poorly known. Presence of base- loving flora distinguishes Calcareous Cliffs from Acidic Cliffs. Marginal examples may occur in which a small amount of calcareous rock is interbedded with more acidic rock. The solubility of the calcareous rock allows it to influence plants on adjacent acidic rock. Occasionally, somewhat calcareous ground water may allow calciphilic plants to exist in seeps on an otherwise acidic cliff. These sites may need to be classified by the predominant vegetation, or considered a mixture of both types.

Piedmont Calcareous Cliffs are distinguished from Montane Calcareous Cliffs by their geographic location and limited montane (in North Carolina) flora.

Variation: Not known. If other examples occur, they are likely to vary widely.

Comments: This type was part of the Basic Cliff type of the Second Approximation. It is distinguished here because regional climatic differences and the substrate differences between calcareous and mafic rock chemistry appear to be significant to plants.

It is frequently difficult to distinguish cliff communities in the literature. Many sites called bluffs have a closed forest not different from forests on gentler slopes. Many descriptions of "outcrops" include both open cliffs and adjacent mesic forests in the same species list.

Rare Plant Species: None known.

Synonyms:
Cliff, bluff, outcrop (general usage).

Examples:
Cedar Mountain, Rockingham County (only known North Carolina example).

References:
None.

Sample Plant Communities:
Pinus virginiana-Juniperus virginiana.

COASTAL PLAIN MARL OUTCROP

Sites: Outcrops of coquina limestone (locally known as "marl"), true marl, or other well- to poorly-consolidated calcareous deposits, generally on bluffs or steep slopes.

Soils: Generally a heterogeneous mosaic of bare rock, shallow soil over rock, and deep soil in crevices and solution cavities. Soils are not distinguished in soil surveys, but are probably Dystrochrepts or some kind of Alfisol.

Hydrology: Terrestrial, xeric to mesic, depending on aspect and occurrence of seepage.

Vegetation: Generally a complex mosaic of bryophytes and herbs on bare rock, herbs in shallow soil, and woody plants in deeper soil pockets and crevices. A closed tree canopy may be present, but most of the site is unavailable for tree establishment. Canopy trees are rooted in soil pockets or in adjacent communities. Trees include Acer saccharum, Fagus grandifolia, Ulmus americana, Juglans nigra, Liriodendron tulipifera, Carya cordiformis, Asimina triloba, and other species from the Basic Mesic Forest. Shrubs include Lindera benzoin, Aesculus pavia, Asimina parviflora, Callicarpa americana, and Hydrangea arborescens. Vines, particularly Toxicodendron (Rhus) radicans, Parthenocissus quinquefolius, Decumaria barbara, Lonicera sempervirens, and Lonicera japonica, sometimes spread over the rocks. Typical herbs include Aquilegia canadensis, Asplenium heteroresiliens, Cystopteris tennesseensis, Asarum canadense, Podophyllum peltatum, Asplenium platyneuron, and Sanguinaria canadensis. Characteristic mosses include Anomodon attenuatus and Thuidium delicatulum.

Dynamics: Fires are probably very rare or absent due to topographic barriers and broken vegetation. If the bluff is not actively eroding, primary succession may eventually lead to a Basic Mesic Forest.

Range: Apparently restricted to Coastal Plain areas south of the Neuse River. Most examples are known in the Jones and Onslow County area and on bluffs along the Cape Fear River.

Associations: Normally associated with Basic Mesic Forest (Coastal Plain Subtype). May grade to Dry-Mesic or Dry Oak--Hickory Forest or Mesic Mixed Hardwoods above and laterally. Grades into Bottomland Hardwoods, Levee, or Small Stream Swamps (Blackwater or Brownwater subtypes) below.

Distinguishing Features: Coastal Plain Marl Outcrops are distinguished from Basic Mesic Forests and all other forest communities by substantial areas of exposed rock. A closed tree canopy is absent because of steepness or rockiness, or, if present, consists of trees rooted in rock crevices or outside the community. Most of the site is unsuitable for trees to root. Coastal Plain Marl Outcrops are distinguished from Piedmont/Coastal Plain Acidic Cliffs by having calcareous substrates and vegetation with abundant base-loving plants. On sites adjacent to streams, the lower limit of the community is where flooding excludes the characteristic plant species.

Variation: Vegetation varies with slope aspect, steepness, and physical and chemical nature of the substrate.

Comments: This type is somewhat equivalent to the Piedmont Calcareous Cliff and Mafic Cliff types, as a regional counterpart to the Acidic Cliff category. However, the nature of the Coastal Plain terrain and calcareous sediments limit the analogy. Most outcrops are smaller than most Acidic Cliffs and may be shaded by trees rooted in adjacent communities. This type potentially includes limestone outcrops that are horizontally oriented as well as vertical.

These communities are extremely rare.

Rare Plant Species: Vascular -- Adiantum capillus-veneris, Arabis lyrata, Asplenium heteroresiliens, Cystopteris tennesseensis, Minuartia (Arenaria) godfreyi, Parnassia grandifolia; nonvascular -- Cylindrocolea rhizantha, Lejeunea bermudiana.

Synonyms:
Marl outcrop, marl forest (general usage).

Examples:
Island Creek Bluffs, Croatan National Forest, Jones County (Sears 1966).
Greenbank Bluff and other bluffs of the Pee Dee Formation along the Cape Fear River, Bladen, Pender, and Brunswick counties (Nifong and Taggart 1981).
New River Limestone Ravine, Onslow County.

References: Jones-Roe (1982), Nifong (1981), Nifong and Taggart (1981), Sears (1966).

Sample Plant Communities:
Mixed mesophytic hardwoods/Mixed calciphilic herbs and vines.
Bare rock.

GRANITIC FLATROCK

Sites: Outcrops of smooth exfoliating granite, adamellite, syenite, or related rock, level or gently sloping, at about the same elevation as the surrounding land.

Soils: Vary from bare rock to shallow mats of mineral or organic matter, to shallow rocky or sandy soils.

Hydrology: Most of the area is xeric because of lack of water-holding capacity in the shallow (or absent) soil. Depressions in the rock may hold pools of water in the winter. Seepage zones often occur at the forest edge, where soil water emerges onto the rock. Rarely, a large portion of the outcrop consists of seepage zones.

Vegetation: Open rock areas are vegetated by mats of distinctive species, zoned with soil depth or age. Characteristic species include Grimmia laevigata, Selaginella rupestris, Portulaca smallii, Minuartia (Arenaria) glabra, Senecio tomentosus, Diamorpha (Sedum) smallii, Talinum teretifolium, Cladonia caroliniana, Cladonia spp., Polytrichum ohioense, Minuartia (Arenaria) uniflora, Hypericum gentianoides, Dichanthelium (Panicum) spp., Crotonopsis elliptica, Diodia teres, Andropogon spp., Senecio anonymus (smallii), and other typical old field species. Woody species include Rhus copallina, Chionanthus virginicus, Pinus spp., Ulmus alata, and Juniperus virginiana. Small pools and seeps may contain wetland species such as Sphagnum lescurii, Lindernia monticola, Utricularia juncea, Isoetes piedmontana, and Philonotis fontana. Surrounding the outcrop frequently is a forest on shallow soil, dominated by Pinus virginiana, P. echinata, and the more xeric oaks and hickories, such as Quercus stellata, Q. marilandica, Q. coccinea, Carya alba (tomentosa), and Carya glabra.

Dynamics: Vegetation mats expand as pioneers establish at their edges, and succeed through various herbaceous stages to dominance by woody species. Succession is fairly frequently interrupted by windthrow of trees, which destroys the soil mats. Windthrow, drought, and other natural disturbances serve to prevent development of continuous soil or vegetation.

Range: Eastern and central Piedmont. Clusters occur in Wake and Franklin County and in Anson County, but occurrences are scattered elsewhere. The overall range is from Virginia to Alabama.

Associations: Grades into various upland forest types, primarily Dry Oak-- Hickory or Dry-Mesic Oak--Hickory Forest.

Distinguishing Features: The boundary between Granitic Flatrocks and the surrounding forests is placed where the shallow soil conditions and associated vegetation give way to the prevalent surrounding forest vegetation, usually Dry or Dry-Mesic Oak--Hickory Forest. Permanent zones of pine or red cedar at the edges of outcrops are included in the Granitic Flatrock community. The boundary may be difficult to determine where the surrounding forest is successional pine.

Granitic Flatrocks are distinguished from Low Elevation Granitic Domes by their horizontal orientation and occurrence in relatively flat terrain. They also generally occur in different parts of the state.

Variation: Very heterogeneous locally, as described under vegetation. Some floristic and vegetational variation occurs among sites (Wyatt and Fowler 1977). Communities probably also vary with kind of rock. There is some loss of characteristic and community-endemic species as one travels away from the center of flatrock distribution in northcentral Georgia. Rare flatrocks have extensive and relatively long-term seepage; multi-acre wetlands on flatrocks may require separation into a separate type.

Comments: Although Granitic Flatrock communities share many species and features with the Granitic Dome categories, the horizontal orientation causes differences. Vegetation mats may more easily form on the level surface and are less frequently destroyed. Thus they are older and tend to dominate more of the surface. Debris from weathering is removed more slowly. Small irregularities and weathering pits will hold water in wet seasons, creating distinct pools. Wet seepage areas are less common. There is also a difference in distribution, with most Flatrocks occurring in the eastern part of the Piedmont, and all Domes in the western part.

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", but we have retained the well-established and long used "Granite Flatrock", modifying it slightly to "Granitic

Flatrock", since the rock is often not (strictly speaking) granite.

Rare Plant Species: Vascular -- Cyperus granitophilus, Cyperus squarrosus, Diamorpha smallii, Isoetes piedmontana, Lindernia monticola, Manfreda virginica, Minuartia alabamensis, Minuartia uniflora, Portulaca smallii, Sedum pusillum, Trichostema setaceum; nonvascular -- Campylopus oerstedianus.

Synonyms:
Granite flatrock, granite outcrop (general usage).

Examples:
Overton Rock Outcrop, Franklin County (Palmer 1970).
Mitchell's Millpond State Natural Area, Wake County (LeGrand and Dalton 1987).
Temple Rock, Wake County (LeGrand and Dalton 1987).
The Rocks, Wake County (LeGrand and Dalton 1987).
Jackson Training School Natural Area and other areas on the Syenite Ring Dike, Cabarrus County
Martin's Rock, Anson County.
Flat Rock Church Outcrop, Anson County.
Red Bud Creek Flatrock, Franklin County.

References: LeGrand and Dalton (1987), McVaugh (1943), Oosting and Anderson (1937), Palmer (1970), Wyatt and Fowler (1977).

Sample Plant Communities:
Bare rock.
Mixed foliose lichens.
Cladonia spp.
Cladonia caroliniana.
Grimmia laevigata.
Polytrichum spp.
Sphagnum lescurii.
Diamorpha (Sedum) smallii.
Talinum teretifolium.
Minuartia (Arenaria) glabra.
Diodia teres.
Dichanthelium sp.
Danthonia sericea.
Andropogon virginicus.
Senecio tomentosus.
Senecio anonymus (smallii).
Piptochaetium (Stipa) avenaceum.
Minuartia glabra-Talinum teretifolium.
Minuartia glabra/Cladonia caroliniana.
Isoetes piedmontana-Lindernia monticola.
Juniperus virginiana.
Pinus virginiana.
Pinus echinata.
Pinus virginiana-Juniperus virginiana.
Mixed xerophytic pines and oaks.
Mixed xerophytic pines and oaks/Piptochaetium avenaceum.

HIGH ELEVATION MAFIC GLADE

Sites: High elevation outcrops of mafic rocks such as amphibolite or hornblende gneiss, gently sloping or flat.

Soils: Shallow organic or mineral accumulations over largely impermeable rock. The soil is apparently classifiable as a Lithic Haplorthent (Weakley, Mehrhoff, and Mansberg 1979).

Hydrology: Extremely variable, from very xeric in droughts to saturated or with standing water in rainy periods.

Vegetation: Small soil-filled depressions are largely barren, with seasonal dominance by the summer annuals Polygala curtissii and Hypericum gentianoides. Areas of exposed rock and crevices have Aster linariifolius, Coreopsis major, Gaultheria procumbens, Viola pedata, Schizachyrium (Andropogon) scoparium, Danthonia spicata, Potentilla canadensis, Sibbaldiopsis (Potentilla) tridentata, and other vascular plants, but are largely dominated by Cladonia caroliniana, Cladonia uncialis, Cladonia psoromica, and other Cladonia spp. and Cladina spp. The moss Rhytidium rugosum is common on very thin soil over rock. Slightly deeper soils occur in patches, with such species as Kalmia latifolia, Vaccinium corymbosum, Vaccinium stamineum, Salix humilis, Aletris farinosa, Pyrola americana, and Cypripedium acaule. Exposed rock is covered with a wide variety of crustose lichens.

Dynamics: Apparently stable, with soils, hydrology, climate, and topography conspiring to prevent succession to woody species.

Range: Currently known only from Bluff Mountain, Ashe County. Potentially elsewhere in the high Blue Ridge where amphibolite or other mafic rocks occur.

Associations: Grades into High Elevation Red Oak Forest in deeper soils. It is related to Southern Appalachian Fen, which differs in remaining saturated (or nearly so) throughout the year.

Distinguishing Features: The High Elevation Mafic Glade type is distinguished by the occurrence of continuous, flat, mafic rock at high elevation. High Elevation Rocky Summits are distinguished by having irregular and fragmented rock with crevices which allow deeper rooted plants to occur. High Elevation Granitic Domes may have continuous flat rock surfaces at the top, but occur on granite, granitic gneiss, or other felsic rocks. The Southern Applachian Fen is similarly underlain by mafic rock, but remains saturated throughout the year and has wetland vegetation.

Variation: Very heterogeneous, with vegetation depending on thickness of soil and frequency and degree of saturation. If other occurrences are found, they may differ substantially from this description, depending on elevation, rock type, soils, and hydrology, requiring a broadening of the description of the community type.

Comments: This is an extremely rare community type, known from only one site. The relative scarcity of mafic rocks in the Southern Appalachians and the specialized physical structure required make discovery of additional well- developed examples unlikely.

Rare Plant Species: Vascular -- Gentianopsis crinita, Helianthemum bicknellii, Helianthemum propinquum, Liatris aspera, Phlox subulata, Polygonum tenue, Pyrola americana; nonvascular -- Cladonia psoromica, Rhytidium rugosum.

Synonyms:
Hornblende flatrock (Weakley, Mehrhoff, and Mansberg 1979).
Mafic Bedrock Glade (Second Approximation).

Examples:
Bluff Mountain, Ashe County (Weakley, Mehrhoff, and Mansberg 1979) (only known example).

References: Weakley, Mehrhoff, and Mansberg (1979).

Sample Plant Communities:
Mixed crustose lichens.
Mixed Cladonia spp.
Vaccinium constablaei-Kalmia latifolia/Schizachyrium (Andropogon) scoparium/Gaultheria procumbens-Cladonia spp.
Schizachyrium scoparium/Mixed herbs/Cladonia spp.
Hypericum gentianoides-Polygala curtissii.

DIABASE GLADE

Sites: On broad, flat, upland Piedmont ridges, level or very nearly so, at elevations similar to adjoining land, over mafic rocks such as diabase or gabbro.

Soils: Soils medium acid to neutral, purplish brown. Unforested parts have soils generally from 0-10 cm deep, with abundant "pea gravel" (apparently manganese nodules) on surface. Sparse and stunted forest parts have deeper, but generally similar, soils. Soil should be classified as a Lithic Hapludalf, based on depth to bedrock. Mapped by the Soil Conservation Service as the Picture Series (Abruptic Argiaquoll), but undoubtedly representing an inclusion within that map unit.

Hydrology: Terrestrial, xeric for most of the year, but may pond water during wet periods.

Vegetation: A mosaic of patches dominated by herbs, shrubs, and stunted trees. Exposed rock and shallow soils are vegetated by herbs such as Diodia teres, Houstonia tenuifolia, Oenothera fruticosa, Portulaca smallii, Talinum teretifolium, Tragia urticifolia, Sporobolus clandestinus, Manfreda (Agave) virginica, Polygonum tenue, Clematis ochroleuca, Lithospermum canescens, Asclepias verticillata, Ruellia humilis, Trichostema dichotomum, Opuntia compressa, Trichostema brachiatum, Aster depauperatus, Cladina spp., Sisyrinchium mucronatum, Schizachyrium (Andropogon) scoparium, Panicum flexile, Parthenium integrifolium var. auriculatum, Hypericum denticulatum, Crotonopsis elliptica, Cyperus granitophilus, Bulbostylis capillaris ssp. capillaris, Aristida longespica, Aquilegia canadensis, Arabis canadensis, and Anemone virginiana, with few or no shrubs or trees. Somewhat deeper soils have a sparse and stunted canopy of Juniperus virginiana, Celtis tenuifolia (occidentalis var. georgiana), Cercis canadensis, Fraxinus americana, Carya alba (tomentosa), Quercus stellata, Ulmus alata, and Quercus marilandica. Characteristic shrubs and vines are Symphoricarpos orbiculatus, Rhus aromatica, Berberis canadensis, Viburnum rafinesquianum, Chionanthus virginicus, Trachelospermum difforme, and Matelea decipiens.

Dynamics: Poorly known. Openings are apparently maintained by the extreme shallowness and dryness of the soils, and possibly also by soil shrink-swell. Natural disturbance, particularly fire, may have a role in the long-term maintenance of the open character. The harsh site conditions would allow only slow recovery of woody cover from fire.

Range: Known only from Durham and Granville counties, and in the vicinity of Rock Hill, South Carolina.

Associations: Grades into Xeric Hardpan Forest or Basic Oak--Hickory Forest.

Distinguishing Features: The Diabase Glade type is distinguished by its structure of mixed physiognomy, with patches of herb, shrub, and stunted tree dominance. The floristic composition, with combinations of base-loving plants, species typical of Granitic Flatrocks, and weedy species, is also very distinctive.

The margins of Diabase Glades include sparse and stunted forest, with much Juniperus virginiana mixed with hardwoods. Trees are generally under 30 feet in height, and do not form a closed canopy. The impression is of scattered to locally dense patches of trees in the deeper soils of what is a fundamentally unforested system. The herb layer remains fairly dense, with a variety of grasses and forbs. In contrast, Xeric Hardpan Forest has a canopy of oaks, hickories and pines, sometimes a bit stunted, but over 30 feet high if not recently cut; although the canopy is somewhat open, this is clearly a forested system (though some or all may have once been prairie-like). The herb layer in Xeric Hardpan Forest is often sparse and is generally of lower diversity. Xeric Hardpan Forest sites that have been pastured or chronically disturbed may resemble Diabase Glades more than intact examples, and the distinction may be difficult. However, these sites will generally not have such shallow, rocky soil.

Variation: Not enough known to adequately describe variation. The one well- developed, relatively intact site is very heterogenous. Other, more disturbed, sites differ substantially.

Comments: This is a peculiar type of glade, clearly related in appearance and flora on the one hand to the limestone cedar glades of Tennessee, Missouri, and Arkansas, and on the other hand to the Granitic Flatrocks of the southeastern Piedmont (LeGrand 1988). In North Carolina, it is also related conceptually (although not floristically) to other rare glade types

developed over mafic rocks in the Blue Ridge -- High Elevation Mafic Glade and Ultramafic Outcrop Barren. The discovery of the "serpentine endemic" Aster depauperatus at these sites (Levy and Wilbur 1990) also suggests a floristic and conceptual connection to the serpentine barrens of Maryland, Pennsylvania, and Delaware.

Rare Plant Species: Vascular -- Aster depauperatus, Baptisia australis var. australis, Berberis canadensis, Echinacea laevigata, Eupatorium incarnatum, Isoetes piedmontana, Lathyrus venosus, Liatris squarrulosa, Linum sulcatum var. sulcatum, Lithospermum canescens, Lotus purshianus var. helleri, Manfreda virginica, Matelea decipiens, Panicum flexile, Parthenium integrifolium var. auriculatum, Polygala senega, Polygonum tenue, Portulaca smallii, Ruellia humilis, Ruellia purshiana, Scutellaria parvula var. leonardii, Senecio pauperculus, Silphium terebinthinaceum, Solidago ptarmicoides, Trichostema brachiatum, Trichostema setaceum.

Synonyms:
Cedar glade (LeGrand 1988).

Examples:
South Butner Diabase Glade, Granville County (LeGrand 1986, 1988) (The only relatively intact, well-developed example known in North Carolina).
Knap of Reeds Creek Diabase Glade, Granville County (LeGrand 1986) (a disturbed example).
Eno River Diabase Area, Durham County (Sutter, Harrison, and Rettig 1987) (a marginal example).

References: LeGrand (1986), LeGrand (1988), Levy and Wilbur (1990), Sutter, Harrison, and Rettig (1987).

Sample Plant Communities:
Talinum teretifolium-Portulaca smallii.
Diodia teres-Houstonia tenuifolia.
Sporobolus clandestinus-mixed forbs.
Mixed xeric grasses and forbs.
Cladina spp.
Juniperus virginiana/Symphoricarpos orbiculatus-Rhus aromatica.
Panicum flexile.

ULTRAMAFIC OUTCROP BARREN

Sites: Outcrops of dunite, serpentinite, or related ultramafic rocks, particularly on southerly exposures or flat.

Soils: Various rock or clayey soils. Mansberg (1981) reports one site with a possible Lithic Hapludoll.

Hydrology: Terrestrial, dry or xeric. Dryness is difficult to judge because of effects of soil chemistry and physical properties on the vegetation.

Vegetation: Open stunted canopy of xerophytic trees such as Pinus rigida, Pinus virginiana, Quercus stellata, and Quercus falcata. Other trees include Quercus rubra, Q. alba, Sassafras albidum, Acer rubrum, and Nyssa sylvatica. Shrubs sparse to dense, species such as Kalmia latifolia, Vaccinium stamineum, Ceanothus americanus, Viburnum nudum var. cassinoides, and Physocarpus opulifolius. Dense grassy herb layer with Schizachyrium (Andropogon) scoparium, Andropogon gerardii, Sporobolus heterolepis, Poa saltuensis (languida), Senecio plattensis, Hexastylis arifolia, Thalictrum macrostylum, Dichanthelium (Panicum) sphaerocarpon, Dichanthelium (Panicum) lanuginosum, and Solidago nemoralis. A number of herbs occur on these sites which are uncommon or rare elsewhere in North Carolina, including Elymus (Agropyron) trachycaulus, Castilleja coccinea, Poa saltuensis, Senecio plattensis, Muhlenbergia glomerata, Deschampsia cespitosa, and Sporobolus heterolepis.

Dynamics: The barren structure is apparently relatively stable, determined by site conditions, but periodic disturbance may play a role in keeping the open structure. The dry, grassy vegetation is flammable and the harsh environment may allow only slow recovery of woody cover from fire. The barren community may be more affected by fire than surrounding communities on more favorable sites which burn at the same time. The natural fire frequency of these communities is not known.

Range: Very rare. A few scattered sites occur in the Blue Ridge. One marginally-developed example is known in the Piedmont, and others are potentially present.

Associations: Grades to other terrestrial communities on other substrate types and on more weathered ultramafic outcrops.

Distinguishing Features: Ultramafic Outcrop Barrens are distinguished by their occurrence on ultramafic rocks and by vegetation which is more open, barren or stunted, and xerophytic than would be expected given the site. Not all ultramafic rock outcrops support Ultramafic Outcrop Barrens. Sheltered sites may have Basic Mesic Forest and other sites have vegetation that does not appear different from that on other rock types. Only areas that have open, savanna- like structure and contrast with other vegetation should be considered Ultramafic Outcrop Barrens.

Variation: Vegetation varies, probably with differences in weathering, rock composition, rock texture, soil drainage, and exposure. Radford (1948) described several different plant community types occurring on olivine deposits, all of which, except the streamside shrub and very mesic forest categories, are included in this natural community type.

A very different example occurs in Wake County. It is dominated by Quercus marilandica, with a different suite of herbs more related to the Xeric Hardpan Forest type. As the only known Piedmont example in North Carolina, it is considered a distinct variant, and may warrant a separate type, along with Piedmont examples in other states.

Comments: Ultramafic rocks have been associated with unusual vegetation and plant species in many parts of the world. Most sites have vegetation of unusually small stature and openness for the climate, and may have endemic species or races which are often genetically dwarfed. The barrens in North Carolina do not appear to have endemic species, but the best developed one supports numerous plant species rare in the region or rare throughout their range. Floristically, these communities appear to have some relation to prairies and glades in areas west of North Carolina.

This is an extremely rare natural community type in North Carolina. While other barrens apparently existed and were destroyed by mining, the majority of ultramafic rocks in the state, particularly in the Piedmont, do not support distinctive communities. The reason for this is not clear but the deep weathering and heavy leaching of most of the Piedmont over geologic time may limit the influence of the rocks on soil and vegetation.

Rare Plant Species: Vascular -- Deschampsia cespitosa ssp. glauca, Elymus trachycaulus, Frasera caroliniensis,

Gentianopsis crinita, Muhlenbergia glomerata, Parnassia grandifolia, Poa saltuensis, Polygala paucifolia, Polygala senega, Senecio plattensis, Sporobolus heterolepis.

Synonyms: Serpentine barren, olivine barren, pine barren (general use).

Examples:
Buck Creek Serpentinized Olivine Barren, Nantahala National Forest, Clay County (Mansberg 1981, Mansberg and Wentworth 1984) (only known, intact, well-developed example in North Carolina).
Adam Mountain, Falls Reservoir, Wake County (LeGrand and Dalton 1987) (a marginal and very different example).

References: LeGrand and Dalton (1987), Mansberg (1981), Mansberg and Wentworth (1984), Radford (1948).

Sample Plant Communities:
Pinus pungens/Gaylussacia baccata.
P. pungens/Leiophyllum buxifolium.
P. pungens-Pinus rigida/Mixed heaths.
Pinus rigida/Viburnum nudum var. cassinoides.
P. rigida/Andropogon gerardii-Sporobolus heterolepis.
P. rigida/Schizachyrium (Andropogon) scoparium.
P. rigida-Pinus echinata/Mixed heaths.
P. rigida-Pinus virginiana/Kalmia latifolia/Vaccinium pallidum (vacillans).
P. rigida-P. virginiana/Vaccinium pallidum.
Quercus alba/Gaylussacia ursina-Rhododendron calendulaceum.
Quercus marilandica/Mixed grasses and forbs.

DUNE GRASS

Sites: Coastal areas immediately behind the beach.

Soils: Coarse shifting or recently stabilized sands, classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Excessively drained, with varying but generally high amounts of salt spray.

Vegetation: Cover ranges from sparse to fairly dense. Generally dominated by Uniola paniculata in most of North Carolina. Ammophila breviligulata becomes dominant in the northern part of the state, and has been widely introduced farther south. Other typical species include Panicum amarum, Spartina patens, Strophostyles helvula, Triplasis purpurea, Hydrocotyle bonariensis, Croton punctatus, Oenothera humifusa, Cenchrus tribuloides, Chamaesyce (Euphorbia) polygonifolia, Chamaesyce bombensis (Euphorbia ammanioides), Schizachyrium (Andropogon) scoparium var. littorale, Andropogon virginicus, Cakile edentula, Yucca filamentosa, Physalis walteri (maritima), Iva imbricata, and Conyza (Erigeron) canadensis var. pusilla.

Dynamics: These communities occur in a highly dynamic and stressful environment. Blowing sand may bury plants and wind erosion may expose their roots. Even stabilized dunes are susceptible to forming blowouts if eroded or disturbed. The sand binding plants of the Dune Grass community trap blowing sand, causing the dune to build up higher and eventually stabilizing it. New dunes form on sand flats by deposition around plants.

Oceanward dunes are exposed to nearly continuous salt spray which, along with excessive drainage and shifting sand, exclude most species and maintain this community type. Sites which become more protected from salt spray by natural or artificial means eventually succeed to Maritime Shrub or Maritime Forest.

Range: Throughout the barrier islands.

Associations: Bordered on the seaward side by the Upper Beach community. May contain swales with Maritime Wet or Dry Grassland or Interdune Pond communities. Grades landward to Wet or Dry Maritime Wet or Dry Grassland, Maritime Shrub, or Maritime Forest.

Distinguishing Features: Dune Grass communities are distinguished from Maritime Dry Grassland by the predominance of salt spray and shifting sand over overwash as the significant environmental factor under natural conditions. They may generally be distinguished by the dominance of Uniola paniculata or Ammophila breviligulata, although other species may occasionally dominate. Dune Grass communities can be distingished from Upper Beach communities by their occurrence on dunes and by dominance of perennial rather than annual plants. However, unvegetated shifting dunes are considered part of the Dune Grass type.

Variation: Cover ranges from sparse on foredunes and on actively moving sand areas to fairly dense on more stable dunes. Godfrey and Godfrey (1976) note that dunes on islands perpendicular to prevailing winds tend to be larger and better developed than those on islands parallel to the winds.

In the northern part of the state, around Nags Head, Ammophila breviligulata replaces Uniola paniculata as the dominant grass. The northern and southern associations may warrant recognition as two types or subtypes, but are treated as variants at present. An apparently natural Dune Grass community dominated by Spartina patens is described by Godfrey and Godfrey (1976) on Core Banks.

Comments: Dune Grass communities, more than most, are closely tied to geologic processes and are of great importance to other communities on the barrier islands. The processes of wind and sand movement both influence the vegetation and are influenced by it. The dunes also control the amount of overwash and salt spray on the rear parts of the barrier island, which determines the location of Maritime Shrub, Maritime Forest, and Maritime Grasslands.

Godfrey and Godfrey (1976) describe the natural dune form on most islands as one of relatively low, discontinuous dunes with overwash passes between them. On many islands, artificial dune building by sand fencing and dense planting of grasses has led to development of a high continuous line of dunes. This has concentrated the effects of storm waves on the

beach, increasing erosion there. It has also allowed Maritime Dry Grassland and Wet Grassland communities to be invaded by shrubs.

Rare Plant Species: Vascular -- Amaranthus pumilus, Chamaesyce bombensis, Ipomoea imperati, Sporobolus virginicus, Trichostema sp. 1, Yucca aloifolia, Yucca gloriosa; nonvascular -- Tortella flavovirens.

Synonyms:
Dune Strand (Godfrey and Godfrey 1976).

Examples:
Shackleford and Core Banks, Cape Lookout National Seashore, Carteret County (Godfrey and Godfrey 1976, Snow and Godfrey 1978, Au 1974).
Bear Island, Hammocks Beach State Park, Onslow County (Dumond 1977b).
Lea Island, Pender County (Weakley 1980a).
Hutaff Island, Pender County (Weakley 1980a).

References: Au (1974), Dumond (1977b), Godfrey and Godfrey (1976), Leonard and Davis (1981), Parnell (1979), Snow and Godfrey (1978), U.S. Fish and Wildlife Service (1980), Weakley (1980a).

Sample Plant Communities:
Uniola paniculata.
Ammophila breviligulata.
Schizachyrium (Andropogon) scoparium var. littorale.
Strophostyles helvula-Croton punctatus.
Hydrocotyle bonariensis.
Panicum amarum.

MARITIME DRY GRASSLAND

Sites: Low stable dunes and overwash terraces behind or between low dunes, with occasional to frequent sea water overwash and sand burial. Most extensive examples are on low barrier islands with only low, open dunes.

Soils: Recent sand deposits with little or no soil development. Most areas are mapped as Corolla (Aquic Quartzipsamment), some as Duckston (Typic Psammaquent) or Newhan (Typic Quartzipsamment).

Hydrology: Terrestrial, excessively drained at the surface, with occasional to frequent sea water flooding.

Vegetation: Generally moderate to dense herbaceous cover except in recently overwashed areas. Dominated by Spartina patens. Other typical species include Solidago sempervirens, Sabatia stellaris, Gaillardia pulchella, Croton punctatus, Fimbristylis spp., Eragrostis pilosa, Cenchrus tribuloides, Chenopodium ambrosioides, Chloris petraea, Setaria geniculata, Strophostyles helvula, Chamaesyce (Euphorbia) polygonifolia, Physalis walteri (viscosa var. maritima), Commelina erecta var. angustifolia, Spiranthes vernalis, and Opuntia pusilla (drummondii). Scattered woody vegetation includes Ilex vomitoria, Smilax auriculata, Yucca aloifolia, Yucca gloriosa, and Myrica cerifera. Some species more typical of the Upper Beach, such as Cakile edentula and Amaranthus pumilus, occur rarely in this community type when seed has been transported by overwash.

Dynamics: As with other barrier island communities, Maritime Dry Grasslands occur in a dynamic environment. Most of these sites, under natural conditions, are overwashed by salt water in severe storms. Overwash sand deposits may temporarily bury the vegetation, but the dominant species are well adapted to recover quickly from such natural disturbance. Most examples are also subject to some salt spray, which represents an ongoing stress that excludes many species. With the artificial stabilization and enhancement of dune on many islands, many of these communities have been invaded by shrubs and are succeeding to Maritime Shrub or Maritime Forest. A similar succession may occur naturally if dune growth, movement, or beach accretion increase protection. Likewise, a Maritime Dry Grassland may develop if dunes are eroded and protection decreased in Martime Shrub or Maritime Forest areas.

Range: Throughout the barrier islands.

Associations: Grades into Dune Grass on higher dunes. May grade into Maritime Shrub or Maritime Forest in areas protected from overwash. May grade to Maritime Wet Grassland where water table is closer to the surface.

Distinguishing Features: Maritime Dry Grasslands are distinguished from Maritime Wet Grasslands by their lower diversity and occurrence on drier or more frequently overwashed sites. The boundary is at the Terrestrial-Palustrine boundary, where upland species begin to dominate over wetland species. Maritime Dry Grasslands are separated from Dune Grass by the predominance of overwash over salt spray and shifting sand as a significant environmental factor. They may generally be distinguished by the dominance of Spartina patens over the dune grasses Uniola paniculata and Ammophila breviligulata, although Spartina- dominated dunes may occasionally occur. Maritime Dry Grasslands are separated from Maritime Shrub and Maritime Forest where shrubs and trees naturally predominate over herbs and bare ground.

Variation: Wetter and less frequently overwashed areas, transitional to Maritime Wet Grassland, are more diverse, with Spartina patens dominating less strongly.

Comments: These communities are not naturally rare but, like all barrier island communities, are of limited extent and are highly threatened by building and by modification of the salt spray and overwash environment. Artificial dune buildup has rendered even much of the acreage under protective ownership subject to unnatural succession. Maritime Dry Grasslands are often not distinguished from Maritime Wet Grasslands, and the relative abundance of these two types is not well known.

The nature of the transition to Maritime Wet Grassland needs further investigation.

Rare Plant Species: Vascular -- Cyperus tetragonus, Hudsonia tomentosa, Trichostema sp. 1; nonvascular --Tortella flavovirens.

Synonyms:
Barrier Flat Grassland (Godfrey and Godfrey 1976).
Grassy Sand Flat (Au 1974).
Open Grassland (Snow and Godfrey 1978).

Examples:
Shackleford and Core Banks, Cape Lookout National Seashore, Carteret County (Snow and Godfrey 1978, Godfrey and Godfrey 1976, Au 1974).
Lea Island, Pender County (Weakley 1980a).
Hutaff Island, Pender County (Weakley 1980a).
Masonboro Island, New Hanover County (Weakley 1980a, Hosier and Cleary 1977).
Ocracoke Island (west end), Cape Hatteras National Seashore, Hyde County.
Bald Head Island, Brunswick County (Mayes 1984).

References: Au (1974), Godfrey and Godfrey (1976), Hosier and Cleary (1977), Mayes (1984), Parnell, Hosier, Sieren, Webster, and Cooper (1987), Snow and Godfrey (1978), U.S. Fish and Wildlife Service (1980), Weakley (1980a).

Sample Plant Communities:
Spartina patens.
Gaillardia pulchella.
Strophostyles helvula.

MARITIME SHRUB

Sites: Stabilized sand dunes, dune swales, and sand flats protected from salt water flooding and the most extreme salt spray.

Soils: Sandy soils with no horizon development. Usually mapped as the Newhan (Typic Quartzipsamment) or Corolla (Aquic Udipsamment) series.

Hydrology: Excessively drained to poorly drained. May have a high water table. Subject to fairly heavy salt spray.

Vegetation: Dense growth of shrubs, most frequently Myrica cerifera, Ilex vomitoria, Baccharis halimifolia, Juniperus virginiana, Zanthoxylum clava- herculis, and stunted Quercus virginiana. North of Nags Head, Myrica pensylvanica is often codominant. Other species include Toxicodendron (Rhus) radicans, Smilax spp., Parthenocissus quinquefolia, Vitis spp., and Callicarpa americana. Openings may contain various species typical of Maritime Dry Grassland communities.

Dynamics: 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 spary, or erosion in severe storms. Some examples are old and have long been stable. Others represent early stages of primary or secondary succession to Maritime Evergreen Forest. Salt spray represents an ongoing environmental stress which excludes most species and limits the stature of the vegetation. Increased protection from salt spray may result in succession to Maritime Evergreen Forest.

On many islands, artificial buildup of the dunes has increased protection from overwash on sand flats, allowing shrubs to invade these areas.

Range: Throughout the barrier islands.

Associations: May grade to Maritime Evergreen Forest. May contain Interdune Ponds. Grades to, or sharply borders, Dune Grass on less protected or more actively moving dunes. Grades to or borders Dry or Wet Maritime Grassland in areas which receive overwash. May grades to Salt Shrub in lower places subject to brackish or salt water.

Distinguishing Features: The Maritime Shrub type is distinguished from Maritime Wet and Dry Grassland and Dune Grass by the natural dominance of shrub-sized woody vegetation. It is distinguished from Maritime Evergreen Forest by its more exposed environment and lower stature. The boundary is defined at a height of 5 meters for the full height canopy. Maritime Shrub is distinguished from Salt Shrub by its occurrence on upland sites only rarely and catastrophically subject to salt water intrusion, and by vegetative composition. Species such as Borrichia frutescens, Iva frutescens, and marsh species are rare or absent in Maritime Shrub, while species such as Quercus virginiana and Ilex vomitoria do not occur in Salt Shrub. Dominance by species of wide tolerance, such as Myrica cerifera, may make distinguishing the two types difficult.

Variation: Varies with successional age, amount of salt spray, and wetness. The oldest examples, in stable dunes, are dominated by stunted Quercus virginiana. Young examples are usually dominated by Myrica cerifera. A latitudinal gradient also exists. In the northernmost part of the state, Myrica pensylvanica largely replaces M. cerifera.

Comments: Successional shrub communities have become more common on former Maritime Dry and Wet Grassland sites due to artificial building of dunes. The older, relatively stable Maritime Shrub communities are subject to the same destruction or modification by development as other maritime communities. Although the natural community type as a whole is not uncommon on the limited area of the barrier islands, good natural examples are rare.

Rare Plant Species: Vascular -- Cyperus tetragonus, Erythrina herbacea, Hudsonia tomentosa, Juniperus virginiana var. silicicola, Parietaria floridana, Parietaria praetermissa, Sageretia minutiflora, Sideroxylon tenax, Yucca aloifolia, Yucca gloriosa.

Synonyms:
Maritime Thicket.

Examples:
Shackleford and Core Banks, Cape Lookout National Seashore, Carteret County (Au 1974, Godfrey & Godfrey 1976).
Bear Island, Onslow County (Dumond 1977b).
Bogue Banks, Carteret County (Lopazanski, Evans, and Shaw 1988).
Sunset Beach, Brunswick County.

References: Au (1974), Dumond (1977b), Fussell and Wilson (1983), Godfrey and Godfrey (1976), Lopazanski, Evans, and Shaw (1988), North Carolina Vegetation Survey (1988), Parnell (1979), Wells (1939), Wells and Shunk (1937).

Sample Plant Communities:
Myrica cerifera.
Myrica pensylvanica.
Ilex vomitoria-Quercus virginiana.
Quercus virginiana.

MARITIME EVERGREEN FOREST

Sites: Old stabilized dunes and flats, protected from salt water flooding and the most extreme salt spray.

Soils: Young, poorly developed sandy soils. Most areas are on the Fripp series (Typic Quartzipsamment); some are mapped as Newhan (Typic Quartzipsamment), Duckston (Typic Psammaquent), or Corolla (Aquic Quartzipsamment).

Hydrology: Terrestrial, xeric to mesic, well to excessively drained, subject to moderate to light salt spray.

Vegetation: Low to moderately high tree canopy, often stunted and pruned by salt spray into streamlined shapes. Dominated by combinations of Quercus virginiana, Pinus taeda, and Q. hemisphaerica, with few other species. Typical understory species are Persea borbonia (sensu stricto), Carpinus caroliniana, Juniperus virginiana, Cornus florida, Osmanthus americana, Ilex opaca, Prunus caroliniana, and Zanthoxylum clava-herculis. Shrubs include Ilex vomitoria, Myrica cerifera, Sabal minor, and Callicarpa americana. Vines such as Toxicodendron (Rhus) radicans, Vitis rotundifolia, Smilax spp., Parthenocissus quinquefolia, Bignonia (Anisostichus) capreolata, Berchemia scandens, Ampelopsis arborea, and Gelsemium sempervirens are often important. The herb layer is sparse and low in diversity, with species such as Mitchella repens, Asplenium platyneuron, Chasmanthium (Uniola) laxum, Piptochaetium (Stipa) avenaceum, Galium pilosum, Dichanthelium (Panicum) commutatum, Elephantopus nudatus, and Passiflora lutea.

Dynamics: These communities occur in sheltered parts of the barrier islands, but they are still somewhat subject to the extremes of the maritime environment. Salt spray has long been recognized as an important on-going stress, sculpting the canopy and excluding most species (Wells 1939, Wells and Shunk 1937). The forests are also subject to periodic severe disturbance by the wind and heavy salt spray of hurricanes. Such disturbance may kill significant portions, but generally not all, of the forest canopy. Smaller storms may produce canopy gaps at a faster rare than is typical inland.

Other environmental factors that may be important in distinguishing the function of maritime communities from inland communities include excessive drainage in the sandy soils, constant supply of nutrients in salt spray, warmer winter temperatures, and longer growing seasons.

Sites that were logged or cleared in the past generally are strongly dominated by Pinus taeda, which apparently succeeds to oak dominance. It is not clear if storm disturbance produces similar succession. Dense thickets of shrubs and vines often develop in canopy openings, and may inhibit pine reproduction.

Geologic processes such as dune migration and erosion may directly destroy Maritime Evergreen Forests. The forests may also be indirectly converted to Maritime Shrub or Maritime Dry Grassland by the natural or artificial loss of the dunes that provied shelter from heavy salt spray.

These communities are capable of carrying fire, and apparently burned in the past, even before settlement (Bratton and Davison 1987). Undergrowth has apparently become much more dense since the cessation of burning and early grazing. Natural fire was probably significantly less frequent than in mainland forests.

Maritime Evergreen Forests are apparently very dependent on the integrity of the canopy for protection from the effects of salt spray. The canopy is often sculpted into a smooth, streamlined shape rising from Maritime Shrub gradually to a tall forest canopy. If a clearing is created, trees adjacent to it are exposed to greater salt deposition and wind, and often die.

Range: Barrier islands.

Associations: Frequently grades into Maritime Shrub at more exposed edges. May border Dune Grass or Maritime Grassland at the edge of actively moving sand dunes or overwash deposits. May grade to Maritime Swamp Forest, Maritime Shrub Swamp, or Interdune Pond in wet swales.

Distinguishing Features: Maritime Evergreen Forest may be distinguished from Maritime Deciduous Forests by the occurrence of Quercus virginiana and Q. hemisphaerica as the dominant, and often the only, canopy hardwoods. Pinus taeda may occur in both types, with its abundance determined by natural and artificial disturbance.

Maritime Evergreen Forest is distinguished from Maritime Shrub by a tree canopy greater than 5 meters tall. It is separated from Maritime Swamp Forest and Maritime Shrub Swamp by the dominance of the canopy species named above over wetland species. It is distinguished from Coastal Fringe Evergreen Forest by its occurrence on barrier islands or the

ocean side of peninsulas, with the environmental differences that implies.

Variation: Examples vary with successional age and protection from salt water. Forests closest to the ocean are usually dominated by Quercus virginiana and Juniperus virginiana, while farther back Pinus taeda and Quercus hemisphaerica become more important. There is also latitudinal variation. A southern variant occurs in the Smith Island Complex at the southern end of North Carolina. It has Sabal palmetto, which is absent northward, as an important canopy component.

Comments: With their limitation 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 construction and other human activities on the islands, and the destruction of maritime forests by development has accelerated in recent years. The creation of numerous small clearings for houses will probably have far-reaching effects on the dynamics of the forest.

The distinction from Coastal Fringe Evergreen Forest is somewhat tentative, because little is known about that newly distinguished type. Although the same canopy species may dominate in both, the mainland locations tend to be more diverse and to differ in amount of salt spray, age of soils, susceptibility to fire spreading from adjacent areas, and exposure to storm damage.

Rare Plant Species: Vascular -- Asplenium platyneuron var. bacculum-rubrum, Cyperus tetragonus, Erythrina herbacea, Hudsonia tomentosa, Iresine rhizomatosa, Juniperus virginiana var. silicicola, Listera australis, Parietaria floridana, Parietaria praetermissa, Sabal palmetto, Sageretia minutiflora, Sideroxylon lycioides, Sideroxylon tenax; nonvascular -- Cheilolejeunea rigidula, Lejeunea dimorphophylla, Syrrhopodon incompletus, Teloschistes flavicans.

Synonyms:
Maritime Forest (Second Approximation and general usage).
Different examples might fall into SAF types 89 or 82: Live Oak or Loblolly Pine hardwood, but are atypical of the general description of these types.

Examples (Lopazanski, Evans, and Shaw 1988, N.C. Vegetation Survey 1988, and references cited):
Smith Island Complex, Brunswick County (Parnell 1979, Nifong 1981, Mayes 1984).
Theodore Roosevelt State Natural Area, Bogue Banks, Carteret County (Fussell and Wilson 1983, Lopazanski 1987).
Buxton Woods, Cape Hatteras National Seashore, Dare County (Dumond 1977b).
Shackleford Banks, Cape Lookout National Seashore, Carteret County (Au 1974, Godfrey and Godfrey 1976).
Emerald Isle Woods, Carteret County (Fussell and Wilson 1983).
Pine Island Audubon Sanctuary and Currituck Shooting Club, Currituck County (Parnell, et al. 1987).

References: Atkinson and List (1978), Au (1974), Bordeau and Oosting (1959), Bratton and Davison (1987), Dumond (1977a), Dumond (1977b), Fussell and Wilson (1983), Godfrey and Godfrey (1976), Lopazanski (1987), Lopazanski, Evans, and Shaw (1988), Mayes (1984), Nifong (1981), North Carolina Vegetation Survey (1988), Parnell (1979), Parnell, Hosier, Sieren, Webster, and Cooper (1987), Wells (1939), Wells and Shunk (1937), Wentworth, Schafale, Weakley, Peet, White, and Frost (1989).

Sample Plant Communities:
Quercus virginiana.
Quercus hemisphaerica-Q. virginiana/Cornus florida.
Quercus virginiana/Prunus caroliniana/Ilex vomitoria.
Quercus virginiana-Q. hemisphaerica-Sabal palmetto/Prunus caroliniana/Ilex vomitoria.
Quercus virginiana-Juniperus virginiana.
Pinus taeda/Persea borbonia.
Pinus taeda/Quercus hemisphaerica.
Pinus taeda/Carpinus caroliniana.

MARITIME DECIDUOUS FOREST

Sites: Most protected parts of old stabilized dunes and beach ridges on widest barrier islands.

Soils: Fripp series (Typic Quartzipsamment).

Hydrology: Terrestrial, dry to mesic, with little salt spray.

Vegetation: Forest dominated by mixtures of Pinus taeda and various hardwoods, particularly Quercus falcata, Fagus grandifolia, Liquidambar styraciflua, Q. nigra, Carya glabra, and C. pallida. Understory trees include Carpinus caroliniana, Ilex opaca, Cornus florida, Vaccinium arboreum, Ostrya virginiana, Juniperus virginiana, Sassafras albidum, and Hamamelis virginiana. Shrubs and vines include Gaylussacia frondosa, Arundinaria gigantea, Callicarpa americana, Myrica cerifera, Rhus copallina, Vaccinium stamineum, Vitis rotundifolia, Toxicodendron (Rhus) radicans, Parthenocissus quinquefolia, Smilax bona-nox, and Gelsemium sempervirens. The herb layer includes Mitchella repens, Pteridium aquilinum, Prenanthes serpentaria, Aster patens, Solidago spp., Panicum spp., Schizachyrium (Andropogon) scoparium, Desmodium spp., Cnidoscolus stimulosus, and Galium hispidulum.

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 may be more frequently disturbed than inland communities. Such disturbance may kill parts, but generally not all, of the canopy, producing a multi-aged population structure.

Sites vary in the amount of Pinus taeda present. This may be a result of past cutting or of natural disturbances.

Geologic processes such as dune migration and erosion may directly destroy Maritime Deciduous Forests. The forests may also be indirectly destroyed by the natural or artificial loss of the dunes that provided shelter from heavy salt spray.

The fire history of this community type is not well known. The rugged topography and interspersion of wetlands in the known examples may make fires unlikely to spread far. Some of the trees present, such as Fagus grandifolia, are rather intolerant of fire, but typically fire-dependent trees such as Pinus palustris may also be present.

Range: Known only from the Nags Head and Kitty Hawk area. Similar communities may occur at Seashore State Park in southern Virginia (Chris Clampitt, Virginia Natural Heritage Program, pers. comm. 1989).

Associations: Grades to Maritime Swamp Forest, Maritime Shrub Swamp, and Interdune Ponds in wet swales. May grade to Maritime Evergreen Forest seaward.

Variation: This community type is heterogeneous within sites. Some differentiation along a moisture gradient may be recognized with more xerophytic species increasing on the higher hills and mesophytic species in swales. However, in general, species appear not to be as segregated by moisture as in mainland communities.

Comments: The Maritime Deciduous Forest type is one of the rarest and most endangered in North Carolina. The distinctive environment in which it occurs is extremely limited, and coastal development is taking an increasing toll on what remains.

This community type is sometimes regarded as similar to mesic forests inland and sometimes regarded as only one extreme of the maritime forest category. While both are true to some degree, it is distinctive in that it includes many species not normally associated with the maritime environment, in a topographic, climatic, and dynamic environment not found inland. In general, the differentiation of species along a topographic moisture gradient seems to be less. Species occur here in associations not generally found inland. This may be a result of the more frequently disturbance, the continuous input of nutrients by salt spray, or the more moderate temperatures.

The name Maritime Deciduous Forest replaces the name Maritime Mesophytic Forest used in the Second Approximation. Although deciduous mesophytic trees are present in this type, many other characteristic species are not mesophytic. The mixture of such species is one of the distinctive characteristics of the type. Although pines may sometimes dominate, most of the distinctive species are deciduous hardwoods.

Rare Plant Species: Vascular -- Listera australis.

Synonyms:
Maritime Mesophytic Forest (Second Approximation).
This type would fall within SAF 82: Loblolly Pine-Hardwoods, but is atypical of the type as described.

Examples (Lopazanski, Evans, and Shaw 1988, N.C. Vegetation Survey 1988, and references cited):
Nags Head Woods, Dare County (Atkinson and List 1978, Otte, Atkinson, and Atkinson 1984) (the only extensive protected example).
Kitty Hawk Woods, Dare County (extensive example, most of which is currently being developed).
Southern Shores Cypress Swamp, Dare County (small remnant example).

References: Atkinson and List (1978), Cobb (1906), Lopazanski, Evans, and Shaw (1988), Otte, Atkinson, and Atkinson (1984), North Carolina Vegetation Survey (1988), Wentworth, Schafale, Weakley, Peet, White, and Frost (1989).

Sample Plant Communities:
Pinus taeda-Quercus hemisphaerica-Fagus grandifolia.
Quercus falcata-Carya glabra/Mixed subcanopy.
Mixed oaks-mixed hickories.
Mixed hardwoods.
Pinus taeda-Quercus falcata/Cornus florida.
Fagus grandifolia/Persea borbonia.

COASTAL FRINGE EVERGREEN FOREST

Sites: Flats and low hills near the mainland coast.

Soils: Moist sandy soils. Most sites are on the Wando series (Typic Udipsamment), a few are mapped as Rimini (Entic Haplohumod), Wakulla (Psammentic Hapludult), Baymeade (Arenic Hapludult), or Pactolus (Aquic Quartzipsamment).

Hydrology: Terrestrial, mesic.

Vegetation: Forest dominated by various mixtures of Quercus hemisphaerica, Q. virginiana, and Pinus taeda. Other canopy trees include Quercus falcata, Carya glabra, Q. nigra, and Pinus palustris. The understory may include Osmanthus americana, Persea borbonia (sensu stricto), Magnolia virginiana, Ilex opaca, Juniperus virginiana, and Sassafras albidum. The most typical shrub is Ilex vomitoria. Other shrubs include Myrica cerifera, Hamamelis virginiana, Sabal minor, and species of the understory. Vines such as Vitis rotundifolia, Smilax bona-nox, Gelsemium sempervirens, and Campsis radicans are sometimes numerous. The herb layer is generally sparse and low in diversity, with Mitchella repens and Asplenium platyneuron most typical.

Dynamics: Little is known about the dynamics of these communities. Their location in low areas near the coast makes them susceptible to wind and flooding caused by hurricanes, though less so than barrier island communities. They are probably susceptible to occasional fires spreading from adjacent drier communities, but they probably do not naturally burn very frequently. Aerosol salt does not appear to be significant as a stress factor, but may be a significant source of mineral nutrients that are limited inland.

Range: Along the mainland coast, primarily from Brunswick to Carteret County. Only small, marginal examples are known north of the Neuse River.

Associations: Frequently grades to Coastal Fringe Sandhill on higher, drier sites. Usually grades to Salt Marsh or Brackish Marsh.

Distinguishing Features: Coastal Fringe Evergreen Forests are most easily distinguished from Maritime Evergreen Forest by their mainland location. Floristically, they are somewhat to much more more diverse than Maritime Evergreen Forests. They are distinguished from Coastal Fringe Sandhills by their closed forest canopy structure and predominance of the species listed above over the sandhill species. They are distinguished from other mainland forest communities by the significant occurrence of species typically confined to maritime areas in North Carolina, such as Quercus virginiana, Osmanthus americana, and Ilex vomitoria.

Variation: The known examples are rather variable. Variation is visible in relation to moisture gradients, with drier examples somewhat open and approaching sandhill. Most examples are fairly low in diversity, but a few are very diverse, with additional species such as Tilia americana var. caroliniana, Magnolia grandiflora (as a native species), Quercus pagoda (falcata var. paogodaefolia), and Q. shumardii. These examples appear to be associated with a high content of shells in the sandy soil.

Comments: The distinction from Maritime Evergreen Forest is somewhat tentative, because little is known about this newly recognized community type. It appears to be distinctive, but the mainland vs. barrier island boundary is somewhat arbitrary, and further investigation may indicate a better basis for division. This type differs from the Maritime Evergreen Forest in being more diverse, and in having less salt spray, older soils, greater susceptibility to fire spreading from adjacent areas, and less susceptibility to storm damage.

The factors producing the distinctive coastal fringe vegetation are not known. The moderated climate near the coast may be an important factor. Many of the distinctive species in these communities are confined to maritime and coastal fringe areas in North Carolina but occur farther inland to the south. Even within North Carolina, this type appears to extend farther inland in the southern part of the state.

This community type is naturally limited in extent. With heavy coastal development pressure and easier access than the

barrier islands, it is rapidly disappearing. It may be one of the most endangered community types in the state.
Rare Plant Species: Vascular -- Magnolia grandiflora, Sideroxylon lycioides, Tilia americana var. caroliniana.

Synonyms:
Maritime Forest (Second Approximation).

Examples:
Boone Neck, Brantley Island, Sunset Harbor, Secession areas on the southern mainland coast of Brunswick County (remnants of what was once the largest occurrence of this type in North Carolina).
Carolina Beach State Park and Military Ocean Terminal Sunny Point buffer zone, New Hanover County (a narrow fringe, relatively young forest).
Cedar Point Natural Area, Croatan National Forest, Carteret County (Fussell and Wilson 1983).
Harbinger Marshes, Currituck County (Frost, LeGrand, and Schneider 1990) (small remnant).

References: Bordeau and Oosting (1959), Frost, LeGrand, and Schneider (1990), Fussell and Wilson (1983), North Carolina Vegetation Survey (1988).

Sample Plant Communities:
Pinus taeda-Quercus hemisphaerica-Quercus virginiana/Osmanthus americanus/Ilex vomitoria.
Quercus hemisphaerica/Ilex vomitoria.

COASTAL FRINGE SANDHILL

Sites: Sandy areas such as relict beach ridge systems, generally within a few miles of the coast. Less commonly on dry, sandy fluvial deposits, as in the floodplain of the Waccamaw River.

Soils: Sandy soils. The most typical series are Kureb (Spodic Quartzipsamment) and Mandarin (Typic Haplohumod), sometimes Leon (Aeric Haplaquod).

Hydrology: Terrestrial, xeric because of excessive drainage.

Vegetation: Open to sparse canopy of Pinus palustris, sometimes with Pinus taeda. Quercus virginiana may form occasional to frequent clumps. Open to sparse understory dominated by Quercus geminata, Q. laevis, and Q. hemisphaerica. Other understory species may include Sassafras albidum, Nyssa sylvatica, Q. incana, Q. margarettae, and Vaccinium arboreum. Shrubs such as Gaylussacia dumosa, Ilex glabra, Myrica cerifera, Ilex vomitoria, and Osmanthus americanus may occur in sparse to dense patches. The herb layer varies with woody cover, with Aristida stricta usually the dominant species. Other common herbs include Rhynchospora sp., Schizachyrium (Andropogon) scoparium, Stipulicida setacea, Euphorbia ipecacuanhae, Stylisma (Bonamia) patens, and Cnidoscolus stimulosus. Macrolichens such as Cladina evansii and Cladonia spp., and sandhill mosses such as Dicranum condensatum, are prominent and often dominate.

Dynamics: Like other sandhill communities, Coastal Fringe Sandhills naturally experienced frequent low intensity surface fire, except in areas with too little herb cover to carry a fire. Without fire, oaks and shrubs increase in dominance. The buildup of litter and shading reduce herb cover. Long suppression of fire may lead to litter buildup and changes in the environment, allowing invasion of more mesic species. It has been suggested that the non-flammability of Quercus virginiana and Q. geminata leaves would inhibit fire if allowed to build up.

Range: Occurs in Carteret, Onslow, Pender, New Hanover, and Brunswick Counties. Generally within a few miles of the coast; somewhat farther inland in Brunswick County. A few communities, apparently of this type, occur as far inland as the Waccamaw River bottomlands of Columbus County.

Associations: Grades to Xeric Sandhill Scrub on the deepest, driest sands. Grades to Maritime Forest, Pond Pine Woodland, or Streamhead Pocosin in wetter places.

Distinguishing Features: Coastal Fringe Sandhills are distinguished from Pine/Scrub Oak Sandhills and Xeric Sandhill Scrub by the occurrence of maritime- associated species such as Quercus geminata, Q. hemisphaerica, Q. virginiana, Ilex vomitoria, and Cladina evansii. They appear to be confined to near the coast. They are distinguished from Wet Pine Flatwoods and Mesic Pine Flatwoods by their structure, which includes a significant scrub oak component and less shrub and herb layer. They often have abundant lichens and bare sand.

Variation: Varies with the dryness of the soil. Drier sites have more Quercus laevis relative to Q. geminata and other hardwoods. More moist sites have more of the mesic shrubs. Past fire frequency strongly affects structure and, to some extent, composition.

Comments: This type is newly distinguished from the Pine/Scrub Oak Sandhill type of the Second Approximation. It is not certain what environmental factors are responsible for limiting the range of "maritime" communities such as this to near the coast. Possible significant factors include nutrient inputs from salt aerosols, differences in fire regime, periodic disturbance by hurricanes, and temperature and rainfall differences. It appears that many of the species associated with the coastal fringe in North Carolina extend farther inland as one goes south, suggesting that temperature is important. If so, a different name may be more appropriate.

Coastal Fringe Sandhills extend to topographically higher, apparently drier sites than inland Pine/Scrub Oak Sandhills; Xeric Sandhill Scrub generally occurs only on the highest sandhills in the coastal zone.

Because of its limited range, widespread fire suppression, forestry practices, and commercial development, this is a very rare and threatened community type.

Rare Plant Species: Vascular -- Amorpha georgiana var. confusa, Tridens carolinianus, Xyris smalliana.

Synonyms:
Sandhill (general usage).
Coastal Scrub Forest (Nifong 1981).
Pine/Scrub Oak Sandhill (in part--Second Approximation).

Examples:
Carolina Beach State Park, New Hanover County (Taggart and Dickerson 1980).
Sunny Point Military Ocean Terminal buffer zone, New Hanover County (N.C. Vegetation Survey 1988).
Boiling Springs Lake area, Brunswick County.
Cedar Island National Wildlife Refuge, Carteret County.
Southport Ferry Landing, Brunswick County.
Sunset Harbor-Ash Swamp area, Brunswick County.
Yaupon Beach Golf Course, Brunswick County (N.C. Vegetation Survey 1988).
Long Beach, Brunswick County (N.C. Vegetation Survey 1988).

References: Nifong (1981), North Carolina Vegetation Survey (1988), Robbins and Myers (1989), Schafale (1988), Taggart and Dickerson (1980).

Sample Plant Communities:
Pinus palustris/Quercus geminata.
Pinus palustris/Quercus geminata-Q. laevis.
Pinus palustris/Quercus geminata/Gaylussacia dumosa.
Pinus palustris/Quercus geminata/Aristida stricta.
Pinus palustris/Quercus geminata-Q. laevis/Cladina evansii.

MESIC PINE FLATWOODS

Sites: Mesic (non-wetland) sites, either flat or rolling Coastal Plain sediments, neither excessively drained nor with a significant seasonal high water table.

Soils: Loamy or fine-textured soils, sometimes on sands. Potential series include Blaney (Arenic Hapludult), Dothan (Plinthic Paleudult), Fuquay (Plinthic Paleudult), Blanton (Grossarenic Paleudult), Rains (Typic Paleaquult), and Wagram (Arenic Paleudult).

Hydrology: Terrestrial, mesic to dry-mesic.

Vegetation: Closed to open canopy of Pinus palustris or sometimes Pinus taeda. Understory sparse (in frequently burned sites) to dense (in unburned sites), containing species such as Quercus falcata, Q. nigra, Q. stellata, Q. marilandica, Q. incana, Carya pallida, Carya alba (tomentosa), and Liquidambar styraciflua. A low shrub layer of varying density may be present, with species similar to those in the Wet Pine Flatwoods type. The herb layer is generally dominated by Aristida stricta in frequently burned areas, though Pteridium aquilinum may dominate in patches. Other typical herb species include Schizachyrium (Andropogon) scoparium, Gymnopogon brevifolius, Panicum virgatum, Anthaenantia villosa, Paspalum bifidum, Sorghastrum nutans, Andropogon gerardii, Lespedeza capitata, Dalea (Petalostemum) pinnata, Euphorbia corollata, and Solidago odora.

Dynamics: These communities naturally experienced frequent low to moderate intensity surface fires which maintained a somewhat open canopy, open to sparse shrub layer, and vigorous herb layer. The peak natural fire season is believed to be in early summer, as in Florida (Robbins and Myers 1989). Natural fires may, however, occur at any time of year, and variation in season as well as predominant season, may be important. Natural fire has been largely eliminated in recent decades, resulting in changes in community structure. In most sites, Pinus taeda and upland hardwood trees quickly invade in the absence of fire, although in a few sites they apparently are excluded by some other factor.

The natural population structure and dynamics of the longleaf pine in North Carolina are believed to be similar to that found by Platt, Evans, and Rathbun (1988) in an old growth longleaf pine forest in Georgia. The age structure there was irregular, reflecting irregularities in both reproduction and mortality of the pines in response to environmental conditions and natural disturbances. 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.

Range: Potentially throughout the Coastal Plain and Sandhills, but few sites remain.

Associations: May grade to Wet Pine Flatwoods, Pine Savanna, Pine/Scrub Oak Sandhill, Xeric Sandhill Scrub, or various wetland community types.

Distinguishing Features: The factors separating this new community type from Pine/Scrub Oak Sandhill are not well determined. Mesic Pine Flatwoods communities are moister and have a denser and more diverse herb layer, with a number of species which are absent in the drier sandhills. Scrub oaks may be present in both types, but under frequent fire are very sparse in Mesic Pine Flatwoods. Without fire, hardwoods may proliferate in both types but Mesic Pine Flatwoods will usually include dry-mesic species as well as the more xeric scrub oaks.

Mesic Pine Flatwoods is separated from the new Wet Pine Flatwoods type at the Terrestrial-Palustrine boundary. However, these two types may grade into each other, and the boundary may be difficult to determine. Examples may contain fairly even mixtures of facultative, facultative wet, and facultative upland species.

Variation: Not well known. This appears to be a very heterogeneous type that may require more splitting as our understanding increases. Presently they are believed to occur in two distinct environments, which may warrant recognition as variants, at least. One is the higher parts of some of the large wet savannas of the outer Coastal Plain, where they are somewhat less diverse than the wetter Pine Savanna communities into which they grade. The other is in shallow swales or depressions in the Sandhills, which do not hold water but support a more diverse, mesic herb layer and apparently partially

exclude scrub oaks, even in the absence of frequent fire.

Comments: The Mesic Pine Flatwoods type as defined here represents only a subset of the communities that have been called flatwoods. Christensen (1988) notes that the name flatwoods has been used for just about any Coastal Plain pine forest with a well-developed woody understory; it is also used for some without a woody understory. Some of these communities have also been given the name savanna. Unfortunately, there seems to be no concise name for this type that does not carry such confusion with it.

The Wet Pine Flatwoods and Mesic Pine Flatwoods types represent a new splitting of the Pine Flatwoods type of the Second Approximation. The split was done both to have separate wetland and upland types and to reduce the range of variation in this broad category. Despite the split, Mesic Pine Flatwoods remains a heterogeneous category that may require future splitting.

The relationships of Mesic Pine Flatwoods, Wet Pine Flatwoods, and Pine/Scrub Oak Sandhill are somewhat unclear. Differences in soil texture, depth to impermeable horizons, and fire regime are probably important. The boundary with Pine/Scrub Oak Sandhill where the types co-occur may be shifted by changes in fire regime. The complex interaction of hydrology, soil type, and fire make sorting out and classifying the communities difficult. The confusion in classification and naming makes it difficult to determine which research results on community function are applicable to which types.

Mesic Pine Flatwoods tend to occur on relatively fertile, favorable sites. Most such sites were long ago cleared for agriculture. In addition, these communities generally are quickly invaded by hardwoods in the absence of frequent fire. They are usually one of the fastest communities to lose their distinctive character in the absence of fire. So few relatively intact sites have been surveyed that much remains unknown about the natural characteristics and composition of these communities. They are usually seen with a well- developed hardwood understory, a dense, remnant longleaf pine canopy, and little herb layer.

Rare Plant Species: Vascular -- Agalinis tenella, Agalinis virgata, Anthaenantia villosa, Asclepias longifolia, Buchnera americana, Calamovilfa brevipilis, Coreopsis gladiata, Dalea pinnata, Dionaea muscipula, Gentiana autumnalis, Gratiola aurea, Hypoxis sessilis, Oenothera perennis, Onosmodium virginianum, Parthenium radfordii, Paspalum bifidum, Prunus umbellata, Pteroglassaspis ecristata, Rhus michauxii, Rudbeckia heliopsidis, Schwalbea americana, Scleria minor, Solidago verna, Sphenopholis filiformis, Tofieldia glabra, Tridens carolinianus, Tridens strictus, Xyris difformis var. curtissii.

Synonyms:
Pine Flatwoods (Second Approximation and general usage) (in part).
Pine/wiregrass woodland.

Examples:
Fort Bragg Military Reservation, Hoke and Cumberland counties (scattered examples are widespread).
Sandhills Game Land, Scotland and Richmond counties.
Millis Road Savanna, Croatan National Forest, Carteret County.

References: Christensen (1988), Hartshorn (1972), North Carolina Vegetation Survey (1989), Platt, Evans, and Rathbun (1988), Robbins and Myers (1989).

Sample Plant Communities:
Pinus palustris/Aristida stricta.
Pinus palustris/Aristida stricta-mixed herbs.

PINE/SCRUB OAK SANDHILL

Sites: Generally on rolling to more steeply sloping sandy Coastal Plain sediments with a clay layer near the surface, or with sandy to loamy well drained soils.

Soils: Usually coarse sands with a clay layer beneath, occasionally on finer textured soils. Series include Gilead (Aquic Hapludult), Blaney (Arenic Hapludult), Lakeland (Typic Quartzipsamment), Centenary (Entic Haplohumod), Vaucluse (Typic Hapludult), Dothan (Plinthic Paleudult), and Fuquay (Plinthic Paleudult).

Hydrology: Terrestrial, usually dry to xeric, but may have a perched water table for brief periods. A clay layer may restrict rooting depth, making deeper moisture unavailable to plants during dry periods.

Vegetation: Open canopy of Pinus palustris, with open to dense understory dominated by scrub oaks, including Quercus laevis, Q. marilandica, Q. margarettae, and Q. incana. Sassafras albidum, Diospyros virginiana, and Cornus florida may also occur in smaller numbers. A sparse low shrub layer consisting primarily of Gaylussacia dumosa and Toxicodendron pubescens (Rhus toxicodendron) is usually present. The moderately sparse to dense herb layer is dominated by Aristida stricta. Other common species include Schizachyrium (Andropogon) scoparium, Andropogon elliotii, Sporobolus junceus, Euphorbia ipecacaunhae, Euphorbia exserta (gracilior), Cnidoscolus stimulosus, Tephrosia virginiana, Cirsium repandum, Baptisia cinerea, Silphium compositum, Carphephorus bellidifolius, Solidago odora, Epigaea repens, Stylisma (Bonamia) patens, and Aster linariifolius.

Dynamics: These communities naturally experienced frequent low intensity surface fires. The peak natural fire season is believed to be in early summer, as in Florida (Robbins and Myers 1989). Natural fires may, however, occur at any time of year, and variation in season as well as predominant season, may be important. With frequent fire the scrub oak understory is sparse, with a few trees growing large enough to withstand fire and the rest existing as sprouts that are killed back by the fires. The herb layer is stimulated by fire. In the absence of fire the oaks become denser and larger, forming a closed or nearly closed subcanopy. The herb layer is greatly reduced in density and diversity. The loss of grass and the presence of oak leaf litter reduces the likelihood and effectiveness of future surface fire.

The natural population structure and dynamics of the longleaf pine in North Carolina are believed to be similar to that found by Platt, Evans, and Rathbun (1988) in an old growth longleaf pine forest in Georgia. The age structure there was irregular, reflecting irregularities in both reproduction and mortality of the pines in response to environmental conditions and natural disturbances. 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.

Range: Primarily in the Sandhills region, but occurs throughout the Coastal Plain in sandy areas.

Associations: Grades to Xeric Sandhill Scrub in more excessively drained sites. May grade to Mesic Pine Flatwoods, Wet Pine Flatwoods, or Pine Savanna in wetter areas. Frequently associated with Sandhill Seeps or Streamhead Pocosins. Occasionally grades to Piedmont/Coastal Plain Acidic Cliff or Heath Bluff.

Distinguishing Features: Pine/Scrub Oak Sandhills are distinguished from Xeric Sandhill Scrub by their greater diversity and by the presence of Quercus marilandica or Quercus incana in the scrub oak layer. Xeric Sandhill Scrub generally has only Q. laevis and sometimes Q. margarettae. Pine/Scrub Oak Sandhills are distinguished from Coastal Fringe Sandhills by the absence of maritime- associated species such as Quercus geminata, Q. hemisphaerica, Q. virginiana, Ilex vomitoria, and Cladina evansii. The factors separating Pine/Scrub Oak Sandhill from the newly defined Mesic Pine Flatwoods type are not well determined. Mesic Pine Flatwoods communities are more moist and more diverse, with a number of herbs which are absent in the drier sandhills. Scrub oaks may be present in both types, but under frequent fire are very sparse in Mesic Pine Flatwoods. Without fire, hardwoods may proliferate in both types but Mesic Pine Flatwoods will usually include dry-mesic species as well as the more xeric scrub oaks.

Variation: Three variants are recognized:

1. Blackjack-Mixed Oak Variant, the most typical variant, best fitting the description above. It occurs in association with a clay layer in the soil, primarily in the Sandhills region.

2. Clay Hilltop Variant, where a clay layer occurs at the surface on a hilltop or upper slope without a source of groundwater. Only occasional scrub oaks, primarily Q. marilandica, are present. Low shrubs and Vaccinium crassifolium may be common along with Aristida stricta. This rare variant may warrant separation into its own type.

3. Loamy Soil Variant, on soils that are finer textured and more fertile but still dry enough to support vegetation with a sandhill structure. Q. incana is the primary scrub oak, and the herb layer is more diverse. This variant is transitional to Mesic Pine Flatwoods.

Comments: These communities in a general sense fit into a moisture and fertility gradient between Xeric Sandhill Scrub and Mesic Pine Flatwoods. 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 mositure stress during droughts. He suggested that lack of nutrients rather than dryness was responsible for excluding Q. marilandica from Xeric Sandhill Scrub.

The diversity of variations within this community type and related types is great and is in need of further study.

Rare Plant Species: Amsonia ciliata, Andropogon tracyi, Asclepias pedicellata, Asclepias tomentosa, Asclepias tuberosa ssp. rolfsii, Astragalus michauxii, Carex tenax, Chamaesyce cordifolia, Chrysoma pauciflosculosa, Chrysopogon pauciflorus, Dichanthelium ovale var. ovale, Gaillardia aestivalis, Galactia mollis, Gentiana autumnalis, Helianthemum rosmarinifolium, Lachnocaulon beyrichianum, Lechea torreyi, Nestronia umbellula, Onosmodium virginianum, Orbexilum lupinellum, Parthenium radfordii, Paspalum bifidum, Pediomelum canescens, Phaseolus sinuatus, Polygala grandiflora, Polygonella articulata, Pyxidanthera barbulata var. brevifolia, Rhus michauxii, Schwalbea americana, Sphenopholis filiformis, Stylisma pickeringii var. pickeringii, Trichostema setaceum, Tridens carolinianus, Warea cuneifolia, Xyris smalliana, Yucca flaccida.

Synonyms:
Xero-mesic phase (Wells 1931).

Examples:
Blackjack-Mixed Oak Variant:
Still Lane Seepage Slopes, Strausburg Road, Millstone Creek, and Bones Fork Natural Areas, Sandhills Game Land, Scotland and Richmond counties.
Moss Foundation, Moore County (Carter and LeGrand 1989).
Extensive areas occur on Fort Bragg, Hoke County.

Loamy Soil Variant:
Beaver Dam Creek-Little Muddy Creek Natural Area, Sandhills Game Land, Scotland County.

Clay Hilltop Variant:
Several examples occur on Fort Bragg, Hoke County.
Paint Hill, Moore County (Carter and LeGrand 1989).

References: Carter and LeGrand (1989), Garren (1943), North Carolina Vegetation Survey (1989), Platt, Evans, and Rathbun (1988), Robbins and Myers (1989), Weaver (1969).

Sample Plant Communities:
Pinus palustris/Mixed Quercus spp./Aristida stricta.
P. palustris/Mixed Quercus spp./Cornus florida.
P. palustris/Mixed hardwoods.
Pinus palustris.

Mixed Quercus spp.
Mixed Quercus spp./Aristida stricta.

XERIC SANDHILL SCRUB

Sites: Coarse deep sands of ridge and swale systems, relict aeolian sand deposits, Carolina bay rims, and sandy uplands.

Soils: Sandy, infertile soils. Typical series are Lakeland (Typic Quartzipsamment), Kureb (Spodic Quartzipsamment), Baymeade (Arenic Hapludult), Candor (Arenic Paleudult), and Centenary (Entic Haplohumod).

Hydrology: Terrestrial, xeric, excessively drained. These communities are the driest in the Coastal Plain.

Vegetation: Open canopy of Pinus palustris, with open to dense understory of Quercus laevis. Occasional Quercus margarettae, Sassafras albidum, and Diospyros virginiana may occur. A sparse low shrub layer consisting primarily of Gaylussacia dumosa and Toxicodendron pubescens (Rhus toxicodendron) is sometimes present. The sparse to moderately dense herb layer consists of species such as Aristida stricta, Stipulicida setacea, Minuartia (Arenaria) caroliniana, Cnidoscolus stimulosus, Selaginella arenicola, Euphorbia ipecacuanhae, Schizachyrium (Andropogon) scoparium, Opuntia compressa, Polygonella polygama, and Tephrosia virginiana. Cryptogams such as Dicranum condensatum and Cladonia spp. may also be important.

Dynamics: Although the least productive, most barren sites produce too little fuel to sustain frequent fires, most Xeric Sandhill Scrub communities naturally experienced frequent low intensity surface fires. The peak natural fire season is believed to be in early summer, as in Florida (Robbins and Myers 1989). Natural fires may, however, occur at any time of year, and variation in season as well as predominant season, may be important. With frequent fire the scrub oak understory is sparse, with a few trees growing large enough to withstand fire and the rest existing as sprouts that are killed back by the fires. In the absence of fire the oaks become denser and larger, sometimes forming a closed or nearly closed subcanopy. The herb layer is reduced in density and diversity. The loss of grass and the presence of oak leaf litter reduces the effectiveness and possibility of surface fire. The rate at which oaks expand depends on the dryness of the site. The driest sites may remain permanently open and barren.

It is not certain how the natural population structure and dynamics of longleaf pine in these communities compares with that described by Platt, Evans, and Rathbun (1988). Reproduction is probably rarer and may be more irregular. Nevertheless, it is likely that the trees are also naturally uneven-aged and long lived, though they are often small.

Range: Most extensive in the Sandhills region and southern Coastal Plain, but also occurs on escarpments and sand ridge areas in other parts of the Coastal Plain.

Associations: Grades into Pine/Scrub Oak Sandhill, Coastal Fringe Sandhill, or Mesic Pine Flatwoods on less xeric sites. May grade directly to Pine Savanna, Wet Pine Flatwoods, Pond Pine Woodland, or Streamhead Pocosin in more steeply sloping areas. May contain small Sandhill Seep, Small Depression Pocosin, Vernal Pool, or Small Depression Pond commuities.

Distinguishing Features: Xeric Sandhill Scrub communities are distinguished from Pine/Scrub Oak Sandhill and Coastal Fringe Sandhill by their lower diversity and by the absence of scrub oaks other than Q. laevis and occasionally Q. margarettae.

Variation: Four variants are recognized:

1. Sand Barren Variant, on the most excessively drained sands which support only sparse woody and herbaceous vegetation. These occur primarily on aeolian sand deposits and Carolina bay rims. This is the most distinctive variant and probably will warrant separation into its own type when studied further.

2. Sandhills Variant, on upland ridgetops and upper slopes in the Sandhills region. They are less barren and may approach Pine/Scrub Oak Sandhill in density and herb diversity.

3. Middle Coastal Plain Variant, on low sand ridges in the middle Coastal Plain. Similar to the Sandhills variant in density

but with floristic differences.
4. Outer Coastal Plain Variant, on sandhills near the coast but too xeric to support Coastal Fringe Sandhill. Often fairly barren but less so than the sand barren variant and apparently floristically distinct from it.

Comments: These communities occupy the xeric end of a moisture and fertility gradient in longleaf pine-dominated sites. Weaver (1969) suggested that nutrients rather than moisture were the most important factor in determining the absence of Q. marilandica. The same may well apply to other oaks as well as various herb species. There is apparently a substantial range of productivity within this type as presently defined, and further splitting may be warranted. The question of productivity is complicated, however, by the effects of past disturbance to the vegetation and soil.

These communities were originally widespread. Because of the poor soils, many are still left in recognizable condition, but most have been severely degraded by lack of fire and by removal of trees. Longleaf pine is often very slow to regenerate after cutting on these sites. High quality examples are very rare.

Rare Plant Species: Vascular -- Amsonia ciliata, Asclepias tomentosa, Chrysoma pauciflosculosa, Lachnocaulon beyrichianum, Lechea torreyi, Orbexilum lupinellum, Pediomelum canescens, Phaseolus sinuatus, Pyxidanthera barbulata var. brevifolia, Rhus michauxii, Stylisma pickeringii var. pickeringii.

Synonyms:
Sandhill, Barren (general usage).
SAF 71 and 72: Longleaf Pine-Scrub Oak and Southern Scrub Oak (in part).

Examples:
Carolina Beach State Park, New Hanover County (Taggart and Dickerson 1980)
421 Sand Ridge, Pender and New Hanover counties (Leonard and Davis 1981).
Extensive areas on the Sandhills Game Land, Richmond and Scotland counties.
Extensive areas on Fort Bragg, Hoke and Cumberland counties.

References: Burk (1959), Carter and LeGrand (1989), Garren (1943), Leonard and Davis (1981), North Carolina Vegetation Survey (1989), Platt, Evans, and Rathbun (1988), Radford, Otte, Atkinson, and Nifong (1979), Schneider (1990), Taggart and Dickerson (1980), Weaver (1969), Wells and Shunk (1931).

Sample Plant Communities:
Pinus palustris.
P. palustris/Quercus laevis.
P. palustris/Q. laevis/A. stricta-Andropogon spp.
P. palustris/Q. laevis/Gaylussacia dumosa/Aristida stricta.
P. palustris/Q. laevis/Stipulicida setacea-Polygonella polygama/Selaginella arenicola.
Q. laevis/Cladonia spp..
Q. laevis/Aristida stricta.
Q. laevis/G. dumosa/A. stricta.
Q. laevis/Stipulicida setacea-Polygonella polygama/Selaginella arenicola.

SAND AND MUD BAR

Sites: Sand and mud deposits in and adjacent to streams and rivers, which are too wet, too young, or too severely flooded to support a forest canopy.

Soils: Coarse or fine-grained alluvial deposits, presumably lacking any soil development.

Hydrology: Bars fall within the Palustrine system of Cowardin, et al. (1979) but they fall into the Riverine System as defined by the Natural Heritage Operations Manual (The Nature Conservancy 1981) because of their occurrence within channel banks. They range from intermittently exposed to intermittently flooded.

Vegetation: Vegetational structure is quite variable, ranging from dense to sparse shrubs or herbs, with or without sparse trees. Typical shrubs and small trees include Cephalanthus occidentalis, Rosa palustris, Sambucus canadensis, and Cornus stricta. Herbs include Panicum spp., Polygonum punctatum, Lindernia anagallidea, Typha latifolia, Scirpus spp., Carex spp., Juncus spp., Pontederia cordata, and Justicia americana. A few trees such as Taxodium distichum, Betula nigra, Salix nigra, or Platanus occidentalis may occur.

Dynamics: Community dynamics are dominated by flooding, sediment input, and disturbance by the river. Nutrients are periodically supplied by flood- deposited sediment. Some bars are reworked frequently enough to remain sparsely vegetated, other undergo succession to shrubs or young trees. If the channel shifts or flooding regime changes, bars may permanently succeed to Natural Levee Forest. This may also occur if alluvial deposition raises the level of the bar above the frequent flood level.

Range: Throughout North Carolina. Most common in the Coastal Plain.

Associations: Borders stream or river channel. Grades into Rocky Bar and Shore or river floodplain communities.

Distinguishing Features: These communities are distinguished by their combination of location, substrate, and lack of a tree canopy.

Variation: This is a very heterogeneous type, varying widely within and among sites with size and gradient of river, frequency and duration of flooding, degree of consolidation of substrate, amount of regular alluvial deposition, location within the state, and chance deposition of propagules. The type will probably require division when studied in more detail. Likely divisions include Mountain and Piedmont vs. Coastal Plain, and blackwater vs. brownwater within the Coastal Plain.

Comments: These communities are small and are seldom described in studies, so specific published examples are hard to cite. They do not seem rare but many have been eliminated or changed, either directly or indirectly, by construction of dams, and other changes in river hydrology. Increased sediment load in streams and river, caused by land clearing and erosion, has also clearly affected these communities.

Sand and Mud Bar communities may be important for aquatic life in the stream or river. By filtering out sediment, vegetated bars also improve water quality.

Rare Plant Species: Vascular -- Echinodorus parvulus, Fimbristylis perpusilla, Gratiola aurea, Heteranthera multiflora, Lipocarpha micrantha, Ludwigia brevipes, Oldenlandia boscii, Paspalum fluitans, Polygonum hirsutum, Ptilimnium costatum, Sabatia kennedyana; nonvascular -- Cylindrocolea andersonii.

Synonyms:
Riverine marsh.

Examples:
Waccamaw River, Columbus and Brunswick counties (Schafale, LeGrand, and Marty 1986).
Marsh at confluence of Uwharrie and Yadkin Rivers, Montgomery County (Matthews 1979).

Sand and Mud Bar communities occur along most medium to large, low-gradient rivers in the state.

References: Cowardin, Carter, Golet, and LaRoe (1979), Matthews (1979), Schafale, LeGrand, and Marty (1986), The Nature Conservancy (1981).

Sample Plant Communities:
None recorded.

ROCKY BAR AND SHORE

Sites: Rock outcrops and gravel bars in or adjacent to rivers and streams, which are too rocky, too wet, or too severely flooded to support trees.

Soils: Gravel or boulder deposits or small soil pockets in rock outcrops.

Hydrology: Bars fall within the Palustrine system of Cowardin, et al. (1979) but they fall into the Riverine System as defined by the Natural Heritage Operations Manual (The Nature Conservancy 1981) because of their occurrence within channel banks. They range from intermittently exposed to intermittently flooded.

Vegetation: Vegetational structure is quite variable, ranging from dense to sparse shrubs or herbs, with or without sparse bottomland or mesophytic trees. Typical shrubs include Alnus serrulata, Cephalanthus occidentalis, Xanthorhiza simplicissima, Salix sericea, Salix nigra, Cornus amomum, Itea virginica, Sambucus canadensis, and Arundinaria gigantea. Herbs include Justicia americana, Impatiens capensis, Carex stricta, C. torta, C. crinita, C. gynandra, other Carex species, Houstonia caerulea, Trauvetteria carolinensis, Polygonum spp., Juncus spp., and Boykinia aconitifolia. Bryophytes include Conocephalum conicum, Grimmia spp., and Fontinalis spp.

Dynamics: Community dynamics are dominated by flooding, sediment input, and disturbance by the river. Nutrients are periodically supplied by flood- deposited sediment. Some bars are reworked frequently enough to remain sparsely vegetated, other undergo succession to shrubs or young trees. In general, Rocky Bar and Shore communities occur in swifter rivers than Sand and Mud Bars and are consequently more disturbed by flooding but less prone to change resulting form channel migration. Alluvial deposition is generally less than in Sand and Mud Bar communities.

Range: Common in the Mountains and rather widespread in the Piedmont.

Associations: Borders stream or river channel. Grades into floodplain forests, cliff communities, or various upland communities.

Distinguishing Features: These communities are distinguished by their combination of location, substrate, and lack of a tree canopy.

Variation: This is a rather heterogeneous type, varying within and among sites with frequency and intensity of flooding, degree of consolidation of the substrate, availability of water during low water seasons, and region of the state. It may require further splitting.

Comments: These communities are small and, although often mentioned, are seldom described in detail in studies, so specific published examples are hard to cite. They do not seem rare but many have been eliminated or changed, either directly or indirectly, by construction of dams, and other changes in river hydrology. A great increase in sediment load in Piedmont and Mountain rivers and streams has certainly had significant effects on these communities, likely including increased deposition of fine sediment and increasing scouring effects.

Rare Plant Species: Vascular -- Campanula aparinoides, Juncus gymnocarpus, Lindernia monticola, Plantago cordata, Ptilimnium nodosum, Solidago plumosa, Spiraea virginiana, Veronica americana; nonvascular -- Cephaloziella obtusilobula.

Synonyms:
Alluvial Thicket (Moore 1973).

Examples:
Beaverdam Creek Plantago cordata site, Davidson County (Lynch 1980).
Broad River Natural Area, Buncombe County.
Eno River State Park, Orange and Durham counties.

New Hope Creek, Duke Forest, Orange County.
Huff Island, French Broad River, Madison County (Wickland and Horton 1978).
Green River Cove, Polk County (Hardin and Shaw 1975).
Chattooga River Gorge, Jackson and Macon counties (Dumond 1969).
Southern escarpment gorges (Eastatoe, Toxaway, Horsepasture, Thompson, Whitewater), Transylvania and Jackson counties (Cooper and Hardin 1970).
Lost Cove Creek, Pisgah National Forest, Avery County.
New River, North and South Forks, Ashe, Watauga, and Allegheny counties.

References: Cooper and Hardin (1970), Dumond (1969), Hardin and Shaw (1975), Lynch (1980), Moore (1973), The Nature Conservancy (1981), Wickland and Horton (1977).

Sample Plant Communities:
Justicia americana.
Carex torta.

COASTAL PLAIN LEVEE FOREST (Blackwater Subtype)

Sites: Natural levee deposits along channels of large blackwater rivers.

Soils: Sandy, loamy, or mucky soils. The levees are small enough that they are seldom distinguished in soils mapping. Mapped series include Muckalee (Typic Fluvaquent), Johnston (Cumulic Humaquept), and Wilbanks (unknown taxonomy), but the levee may represent an inclusion of a different series.

Hydrology: Palustrine, seasonally to intermittently flooded. Blackwater rivers, in contrast to brownwater, tend to have highly variable flow regimes, with floods of short duration and periods of very low flow. The water tends to be very acidic, low in mineral sediment, low in nutrients, and colored by tannins but relatively clear.

Vegetation: Forest dominated by various combinations of wetland hardwoods such as Quercus laurifolia, Q. lyrata, Q. phellos, Betula nigra, Liquidambar styraciflua, Acer rubrum, Fraxinus tomentosa, and Ulmus americana. Taxodium distichum and Nyssa biflora may be components on the levees, though they do not dominate. Pinus taeda may also be an important component, both in obviously disturbed sites and in areas with no apparent disturbance. The understory is usually dominated by Acer rubrum or Carpinus caroliniana, with Ilex opaca, Ilex decidua, and Fraxinus caroliniana. The shrub layer ranges from sparse to dense, with Vaccinium elliottii, Cyrilla racemiflora, Itea virginica, and Clethra alnifolia typical. Vines are frequently diverse and often of large size. Species include Vitis rotundifolia, Toxicodendron (Rhus) radicans, Berchemia scandens, Decumaria barbara, Parthenocissus quinquefolia, Smilax rotundifolia, Smilax walteri, Gelsemium sempervirens, Gelsemium rankinii, Campsis radicans, Bignonia (Anisostichus) capreolata, and Wisteria frutescens. The herb layer is often well developed and especially prominent in the spring. Typical herbs include Viola spp., Carex gigantea, Carex intumescens, other Carex species, Hypoxis sp., Luzula sp., and Boehmeria cylindrica. Epiphytes, particularly Tillandsia usneoides, Polypodium polypodioides, and Phoradendron serotinum, are often present and sometimes abundant.

Dynamics: These communities are affected by the forces of the river. Levees outside of bends may be undercut and eroded by the river; those inside may be abandoned by the channel. Point bar processes may create new sites for invasion by Levee Forests. In addition, vegetation may be directly disturbed by flooding, but floods on blackwater rivers are generally less intense than on brownwater. The levee vegetation may consist of mature climax forest, or may be in various stages of primary or secondary succession.

Because blackwater rivers carry very little inorganic sediment, flooding does not provide as substantial a nutrient input as in brownwater systems but it may, however, still be significant in comparison with other blackwater river communities.

Range: Lower and middle parts of the Coastal Plain.

Associations: Borders blackwater river channel or Sand and Mud Bar communities. Grades into Cypress--Gum Swamp (Blackwater subtype) in backswamps and sloughs away from the channel. May grade downstream to brownwater or tidal communities. Some levees may grade to sandy deposits high enough to support terrestrial sandhill communities.

Distinguishing Features: Natural Levee Forests are distinguished from Cypress-- Gum Swamps by the dominance of Quercus, Ulmus, Betula, Fraxinus, and Pinus over Nyssa and Taxodium, as well as by their higher, drier location. Levees on blackwater rivers are often poorly developed and low, and are therefore closer to Cypress--Gum Swamps than those of brownwater rivers. They are often completely absent. A community should be classified in this type only if it is high enough to be dominated by trees less hydric than cypress and gum. Occasionally sand deposits deep enough to support sandhill vegetation may occur on the banks of blackwater rivers. These are separated from the Levee Forest at the Terrestrial-Palustrine boundary.

Levee Forests are distinguished from Bottomland Hardwoods communities by their location on natural levee or point bar deposits adjacent to the river, receiving what alluvial deposition there may be. Betula nigra occurs primarily on levees but is not always present. It may also be present in disturbed Bottomland Hardwoods communities, as well as in Small Stream Swamps.

Natural Levee Forests and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and is difficult

to place. Levees high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be considered Levee Forests.

The Blackwater Subtype is most easily distinguished from the Brownwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. Blackwater levees are much less diverse than brownwater. Nifong and Taggart (1981), noted Platanus occidentalis, Fraxinus pennsylvanica, Carya aquatica, and Acer negundo, present along the brownwater Cape Fear River, were replaced by Liquidambar styraciflua and Acer rubrum on the blackwater Northeast Cape Fear. They mention Nyssa aquatica being replaced in blackwater by Nyssa biflora, but Nyssa aquatica is present on the levees of the blackwater upper Waccamaw River (Schafale, LeGrand, and Marty 1986).

The gradation of blackwater river communities to tidal communities is not known. It is likely that the low natural levees have disappeared or become too low to support a distinctive community before tidal regions are reached.

Variation: Little information is available. Variation is probably related to height, flooding regime, and texture of levee material. Some compositional difference is apparent between descriptions of the Northeast Cape Fear River (Nifong and Taggart 1981) and Waccamaw River (Schafale, LeGrand, and Marty 1986).

Comments: Blackwater rivers have their headwaters in the Coastal Plain. Relative to brownwater rivers they generally have a low sediment load, lower pH (generally very acidic), high concentrations of organic matter, and low concentrations of dissolved and suspended inorganics. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Natural levees are the rarest of the blackwater floodplain communities. The formation of levees at all is surprising in these sediment-poor rivers, and indeed they are often absent. Most of the information about this type is based on studies of the Waccamaw River, where distinctive, though low, levee communities exist on the upper part of the river (Schafale, LeGrand, and Marty 1986, Marty 1988). Nifong and Taggart (1981) briefly describe levees on the Northeast Cape Fear. Little is known about the presence or nature of levee communities on North Carolina's other blackwater floodplains.

Rare Plant Species: Vascular -- Crataegus aestivalis, Epidendrum conopseum, Gelsemium rankinii, Ilex amelanchier, Planera aquatica, Sebastiania fruticosa.

Synonyms:
SAF 92, 95, and 63: Sweetgum-Willow Oak, Black Willow, and Cottonwood.

Examples:
Waccamaw River, Columbus and Brunswick counties (Schafale, LeGrand, and Marty 1986).
Northeast Cape Fear River, Pender, Duplin, and New Hanover counties (Nifong and Taggart 1981).

References: Gosselink, Bayley, Conner, and Turner (1980), Lynch (1981), Maki, et al. (1980), Marty (1988), Nifong and Taggart (1981), Schafale, LeGrand, and Marty (1986), Wharton, Kitchens, Pendleton, and Sipe (1982), Woodwell (1956).

Sample Plant Communities:
Betula nigra.
Quercus laurifolia/Acer rubrum.
Quercus laurifolia-Q. lyrata-Taxodium distichum/Acer rubrum.

COASTAL PLAIN LEVEE FOREST (Brownwater Subtype)

Sites: Natural levee and point bar ridge deposits adjacent to channels of brownwater (alluvial) rivers.

Soils: Coarse-textured alluvial soils. Most levees are mapped as Chewacla (Fluvaquentic Dystrochrept) or Congaree (Typic Udifluvent).

Hydrology: Palustrine, seasonally to intermittently flooded. Brownwater rivers, in contrast to blackwater, tend to have periods of sustained high flow, usually in the winter and spring. The water tends to be relatively high in pH, in nutrients, and in mineral sediment.

Vegetation: Forest dominated by combinations of bottomland hardwoods such as Platanus occidentalis, Celtis laevigata, Fraxinus pennsylvanica, Betula nigra, Acer negundo, Carya aquatica, and Liquidambar styraciflua. Understory trees include Asimina triloba and Carpinus caroliniana. Shrubs may be moderately dense, with Lindera benzoin, Aesculus pavia, and A. sylvatica most characteristic. Arundinaria gigantea may be abundant in patches. Vines are often abundant and large, with typical species including Toxicodendron (Rhus) radicans, Vitis rotundifolia, Parthenocissus quinquefolia, Bignonia (Anisostichus) capreolata, Campsis radicans, and Berchemia scandens. The herb layer is commonly dense and tall, with Elymus hystrix (Hystrix patula), Boehmeria cylindrica, Chasmanthium (Uniola) latifolium, and Viola spp. characteristic. Spring ephemeral herbs may be abundant, especially on very fertile deposits, and may contain many herbaceous species generally associated with Piedmont bottomlands and rich slopes.

Dynamics: Levee communities are dominated by forces of the river. Levees outside of bends may be undercut and eroded by the river; those inside may be abandoned by the channel. Point bar processes may create new sites for invasion by Levee Forests. In addition, vegetation may be directly disturbed by flooding (scouring and battering by debris). The vegetation may consist of mature climax forest, or may be in various stages of primary or secondary succession.

The periodic input of nutrients in flood-deposited sediment makes levee sites very fertile, and growth is rapid in these communities.

The construction of dams on the upper portions of large rivers has changed the dynamics of flooding and sediment supply. These changes may eventually lead to changes in the floodplain communities.

These communities are frequently subject to invasion by exotic plants, especially if disturbed and opened up to sunlight. Lonicera japonica, Microstegium vimineum, and Ligustrum sinense may come to dominate large areas to the exclusion of the native herb layer.

Range: Throughout the Coastal Plain along large and medium size rivers.

Associations: Grades into Cypress--Gum Swamp (Brownwater subtype) away from the channel. Borders river channel or Sand and Mud Bar communities. May grade to Coastal Plain Small Stream Swamp (Brownwater subtype) in tributaries and upstream parts of smaller rivers.

Distinguishing Features: Natural Levee Forests are distinguished from Cypress-- Gum Swamps by the dominance of the bottomland and alluvial hardwoods listed above, over Nyssa and Taxodium, as well as their higher, drier location. They are distinguished from Bottomland Hardwoods communities by their location on natural levee or point bar deposits adjacent to the river, receiving alluvial deposition. The presence of Platanus and Betula nigra is usually characteristic of levees, but these species may be present in disturbed Bottomland Hardwoods communities, as well as in Small Stream Swamps.

Natural Levee Forests and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and is difficult to place. Levees high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be considered Natural Levee Forests.

The Brownwater Subtype is most easily distinguished from the Blackwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In general, brownwater river floodplains support more diverse communities. Nifong and Taggart (1981), noted Platanus occidentalis, Fraxinus pennsylvanica, Carya aquatica, and Acer negundo, present along the Cape Fear River, were replaced

by Liquidambar styraciflua and Acer rubrum on the blackwater Northeast Cape Fear.

In the lower reaches of rivers the natural levees become lower and wetter. They may remain a distinctive character downstream into drowned stretches with tidal influence. These levees are included in this type, even if surrounded by Tidal Cypress--Gum Swamp, as long as cypress and gums do not predominate over less hydric hardwoods. Their low, wet vegetation is distinctive and may warrant separation with further study.

Variation: Height of levees generally decreases downstream along a river. The associated plant communities vary accordingly, with an increase in Taxodium distichum, Nyssa aquatica, Quercus lyrata, and Carya aquatica. Variation from river to river in response to differences in sediment load and hydrology are likely but are not known. The edge of the levee open to the channel may have dense shrub and vine growth due to light penetration.

Comments: Brownwater rivers have their headwaters in the Piedmont or Blue Ridge. Relative to blackwater rivers they generally have a heavy sediment load, have higher pH (generally circumneutral), have relatively low concentrations of total organic carbon and high concentrations of dissolved inorganics (derived from weathering and leaching of parent rocks and soils). All brownwater rivers now carry unnatural sediment loads; damming reduces sediment load, but tremendously increased erosion rates throughout the state have added to sediment burdens. The relative effects of these modifications vary from river to river and are unknown. Some rivers draining agricultural parts of the Coastal Plain also now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Rare Plant Species: Vascular -- Carya laciniosa, Cynanchum laeve, Enemion biternatum, Mertensia virginica, Trillium sessile, Urtica chamidryoides.

Synonyms:
Alluvial forest, bottomland hardwoods (general usage).
SAF 94 and 93: Sycamore-Sweetgum-American Elm and Sugarberry-American Elm-Green Ash.
Sometmes SAF 92, 95, or 98: Sweetgum-Willow Oak, Black Willow, or Cottonwood.

Examples:
Broadneck Ridge, Larkspur Ridge, Roanoke Big Oak Woods, and other sites along the Roanoke River, in Bertie, Halifax, and Northhampton counties (Lynch 1981).
Examples also exist along the Cape Fear, Neuse, and other major rivers.

References: Gosselink, Bayley, Conner, and Turner (1980), Lynch (1981), Maki, et al. (1980), Nifong and Taggart (1981), Tingley (1985), Wharton, Kitchens, Pendleton, and Sipe (1982).

Sample Plant Communities
Celtis laevigata-Fraxinus pennsylvanica-Platanus occidentalis/Acer negundo/Aesculus sylvatica-Asimina triloba-Lindera benzoin/mixed herbs.
Betula nigra.
Betula nigra-Platanus occidentalis.
Platanus occidentalis.
Acer saccharinum-Mixed bottomland hardwoods/Lindera benzoin/Mixed herbs.
Taxodium distichum-mixed bottomland hardwoods/Acer rubrum-Carpinus caroliniana (at river mouth).

CYPRESS--GUM SWAMP (Blackwater Subtype)

Sites: Backswamps, sloughs, swales, and featureless floodplains of blackwater rivers.

Soils: Mineral or organic soils. Series include Muckalee (Typic Fluvaquent, Dorovan (Typic Medisaprist), and Croatan (Terric Medisaprist).

Hydrology: Palustrine, seasonally to semipermanently flooded. Blackwater rivers, in contrast to brownwater, tend to have highly variable flow regimes, with floods of short duration and periods of very low flow. The water tends to be very acidic, low in mineral sediment, low in nutrients, and colored by tannins but relatively clear.

Vegetation: Canopy dominated by Nyssa biflora, Taxodium distichum, or T. ascendens. The understory and shrub layer are usually poorly developed, though they may be dense in some sites. Fraxinus caroliniana, Nyssa biflora, and Acer rubrum are the most typical species. Planera aquatica, Persea palustris, Magnolia virginiana, Crataegus marshallii, and Cepahlanthus occidentalis may occur in places. Shrub species include Cyrilla racemiflora, Clethra alnifolia, and Lyonia lucida. The herb layer ranges from nearly absent to moderate cover. Species include Saururus cernuus, Carex gigantea, Polygonum punctatum, Centella asiatica, Hydrocotyle verticillata var. triradiata, Dulichium arundinaceum, and Woodwardia areolata. Tillandsia usneoides, Polypodium polypodioides, and Phoradendron serotinum are often common. Herbs of drier communities may occur on stumps or logs.

Dynamics: These communities form stable climaxes, but are slow to recover from logging. In most places Taxodium has regenerated poorly and the communities have become dominated by Nyssa. River channel shifts may disturb small areas. Because of the low diversity of canopy trees, pests or diseases of a particular species may have major effects on the community. Complete spring defoliation of Nyssa by caterpillars was observed two years in a row on the Waccamaw River.

Because blackwater rivers carry very little inorganic sediment, flooding does not provide as substantial a nutrient input as in brownwater systems but it may still be significant. The infertile acidic soils and wetness produce slow growth in the trees in these communities, and only very old trees generally attain large size.

Range: Lower and middle parts of the Coastal Plain.

Associations: Grades into Coastal Plain Bottomland Hardwoods and Levee Forest (Blackwater Subtype). May grade into Coastal Plain Small Stream Swamp and upland communities at the edge of the floodplain. In places these communities may border directly on a channel without levees. May grade downstream to brownwater communities or tidal communities.

Distinguishing Features: Cypress--Gum Swamps are distinguished from Levee Forests and Bottomland Hardwoods by the dominance of Taxodium and Nyssa over species of adjacent communities. They occur in the lowest, wettest parts of the floodplain.

Cypress--Gum Swamps, Levee Forests, and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and may be difficult to place. Small Stream Swamps generally have only small, discontinuous levees, ridges, basins, and sloughs, and more variable flooding regimes that blur the differences between them. The floodplain forest is usually a mixture of trees of the different types growing in close proximity. They may be associated with different microenvironments but are close enough together to interact with trees in different microenvironments. If a floodplain contains levees and ridges large enough to support distinctive communities, larger than the zone of edge effect between them, then the low areas between them may be considered the Cypress--Gum Swamp type. Many medium and small blackwater stream floodplains are flat and featureless and support a canopy of Taxodium and Nyssa. These are tentatively included in the Cypress--Gum Swamp type rather than the Small Stream Swamp type because both their vegetation and environment appear to be very similar.

Variation: Variation is not well known. The difference between cypress and gum dominance is probably related to logging history, but the difference between the two species in each genus is probably related to environment. Important environmental factors for variation include flooding frequency and depth, water chemistry, mineral vs. organic soil, and latitude.

In the southern part of the state, in the Waccamaw and Lumber drainages, Planera aquatica is an important understory component that is absent further north.

On the Waccamaw River, four variants of Cypress--Gum Swamp, occurring in different environments, were recognized (Schafale, LeGrand, and Marty 1986). Because these environments appear to occur on other blackwater rivers, they are recognized as variants:

1. Backswamp Variant, with long flooding by stagnant water, organic soils, sparse understory and shrub layer, and variable but fairly diverse herb layer.

2. Active Slough Variant, in small channels carrying deep flowing water in flood, with sparser canopy, better developed understory, few herbs, and sharing species with the river bank and bars.

3. Relict Slough Variant, in small swales and channels holding stagnant water in most floods, with fairly dense shrub layer, and pocosin elements such as Smilax laurifolia, Lyonia lucida, Woodwardia virginica, and Sphagnum.

4. Backwater Variant, in wide ends of active sloughs adjacent to the river, almost permanently flooded, with a sparse canopy of small trees with huge buttresses, a dense understory, and an ephemeral community of drawdown herbs similar to that on the lower river bars.

Comments: Blackwater rivers have their headwaters in the Coastal Plain. Relative to brownwater rivers they generally have a low sediment load, lower pH (generally very acidic), high concentrations of organic matter, and low concentrations of dissolved and suspended inorganics. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Because Cypress--Gum Swamps are flooded for long periods, their vegetation is of low diversity, but they may have an important component of aquatic animals and plants. They may be important habitat for organisms that are generally associated with the river channel. Little is known about the aquatic role of these communities, but the differing environments within and among the blackwater, brownwater, tidal, and nonriverine Cypress--Gum Swamps are likely to produce more major differences in them than they are in the more visible vegetation. The dynamics of these communities are also likely to be very different. These potential differences are good reason for monitoring and protecting examples of all of these as different natural community types or subtypes.

Rare Plant Species: Vascular -- Cardamine longii, Carex decomposita, Crataegus aestivalis, Dryopteris carthusiana, Dryopteris cristata, Epidendrum conopseum, Gelsemium rankinii, Isoetes riparia, Lilaeopsis carolinensis, Lilium sp. 2, Luziola fluitans, Planera aquatica, Ranunculus flabellaris, Sagittaria kurziana, Sagittaria stagnorum, Torreyochloa pallida; nonvascular -- Lejeunea bermudiana, Lopholejeunea muelleriana.

Synonyms:
Zone II. (Wharton et al. 1982).
SAF 101, 102, and 103: Baldcypress, Baldcypress-Tupelo, and Water Tupelo-Swamp Tupelo.

Examples:
Black River, Pender and Bladen counties (a deeply flooded virgin stand containing trees well over 1000 years old) (Leonard and Davis 1981, Stahle, Cleaveland, and Hehr 1988).
Waccamaw River, Columbus and Brunswick counties (Schafale, LeGrand, and Marty 1986, Marty 1988) (widespread examples of all four variants).
Northeast Cape Fear River, Pender County.
Lumber River, Robeson, Hoke, and Scotland counties.

References: Gosselink, Bayley, Conner, and Turner (1980), Leonard and Davis (1981), Lynch (1981), Maki, et al. (1980), Marty (1988), Nifong and Taggart (1981), Schafale, LeGrand, and Marty (1986), Stahle, Cleaveland, and Hehr (1988), Wharton, Kitchens, Pendleton, and Sipe (1982), Woodwell (1956).

Sample Plant Communities:
Taxodium distichum-Nyssa biflora.
Taxodium distichum/Fraxinus caroliniana.
Nyssa biflora.
Taxodium distichum/Fraxinus caroliniana-Planera aquatica.
Taxodium ascendens/Fraxinus caroliniana-Planera aquatica.

CYPRESS--GUM SWAMP (Brownwater Subtype)

Sites: Backswamps, sloughs, and other areas flooded for long periods, on floodplains of brownwater (alluvial) rivers.

Soils: Generally fine-textured or mucky soils, though sandy soils may occur locally. Wehadkee (Typic Udifluvent) and Chewacla (Fluvaquentic Dystrochrept) are common series. Other series include Kinston (Typic Fluvaquent) and Bibb (Typic Fluvaquent).

Hydrology: Palustrine, seasonally to semipermanently flooded. Generally flooded for substantial parts of the year. Brownwater rivers, in contrast to blackwater, tend to have periods of sustained high flow, usually in the winter and spring. The water tends to be relatively high in pH, in nutrients, and in mineral sediment, though water retained in backswamps for long periods may be modified.

Vegetation: Forest dominated by Nyssa aquatica or Taxodium distichum, with occasional Salix nigra, Populus heterophylla, or Carya aquatica. Fraxinus caroliniana is the only common understory species. Herbs are few, with Saururus cernuus being the most typical. A few herbs, including Boehmeria cylindrica and Mitchella repens occur on stumps and logs.

Dynamics: These communities form stable climaxes, not subject to frequent natural disturbance, but have been slow to recover from logging. Sloughs which carry large amounts of water in flood may be subject to scour. River channel shifts may alter hydrology of some areas. Beaver activity may semi-permanently inundate Cypress--Gum Swamps. Clayey and silty sediment deposited during floods adds nutrients to these communities.

The dominance of Nyssa in most of these communities is probably due to logging of cypress. Taxodium may regain dominance in the future.

Range: Throughout the Coastal Plain along large and medium size rivers.

Associations: Grades into Levee Forest and Bottomland Hardwoods communities. May contain beaver ponds or blocked embayments (Semipermanent Impoundment community type).

Distinguishing Features: Cypress--Gum Swamps are distinguished from Levee Forests and Bottomland Hardwoods by the dominance of Taxodium and Nyssa over species of adjacent communities. They occur in the lowest, wettest parts of the floodplain.

Cypress--Gum Swamps, Levee Forests, and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and may be difficult to place. Small Stream Swamps generally have only small, discontinuous levees, ridges, basins, and sloughs, and more variable flooding regimes that blur the differences between them. The floodplain forest is usually a mixture of trees of the different types growing in close proximity. They may be associated with different microenvironments but are close enough together to interact with trees in different microenvironments. If a floodplain contains levees and ridges large enough to support distinctive communities, larger than the zone of edge effect between them, then the low areas between them may be considered the Cypress--Gum Swamp type.

The Brownwater Subtype is most easily distinguished from the Blackwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In general, brownwater river floodplains support more diverse communities. The brownwater Cypress--Gum Swamps tend to be dominated by Nyssa aquatica, though Nyssa biflora may also be present. The cypress is always Taxodium distichum rather than Taxodium ascendens.

In the lower reaches of many rivers, Brownwater Cypress--Gum Swamp grades into Tidal Cypress--Gum Swamp. The boundary between the two types should be placed where tidally-controlled flooding overrides river flooding as the significant factor in the environment. The vegetational indicators of this are not well known, though it appears that Nyssa biflora becomes more abundant. In rivers which empty into large estuaries with little tidal action, different changes may occur near the mouth. The Roanoke River mouth, also influenced by the blackwater Cashie River and Conaby Creek, appears to contain vegetation resembling brownwater, blackwater, and nonriverine communities in a mosaic determined by distance from channels and by substrate (Tingley 1985).

Variation: The low diversity of the vegetation allows for little compositional variation other than the proportions of cypress and gum. There may be considerable variation in the successional dynamics and nutrient cycles of these communities in different flooding and depositional regimes. Backswamp areas may be deeply flooded with still water for long periods, allowing considerable clay deposition. Sloughs generally contain flowing water and vary in duration of flooding.

Comments: These communities occur in the lower parts of the floodplain, where few plant species are able to tolerate the long flooding. During the flooded season they may be important habitat for aquatic organisms.

Brownwater streams have their headwaters in the Piedmont or Blue Ridge. Relative to blackwater rivers they generally have a heavy sediment load, have higher pH (generally circumneutral), have relatively low concentrations of total organic carbon and high concentrations of dissolved inorganics (derived from weathering and leaching of parent rocks and soils). All brownwater rivers now carry unnatural sediment loads; damming reduces sediment load, but tremendously increased erosion rates throughout the state have added to sediment burdens. The relative effects of these modifications vary from river to river and are unknown. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwaer rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Rare Plant Species: Vascular -- Heteranthera multiflora, Hottonia inflata, Ranunculus laxicaulis.

Synonyms:
SAF 101, 102, and 103: Baldcypress, Baldcypress-Tupelo, and Water Tupelo-Swamp Tupelo.
Zone II (Wharton, et al. 1982).

Examples:
Broadneck Ridge, Company Swamp, Great and Goodman Islands, Devil's Gut, Occoneechee Neck, and other areas along the Roanoke River, Bertie, Martin, Halifax, and Northampton counties (Lynch 1981).
Neuse River Floodplain, Craven County (McDonald, Ash, and Fussell 1982).

References: Gosselink, Bayley, Conner, and Turner (1980), Lynch (1981), McDonald, Ash, and Fussell (1981), Maki, et al. (1980), Nifong and Taggart (1981), Tingley (1985), Wharton, Kitchens, Pendleton, and Sipe (1982).

Sample Plant Communities:
Nyssa aquatica.
N. aquatica/Fraxinus caroliniana.
N. aquatica/Spirodela polyrrhiza.
N. aquatica/Hymenocallis crassifolia.
Taxodium distichum/Toxicodendron (Rhus) radicans.
T. distichum/Planera aquatica//Mixed vines.
T. distichum/Nyssa aquatica.
Nyssa aquatica-Taxodium distichum.

COASTAL PLAIN BOTTOMLAND HARDWOODS (BLACKWATER SUBTYPE)

Sites: Abandoned or relict natural levee deposits, point bar ridges, and other relatively high parts of the floodplain, away from the channel.

Soils: Bottomland mineral soils of various textures, often very sandy. Series include Muckalee (Typic Fluvaquent), Johns (Aquic Hapludult), Lumbee (Typic Ochraquult), and Pactolus (Aquic Quartzipsamment).

Hydrology: Palustrine, seasonally to intermittently flooded. Blackwater rivers, in contrast to brownwater, tend to have highly variable flow regimes, with floods of short duration and periods of very low flow. The water tends to be very acidic, low in mineral sediment, low in nutrients, and colored by tannins but clear.

Vegetation: Canopy dominated by various combinations of bottomland hardwoods and conifers, primarily Quercus laurifolia, Q. lyrata, Q. phellos, Q. nigra, Acer rubrum, Pinus taeda, Chamaecyparis thyoides, and Liquidambar styraciflua. The understory may include Acer rubrum, Persea palustris, Ilex opaca, and Magnolia virginiana. The shrub layer is often well developed and may be very dense. Typical species are Vaccinium elliottii, Cyrilla racemiflora, Clethra alnifolia, and Itea virginica. Arundinaria gigantea may be common. Vines are sometimes dense, though usually not as diverse as on the levees. Smilax rotundifolia, Toxicodendron (Rhus) radicans, Vitis rotundifolia, and Berchemia scandens are the most typical species. The herb layer is usually poorly developed, and typical species are not known.

Dynamics: These communities are flooded, at least occasionally. Unlike the Levee Forest they are seldom disturbed by flowing water. Because blackwater rivers carry little inorganic sediment, flooding does not provide a substantial nutrient input as it does in brownwater systems.

Bottomland Hardwoods are expected to form a stable climax forest, having an uneven-aged canopy with primarily gap phase regeneration. However, most of the Bottomland Hardwoods on the Waccamaw River are dominated by a mixture of oaks, Pinus taeda, and Chamaecyparis thyoides which appear to be of the same age. It is not clear what the successional course of these areas will be following logging in the past.

The density of the lower strata in many of these communities may make them able to carry fires when dry. The occurrence of fire-maintained communities on the highest ridges along the Waccamaw River suggest that fires can reach some floodplain ridges, even if others are protected by being surrounded by wet swamp.

Range: Throughout the Coastal Plain.

Associations: Grades into Cypress--Gum Swamp and upland communities. May border a river channel. May grade to various communities on relict ridges above flood level, including Mesic Mixed Hardwoods, Pine Savanna, Pine Flatwoods, Xeric Sandhill Scrub, and Small Depression Pocosin.

Distinguishing Features: Bottomland hardwoods are distinguished from Cypress-- Gum Swamp by the dominance of the trees listed above over Nyssa and Taxodium, as well as their higher, drier location. They are distinguished from Levee Forests by their location on floodplain areas other than natural levee or point bar deposits adjacent to the river. The presence of Betula nigra is usually characteristic of levees but this species is often not present on blackwater levees.

Bottomland Hardwoods are separated from Mesic Mixed Hardwoods at the terrestrial-palustrine boundary. This is best indicated by the predominance of facultative upland species over the facultative and facultative wetland species listed above. Because many of the dominants of the Blackwater Subtype are widespread facultative species, the subordinate plants may need to be used for indicators.

Natural Levee Forests, Cypress--Gum Swamp, and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and is difficult to place. Floodplains with levees and ridges high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be classified as Natural Levee, Cypress--Gum Swamps, Bottomland Hardwoods.

The Brownwater Subtype is most easily distinguished from the Blackwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In

general, brownwater river floodplains support more diverse communities. Nifong and Taggart (1981) noted differences in levee and backswamp vegetation between a brownwater and blackwater river but did not address Bottomland Hardwoods specifically.

Variation: Little is known about the variation in this subtype. Variations are likely with the height of ridges relative to flood levels, soil textures, and latitude. The low diversity of the dominant vegetation may allow less variation among different environments than occurs in brownwater Bottomland Hardwoods. In the Waccamaw floodplain similar communities occupy ridges of very different height, on both active floodplain and relict terraces.

Comments: These communities are distinguished from Levee Forest communities because of their occurrence away from the river, and the differences in disturbance, nutrient input, and sedimentation which that entails. It is a broad category, encompassing a wide range of wetness and composition; the breadth and diversity of the category should be recognized in protection and research efforts.

Because Bottomland Hardwood sites are the most easily accessible and the most productive sites on a floodplain, most have had heavy human disturbance. Most areas have been frequently logged.

Blackwater rivers have their headwaters in the Coastal Plain. Relative to brownwater rivers they generally have a low sediment load, lower pH (generally very acidic), high concentrations of organic matter, and low concentrations of dissolved and suspended inorganics. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Blackwater Bottomland Hardwoods in general are very poorly known. Almost all of the information included here is based on the Waccamaw River, which is atypical of North Carolina's blackwater rivers in several respects.

Rare Plant Species: Vascular -- Gelsemium rankinii.

Synonyms:
Zone III, IV, and V (Wharton et al. 1982).
SAF 88 and 92: Willow Oak-Water Oak-Diamondleaf Oak, Sweetgum-Willow Oak (in part).

Examples:
Extensive examples of varying quality occur along the Waccamaw River, Columbus and Brunswick counties (Schafale, LeGrand, and Marty 1986).

References: Gosselink, Bayley, Conner, and Turner (1980), Lynch (1981), Maki, et al. (1980), Marty (1988), Nifong and Taggart (1981), Schafale, LeGrand, and Marty (1986), Wharton, Kitchens, Pendleton, and Sipe (1982), Woodwell (1956).

Sample Plant Communities:
Quercus laurifolia.
Pinus taeda-Quercus laurifolia-Chamaecyparis thyoides.

COASTAL PLAIN BOTTOMLAND HARDWOODS (Brownwater Subtype)

Sites: Abandoned levees and point bar ridges, terraces, and other relatively high parts of the floodplain, away from the active channel.

Soils: A variety of coarse- to fine-grained alluvial soils. Series include Chewacla (Fluvaquentic Dystrochrept), Wahee (Aeric Ochraquult), Kalmia (Typic Hapludult), Muckalee (Typic Fluvaquent), Tarboro (Typic Udipsamment), and Johns (Aquic Hapludult).

Hydrology: Palustrine, seasonally to intermittently flooded. The water table may be high for long periods even when the site is not flooded. Brownwater rivers, in contrast to blackwater, tend to have periods of sustained high flow, usually in the winter and spring. The water tends to be relatively high in pH, in nutrients, and in mineral sediment, though water retained in backswamps for long periods may be modified.

Vegetation: Canopy of various mixtures of bottomland oaks -- Quercus michauxii, Q. pagoda (falcata var. pagodaefolia), Q. laurifolia, Q. nigra, Q. phellos, Q. shumardii -- and other bottomland hardwoods such as Liquidambar styraciflua, Fraxinus pennsylvanica, Carya ovata, C. cordiformis, C. aquatica, Juglans nigra, Celtis laevigata, and Ulmus americana. Understory species include Carpinus caroliniana, Ilex decidua, Asimina triloba, and Ilex opaca. Vines may be prominent though they are not usually as dense as in the Levee Forest, except in canopy gaps. Typical vine species include Toxicodendron (Rhus) radicans, Vitis rotundifolia, Smilax spp., and Berchemia scandens. Arundinaria gigantea may be common in places. The herb layer is generally sparse, with Carex spp., Chasmanthium (Uniola) latifolium, Chasmanthium (Uniola) laxum, Viola spp., and Boehmeria cylindrica typical.

Dynamics: These communities are flooded, at least occasionally. Unlike the Levee Forest they are seldom disturbed by flowing water. They receive less sediment deposition than the Levee Forest but still receive significant input of nutrients through it.

Bottomland Hardwoods are believed to form a stable climax forest, having an uneven-aged canopy with primarily gap phase regeneration, although the possibility of unusually deep and prolonged flooding may make widespread mortality more likely than in uplands. Areas that have been cleared or logged in the past may have abundant or dominant disturbance species such as Pinus taeda, Acer rubrum, Liquidambar styraciflua, or Platanus occidentalis.

Range: Throughout the Coastal Plain along large and medium size rivers.

Associations: Grades to Cypress--Gum Swamp in adjacent lower areas and to upland communities on the edge of the floodplain. May also grade to Mesic Mixed Hardwoods on the highest relict ridges which are above current flood levels and high water tables. May grade to Small Stream Swamp (Blackwater or Brownwater subtype) at tributary streams. Grades to Mesic Mixed Hardwood Forest (Coastal Plain Subtype) or other upland communities at edge of floodplain.

Distinguishing Features: Bottomland Hardwoods are distinguished from Cypress-- Gum Swamp by the dominance of the bottomland hardwood tree species listed above over Nyssa and Taxodium, as well as their higher, drier location. They are distinguished from Levee Forests by their location on floodplain areas other than natural levee or point bar deposits adjacent to the river. The presence of Platanus and Betula nigra is usually characteristic of levees but these species may be present in disturbed Bottomland Hardwoods communities, as well as in Small Stream Swamps.

Bottomland Hardwoods are separated from Mesic Mixed Hardwoods at the terrestrial-palustrine boundary. This is best indicated by the predominance of facultative upland species over the facultative and facultative wetland species listed above.

Natural Levee Forests, Cypress--Gum Swamp, and Bottomland Hardwoods are distinguished from Small Stream Swamp communities by their occurrence on large river floodplains with well developed alluvial landforms. The boundary is fairly arbitrary and is difficult to place. Floodplains with levees and ridges high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be classified as Natural Levee, Cypress--Gum Swamps, Bottomland Hardwoods.

The Brownwater Subtype is most easily distinguished from the Blackwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In

general, brownwater river floodplains support more diverse communities. Nifong and Taggart (1981) noted differences in levee and backswamp vegetation between a brownwater and blackwater river but did not address Bottomland Hardwoods specifically.

In the lower reaches of rivers the natural levees and floodplain ridges become lower and wetter. They may retain a distinctive character downstream into drowned stretches with tidal influence. These ridges are included in this type, even if surrounded by Tidal Cypress--Gum Swamp, as long as cypress and gum do not predominate over bottomland hardwoods. Their low, wet vegetation is distinctive and may warrant separation with further study.

Variation: Great variation occurs with height of ridges relative to flood levels, and probably also with soil texture. The wettest areas, transitional to Cypress--Gum Swamp, are dominated by Quercus lyrata and Carya aquatica. They may occasionally occupy larger areas of broad alluvial flats. The highest areas, transitional to Mesic Mixed Hardwoods, may contain Fagus grandifolia, Quercus alba, and Cornus florida. These variations may warrant division into separate types or subtypes.

Comments: These communities are distinguished from Levee Forest communities because of their occurrence away from the river, and the differences in disturbance, nutrient input, and sedimentation which that entails. It is a broad category, encompassing a wide range of wetness and composition, which should be recognized in protection and research efforts.

Because Bottomland Hardwood site are the most easily accessible and the most productive sites on a floodplain, most have had heavy human disturbance. The higher areas make excellent farmland. Many intermediate areas have been planted to loblolly pine or otherwise destroyed by intensive forestry activities.

The abundance of Arundinaria in many Bottomland Hardwoods communities raises the question whether these sites may represent some of the canebrakes that were once widespread on the Coastal Plain. Hughes (1957) mentioned that canebrakes sometimes occurred with "lowland hardwoods" but it is unclear if these were Bottomland Hardwoods or Nonriverine Wet Hardwoods communities. The canebrakes contained dense Arundinaria and sparse or no trees. They were highly flammable and apparently were maintained by frequent fire. The isolation of most Bottomland Hardwoods on ridges surrounded by nonflammable swamp makes it unlikely that they could carry the regular fires necessary to maintain open canebrakes.

Brownwater streams have their headwaters in the Piedmont or Blue Ridge. Relative to blackwater rivers they generally have a heavy sediment load, have higher pH (generally circumneutral), have relatively low concentrations of total organic carbon and high concentrations of dissolved inorganics (derived from weathering and leaching of parent rocks and soils). All brownwater rivers now carry unnatural sediment loads; damming reduces sediment load, but tremendously increased erosion rates throughout the state have added to sediment burdens. The relative effects of these modifications vary from river to river and are unknown. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Rare Plant Species: Vascular -- Carex projecta, Lathyris palustris, Trillium sessile.

Synonyms:
SAF 88, 91, 92, 93, and 96: Willow Oak-Water Oak- Diamondleaf Oak, Swamp Chestnut Oak-Cherrybark Oak, Sweetgum-Willow Oak, Sugarberry-American Elm- Green Ash, and Overcup Oak-Water Hickory.
Zone III, IV, V (Wharton, et al. 1982).

Examples:
Ventosa Plantation, Devil's Gut and other areas along the Roanoke River, Halifax, Martin, Bertie, and Northampton counties (Lynch 1981).
Other examples occur along the Neuse, Cape Fear, Tar, and other brownwater rivers, but have not been well explored.

References: Gosselink, Bayley, Conner, and Turner (1980), Hughes (1957), Lynch (1981), Maki, et al. (1980), Nifong and Taggart (1981), Wharton, Kitchens, Pendleton, and Sipe (1982).

Sample Plant Communities:
Liquidambar styraciflua/Asimina triloba.

Fraxinus pennsylvanica-Celtis laevigata-Ulmus americana.
Carya aquatica-Ulmus americana.
Quercus lyrata-Acer rubrum var. drummondii.
Quercus lyrata-Carya aquatica.
Quercus laurifolia.
Quercus michauxii.
Quercus michauxii-Quercus lyrata.
Quercus pagoda (falcata var. pagodaefolia)-Quercus phellos.
Quercus nigra/Vaccinium elliottii.
Mixed bottomland oaks.

OXBOW LAKE

Sites: Abandoned river channel meanders with permanent nonflowing water.

Soils: These permanently flooded areas are not included in soil surveys.

Hydrology: Permanently flooded. These sites are classified as Lacustrine in the Natural Heritage Operations Manual (The Nature Conservancy 1981), but are considered Palustrine by Cowardin, et al. (1979) because they are less than 20 acres in size.

Vegetation: Open water or various rooted or floating aquatic plants. May contain Taxodium distichum, Taxodium ascendens, Nyssa aquatica, or N. biflora.

Dynamics: May be gradually filled with sediment or destroyed by later river meanders. Occasional flushing or sediment input by floods may have major effects on the dynamics of the community.

Range: Potentially throughout the Coastal Plain along major rivers.

Associations: Grades into other floodplain communities, particularly Cypress-- Gum Swamp and Bottomland Hardwoods.

Distinguishing Features: These communities are distinguished by their occurrence in permanently flooded depressions with open water at least in the center. Oxbows on both brownwater and blackwater rivers are included in this type.

Variation: Environmental factors likely to produce significant variation include size, water depth, degree of connection to the river, and blackwater vs. brownwater.

Comments: Well-developed oxbows are rare in North Carolina and little information is available on them. They are primarily aquatic communities. Because the water is still most of the time and is not carrying sediment, it is unclear that oxbow lakes will differ between blackwater and brownwater floodplains. This type may need to be subdivided when more information is available.

Rare Plant Species: Vascular -- Hottonia inflata.

Synonyms: Lake, pond (general usage).

Examples:
Oxbow Site and Reeves Area Floodplain, Waccamaw River, Columbus and Brunswick counties (Schafale, LeGrand, and Marty 1986).

References: Lynch (1981), Schafale, LeGrand, and Marty (1986), The Nature Conservancy (1981).

Sample Plant Communities:
Taxodium ascendens.
Cephelanthus occidentalis.

COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT

Sites: Beaver ponds, blocked embayments, and similar small, old, manmade impoundments with similar biota.

Soils: Unknown. Soils existing before the impoundment will be modified by flooding and will be gradually covered with clayey or mucky sediments. They are generally not distinguished in soil surveys.

Hydrology: Palustrine, permanently flooded in center, grading outward to the prevailing hydrology of the surrounding area.

Vegetation: Floating or submergent aquatics in interior, with or without zoned emergent vegetation at margins and with or without an open of closed canopy of Taxodium spp. or Nyssa spp. May contain remnants of drowned trees. Herb species may include Polygonum spp., Peltandra virginica, Nymphaea odorata, Nuphar lutea, Ceratophyllum spp., Myriophyllum spp., Lemna spp., Egeria densa, Elodea spp., Limnobium spongia, Nymphoides spp., Potamogeton spp., Utricularia spp., Lemna spp., Pontederia cordata, and Sagittaria spp. Shrubs include Cephalanthus occidentalis, Rosa palustris, and Decodon verticillatus.

Dynamics: These communities may be subject to severe perturbations at irregular intervals. Since they are located on floodplains, flooding may bring in nutrients and sediment. Damage or deterioration may break the dam and temporarily or permanently drain the pond. Beavers may raise the water level, dig channels, and cut trees. In the absence of such disturbance, the ponds will slowly fill with clayey or mucky sediment and be invaded by trees.

Range: Throughout the Coastal Plain.

Associations: Grades into Small Stream Swamp or Cypress--Gum Swamp communities at the upper end. Borders similar communities below the dam. May border either upland or floodplain communities on the sides.

Distinguishing Features: Coastal Plain Semipermanent Impoundments are separated from surrounding floodplain communities by the occurrence of permanent or semi- permanent standing water. They are distinguished from Oxbow Lakes by being flooded by impounded water rather than occurring in a depression. They generally are younger and are likely to be suddenly drained. Floodplain Pools are usually older and have more regular seasonal fluctuation of water levels. Small Depression Ponds occur in depressions in upland areas rather than in floodplains.

Coastal Plain Semipermanent Impoundments are generally separated from Piedmont/Mountain Semipermanent Impoundments by physiographic province. Sites near the fall zone should be classified according to vegetation.

Man-made ponds are considered part of this category if they are in small to large floodplains, are of the same size scale as natural beaver ponds, have been established a long time, and have not had the site significantly modified other than by the flooding.

Variation: Impoundments may vary with age, water depth, and disturbance history. There may be differences between examples in brownwater and blackwater stream floodplains. The isolation of ponds may make accidents of dispersal important factors in flora and fauna present.

Comments: This category is unusual in that some artificial ponds as well as natural beaver ponds are allowed. Unlike most natural communities, beaver ponds result from relatively recent modification of other community types; thus there is the potential for human action to mimic them effectively. In both, the biota consist of species surviving from before impoundment and species that are able to colonize in relatively short times. It is likely that only relatively few man-made ponds meet the criteria for inclusion.

With stable beaver populations, ponds may be maintained for many decades, but will still be subject to temporary or permanent destruction of the dams. Although manmade ponds may not strictly be natural, they are similar to the beaver pond environment. With beaver populations reduced, they may have been, and may still be, the primary place where these aquatic natural communities survived. Blocked embayments are rare ponds created by river sediment damming a small tributary stream.

In the Second Approximation, only one Semipermanent Impoundment type was included, and the description of it was

for the Coastal Plain. The Piedmont/Mountain type differs from the Coastal Plain in climate, flora, and probably flooding dynamics. The general lack of flood tolerant trees such as Taxodium distichum and Nyssa spp. means that Piedmont/Mountain ponds will seldom have a significant tree component. A number of wetland and aquatic herb species are restricted to the Coastal Plain, and the Piedmont/Mountain impoundments have lower potential species diversity.

Rare Plant Species: Vascular -- Eupatorium resinosum, Glyceria obtusa, Hottonia inflata, Lilaeopsis carolinensis, Ludwigia brevipes, Potamogeton confervoides, Rhynchospora alba, Sagittaria isoetiformis; nonvascular -- Sphagnum torreyanum.

Synonyms: Beaver pond, millpond, blocked embayment.

Examples:
Creek and Corridor Below Kinney Cameron Lake Natural Area, Beaver Dam Creek-Little Muddy Creek Natural Area and other sites on Sandhills Game Land, Scotland and Richmond counties.
Merchant's Millpond, Gates County (Frost 1982).
Walker's Millpond, Carteret County (Fussell and Wilson 1981).

References: Frost (1982), Fussell and Wilson (1983), Lynch (1981).

Sample Plant Communities:
Nyssa aquatica/Rare aquatic herbs.
Taxodium distichum-Nyssa aquatica/mixed wetland shrubs/mixed aquatic herbs.
Taxodium distichum/mixed aquatic herbs.

COASTAL PLAIN SMALL STREAM SWAMP (Blackwater Subtype)

Sites: Floodplains of small blackwater streams in which separate fluvial features and associated vegetation are too small or poorly developed to distinguish.

Soils: Various alluvial or organic soils. The most typical series is Muckalee (Typic Fluvaquent). Other series include Masontown (Cumulic Humaquept), Pamlico (Terric Medisaprist), and Croatan (Terric Medisaprist).

Hydrology: Palustrine, intermittently, temporarily, or seasonally flooded. Blackwater streams, in contrast to brownwater, tend to have highly variable flow regimes, with floods of short duration, and periods of very low flow. The water tends to be very acidic, low in mineral sediment, low in nutrients, and colored by tannins, but relatively low in turbidity.

Vegetation: Canopy dominated by various combinations of Taxodium distichum, Nyssa biflora, and various species of the other blackwater river floodplain communities, including Liquidambar styraciflua, Liriodendron tulipifera, Acer rubrum, Quercus laurifolia, Q. lyrata, Q. michauxii, Betula nigra, Ulmus americana, Pinus taeda, and P. serotina. The understory may be similarly variable. Species include Carpinus caroliniana, Acer rubrum, Ilex opaca, Magnolia virginiana, Persea palustris, and Cyrilla racemiflora. The shrub layer ranges from sparse to dense and almost pocosin-like. Species include Leucothoe racemosa, Leucothoe axillaris, Itea virginica, Lyonia lucida, and Vaccinium elliottii. Arundinaria gigantea ssp. tecta may form dense thickets. Vines, particularly Toxicodendron (Rhus) radicans, Smilax spp., Vitis rotundifolia, and Berchemia scandens, may be prominent. Herbs are generally relatively sparse.

Dynamics: These communities are affected by forces of the river. Along meandering streams channel migration may erode part of the floodplain and create new point bar deposits. Because of the low gradients of blackwater streams, flood waters do not usually directly disturb vegetation, although scour may be important locally.

Because blackwater rivers carry very little inorganic sediment, flooding does not provide as substantial a nutrient input as in brownwater systems but it may still be significant.

Range: Throughout the Coastal Plain and Sandhills.

Associations: Grades to upland community types away from channel. In the Sandhills, often grades upstream to Streamhead Pocosin. Grades downstream to the distinct community types of the larger floodplains (Bottomland Hardwood Forest, Cypress--Gum Swamp, or Coastal Plain Levee Forest).

Distinguishing Features: Small Stream Swamp communities are distinguished from Natural Levee Forests, Cypress--Gum Swamps, and Bottomland Hardwoods by their occurrence on small stream floodplains without well developed alluvial landforms. The boundary is fairly arbitrary and is difficult to place. Floodplains with levees and ridges high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be classified as Natural Levee, Cypress--Gum Swamps, and Bottomland Hardwoods. Featureless, very wet floodplains completely dominated by cypress and gum are placed in the Cypress--Gum Swamp type.

Small Stream Swamps are separated from upland communities at the terrestrial-palustrine boundary. This is best indicated by the predominance of facultative upland species over the facultative and facultative wetland species listed above. On streams with infrequent flooding, wetland and upland species may intermingle.

The Blackwater Subtype is most easily distinguished from the Brownwater Subtype by the nature of the river itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In general, brownwater river floodplains support more diverse communities.

Variation: This is a very heterogeneous category, but the variation has been little studied. Small Stream Swamps vary with flooding depth and frequency, substrate, geographic location, and water chemistry.

A distinctive variant is recognized for streams that drain from Streamhead Pocosins or other pocosin communities. These swamps often have abundant bay species (particularly Persea palustris) and fairly dense pocosin shrubs beneath a Nyssa biflora-Acer rubrum canopy. These "bay swamps" may be worthy of recognition as a distinctive subtype or type. The

more typical variant has a greater diversity of deciduous hardwoods and a less dense shrub layer.
Comments: These communities are distinguished from the communities of larger floodplains partly for convenience but mainly because differences in the ecosystems are expected. In smaller floodplains the relief and size of the fluvial landforms, which differentiate the communities in large floodplains, become smaller. The smaller watershed leads to a more variable flooding regime. These factors reduce the ecological differences between the different fluvial landforms; this apparently results in a highly variable mixture of the species of the communities of larger river floodplains. While these can in some senses be regarded as simply fine-scale mosaics of Levee, Bottomland Hardwoods, and Cypress--Gum Swamp communities, the patches are too small to function as separate communities. In many cases they may contain only a few trees, and most individual trees may interact primarily with trees in other microenviroments. Thus, a combination of level of resolution and somewhat different environment supports the idea of a separate category for small stream floodplains.

Blackwater streams have their headwaters in the Coastal Plain. Relative to brownwater rivers they generally have a low sediment load, lower pH (generally very acidic), high concentrations of organic matter, and low concentrations of dissolved and suspended inorganics. Some rivers draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater rivers in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Rare Plant Species: Vascular -- Amorpha georgiana var. georgiana, Carex bullata, Carex collinsii, Chasmanthium nitidum, Crataegus aestivalis, Didiplis diandra, Dryopteris ludoviciana, Epidendrum conopseum, Eriocaulon aquaticum, Gelsemium rankinii, Glyceria obtusa, Hibiscus coccineus, Ilex amelanchier, Ilex cassine, Lilaeopsis carolinensis, Lilium sp. 2, Lycopus cokeri, Macbridea caroliniana, Nuphar lutea ssp. sagittifolia, Ponthieva racemosa, Quercus austrina, Sagittaria engelmanniana, Scirpus etuberculatus, Scirpus subterminalis, Sebastiania fruticosa, Thalictrum macrostylum; nonvascular -- Cheilolejeunea rigidula, Fissidens hallii.

Synonyms:
Bottomland, swamp (general usage).
Most would not be distinguishable as single SAF types.

Examples:
Holston Creek and other creeks on Croatan National Forest, Carteret, Craven, and Jones counties.
Island Creek, Croatan National Forest and private, Jones County (Sears 1966) (an unusual example bordered by limestone bluffs).
Bennett's Creek below Merchant's Millpond, Gates County (Frost 1982).
Otter Creek Natural Area, East Carolina University, Pitt County.
Turnbull Creek Swamp, Bladen Lakes State Forest, Bladen County.
Wallace Creek Natural Area, Camp Lejeune, Onslow County.

References: Gosselink, Bayley, Conner, and Turner (1980), Lynch (1981), Maki, et al. (1980), Marty (1988), Nifong and Taggart (1981), Schafale, LeGrand, and Marty (1986), Wharton, Kitchens, Pendleton, and Sipe (1982), Woodwell (1956).

Sample Plant Communities:
Taxodium distichum-Mixed bottomland hardwoods.
Taxodium distichum-Mixed bottomland hardwoods/Carpinus caroliniana.
Taxodium distichum-Mixed bottomland hardwoods/Acer rubrum.
Mixed bottomland hardwoods/Mixed subcanopy hardwoods/Mixed shrubs.
Nyssa biflora-Acer rubrum.
Nyssa biflora-Acer rubrum/Persea palustris/Mixed pocosin shrubs.

COASTAL PLAIN SMALL STREAM SWAMP (Brownwater Subtype)

Sites: Floodplains of small brownwater streams in which separate fluvial features and associated vegetation zones are too small or poorly developed to be distinguishable at a natural community level.

Soils: Various alluvial soils such as Wilbanks (Cumulic Humaquept), Bibb (Typic Fluvaquent), Wehadkee (Typic Fluvaquent), and Meggett (Typic Albaqualf).

Hydrology: Palustrine, intermittently, temporarily, or seasonally flooded.

Vegetation: Canopy variable, dominated by combinations of Taxodium distichum, Nyssa aquatica, and various bottomland hardwoods such as Quercus michauxii, Q. shumardii, Q. pagoda (falcata var. pagodaefolia), Q. laurifolia, Q. nigra, Q. phellos, Liquidambar styraciflua, Celtis laevigata, Platanus occidentalus, Betula nigra, Fraxinus pennsylvanica, Salix nigra, and Populus heterophylla. Understory includes Carpinus caroliniana, Fraxinus caroliniana, Ilex opaca, and Acer rubrum.

Dynamics: These communities probably form stable climaxes, but may be affected by changes in runoff characteristics and sedimentation.

Range: Limited to the area just below the Fall Zone, where small Piedmont streams flow into the Coastal Plain.

Associations: Grades downstream to the distinct community types of the larger floodplains. Grades to upland communities. May grade to Streamhead Pocosin or Coastal Plain Small Stream Swamp (Blackwater Subtype) where joined by tributaries with Coastal Plain headwaters. May contain Semipermanent Impoundments.

Distinguishing Features: Small Stream Swamp communities are distinguished from Natural Levee Forests, Cypress--Gum Swamps, and Bottomland Hardwoods by their occurrence on small stream floodplains without well developed alluvial landforms. The boundary is fairly arbitrary and is difficult to place. Floodplains with levees and ridges high enough to support vegetation distinct from that in the floodplain behind them and broad enough to fit several tree canopy widths beyond the transition to adjacent communities should be classified as Natural Levee, Cypress--Gum Swamps, Bottomland Hardwoods. Featureless, very wet floodplains completely dominated by cypress and gum should be placed in the Cypress--Gum Swamp type.

The Brownwater Subtype is most easily distinguished from the Blackwater Subtype by the nature of the stream itself (see comments). Floristic and vegetational differences between the subtypes have not been well studied but appear to be real. In general, brownwater river floodplains support more diverse communities. Small Stream Swamps are separated from upland communities at the terrestrial-palustrine boundary. This is best indicated by the predominance of facultative upland species over the facultative and facultative wetland species listed above. On streams with infrequent flooding, wetland and upland species may intermingle.

Variation: Little is known about variation. Expected to vary with stream gradient, flooding frequency and duration, and nature of sediment deposition. Some will probably be more dominated by cypress and gum, others by bottomland hardwood species.

Comments: Little is known about communities of this type. Their rather narrow range occurs in a part of the state where little natural vegetation remains. No protected examples are known.

These communities are distinguished from the communities of larger floodplains partly for convenience but mainly because of differences in the ecosystems. In smaller floodplains the relief and size of the fluvial landforms, which differentiate the communities in large floodplains, become smaller. The smaller watershed leads a more variable flooding regime. These factors reduce the ecological differences between the different fluvial landforms; this apparently results in a highly variable mixture of the species of the communities of larger river floodplains. While these can in some senses be regarded as simply fine-scale mosaics of Levee, Bottomland Hardwoods, and Cypress--Gum Swamp communities, the patches are too small to function as separate communities. In many cases they may contain only a few trees, and most individual trees may interact primarily with trees in other microenviroments. Thus, a combination of level of resolution and

somewhat different environment supports the idea of a separate category for small stream floodplains.

Brownwater streams have their headwaters in the Piedmont. Relative to blackwater rivers they generally have a heavy sediment load, have higher pH (generally circumneutral), have relatively low concentrations of total organic carbon and high concentrations of dissolved inorganics (derived from weathering and leaching of parent rocks and soils). These sites seem to show some mixing of blackwater and brownwater character. Because of the relatively small watersheds of these small streams, they carry low volumes of water. In flood they carry much sediment, but at lower flow this quickly settles out and the presence of organic matter (particularly away from the channel) stains the water with tannins. Their sediments, however, are apparently higher in pH than those of blackwater streams, and this is likely responsible for the general absence of pocosin shrubs and trees often found in the Blackwater Subtype. The best known example, Swift Creek Swamp Forest, occurs over calcareous clays and has a high pH soil (Meggett series). It is unclear how many of its characteristics apply to other examples.

Some streams draining agricultural parts of the Coastal Plain may now carry heavy sediment loads and resemble brownwater streams in water chemistry, though they are fundamentally blackwater rivers. This may produce gradual changes in floodplain communities that blur the distinction between the subtypes.

Rare Plant Species: Vascular -- Carex crus-corvi, Ranunculus flabellaris.

Synonyms:
Bottomlands (general usage).
Most would not be large or homogeneous enough to distinguish as SAF types.

Examples:
Swift Creek Swamp, Edgecombe County (Weakley 1978).
Turkey Creek Least Trillium Site, Nash County.

References: Weakley (1978).

Sample Plant Communities:
None listed.

PIEDMONT/MOUNTAIN LEVEE FOREST

Sites: Natural levee and point bar deposits on large floodplains.

Soils: Medium or coarse-textured alluvial soils. Generally mapped as Congaree (Typic Udifluvent) or Chewacla (Fluvaquentic Dystrochrepts).

Hydrology: Palustrine, seasonally to intermittently flooded.

Vegetation: Canopy dominated by a mixture of bottomland trees such as Platanus occidentalis, Betula nigra, Celtis laevigata, Acer negundo, Liquidambar styraciflua, Quercus pagoda (falcata var. pagodaefolia), Quercus michauxii, Liriodendron tulipifera, Fraxinus pennsylvanica, Ulmus americana, Carya cordiformis, Juglans nigra, and Carya ovata. Understory species include Acer negundo, Asimina triloba, Carpinus caroliniana, and Ilex opaca. Shrubs include Lindera benzoin, Aesculus sylvatica, Xanthorhiza simplicissima, and Arundinaria gigantea. Woody vines, such as Toxicodendron (Rhus) radicans, Parthenocissus quinquefolia, Bignonia (Anisostichus) capreolata, Smilax spp., Campsis radicans, and Vitis spp., are frequently prominent. The herb layer is lush and usually fairly diverse. Species include Boehmeria cylindrica, Chasmanthium (Uniola) latifolium, Chasmanthium (Uniola) laxum, Elymus hystrix (Hystrix patula), Verbesina alternifolia, Saxifraga virginiensis, Sedum ternatum, Solidago caesia, Aster divaricatus, Clematis virginiana, Botrychium virginianum, Elymus virginicus, Claytonia virginiana, Stellaria pubera, Viola spp., Rudbeckia laciniata, and Corydalis flavula. Many places are heavily invaded by Lonicera japonica, Microstegium vimineum, and Ligustrum sinense, and the native herbs are suppressed.

Dynamics: Although Piedmont and Mountain rivers meander less than Coastal Plain rivers, their levee communities are still dominated by forces of the river. Levees outside of bends may be undercut and eroded by the river; those inside may be abandoned by the channel. Point bar processes may create new sites for invasion by Levee Forests. In addition, vegetation may be directly disturbed by flooding (scouring and battering by debris). The vegetation may consist of mature climax forest, or may be in various stages of primary or secondary succession.

The periodic input of nutrients in flood-deposited sediment makes levee sites very fertile, and growth is rapid in these communities.

The construction of dams on the upper portions of large rivers has changed the dynamics of flooding and sediment supply. These changes may eventually lead to changes in the floodplain communities.

These communities are frequently subject to invasion by exotic plants, especially if cut in the past. Lonicera japonica, Microstegium vimineum, and Ligustrum sinense may come to dominate large areas to the exclusion of the native herb layer.

Range: Potentially throughout the Piedmont and Blue Ridge. Best developed in the Durham and Wadesboro Triassic basins.

Associations: Grades into Swamp or Bottomland Forest away from the channel. May be bordered by the river channel, Sand and Mud Bar or occasionally by Rocky Bar and Shore communities.

Distinguishing Features: Piedmont/Mountain Levee Forests are distinguished from Piedmont/Mountain Swamp Forests by occurring on natural levee deposits adjacent to the river. They are distinguished from Piedmont/Mountain Swamp Forests by being higher, drier, and having more diverse characteristic vegetation. The significant presence of Platanus occidentalis, Betula nigra, and Acer negundo usually indicate levee forest.

Natural Levee Forests are distinguished from Piedmont/Low Mountain Alluvial Forests by occurring on larger floodplains with well-developed fluvial landforms that influence the vegetation. Levees, sloughs, and ridges may be visible in parts of Alluvial Forest communities, but they are generally small, often on the same scale as individual trees.

Variation: Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but all levee sites are more fertile than surrounding uplands. Species composition varies somewhat between Piedmont and Mountain sites.

Comments: Because of the relatively steep gradients and narrow floodplains in the Piedmont and especially in the Blue

Ridge, rivers with fluvial landforms large enough to allow recognition of levee, swamp, and bottomland are much less common than in the Coastal Plain.

This community type is distinguished from the Coastal Plain Levee Forest because of the differences in gradient and hydrology and the differences in species associated with levees in the two regions.

Rare Plant Species: Vascular -- Amorpha schwerinii, Cardamine douglassii, Enemion biternatum, Mertensia virginica, Panax trifolius, Phacelia ranunculacea.

Synonyms:
Alluvial Forest (Peet and Christensen 1981, Moore 1973, Moore and Wood 1976) (in part).
SAF 61, 93, and 94: River Birch-Sycamore, Sugarberry-American Elm-Green Ash, and Sycamore-Sweetgum-American Elm (in part).

Examples:
Pee Dee National Wildlife Refuge, Anson County New Hope Creek Bottomland, above Jordan Reservoir, Durham County (Sutter, Harrison, and Rettig 1987).

References: Moore (1973), Moore and Wood (1976), Peet and Christensen (1980), Sutter, Harrison, and Rettig (1987).

Sample Plant Communities:
Acer negundo/Mixed herbs.
Acer floridanum-Mixed bottomland hardwoods/Mixed subcanopy/Mixed herbs//Lonicera japonica.
Betula nigra/Mixed subcanopy hardwoods/Mixed tall herbs.
B. nigra-Juglans nigra/Acer negundo/Lindera benzoin/Mixed tall herbs.
B. nigra-Platanus occidentalis/Acer negundo/Lindera benzoin/Mixed tall herbs.
B. nigra-Platanus occidentalis/Lindera benzoin/Mixed tall herbs.
B. nigra-Mixed floodplain hardwoods/Carpinus caroliniana/Mixed tall herbs.
Fraxinus americana-Betula nigra/Asimina triloba/Mixed herbs.
Mixed alluvial hardwoods.
Mixed alluvial hardwoods/Acer negundo/Mixed herbs.
Mixed alluvial hardwoods/Carpinus caroliniana/Mixed shrubs.
Mixed alluvial hardwoods/Carpinus caroliniana/Mixed herbs/Mixed vines.
Mixed alluvial hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
Mixed alluvial hardwoods/Mixed shrubs/Mixed herbs.
Mixed alluvial hardwoods//Lonicera japonica.
Mixed alluvial hardwoods/Mixed herbs-Viola sp.

PIEDMONT/MOUNTAIN SWAMP FOREST

Sites: Backswamp deposits and sloughs on large floodplains.

Soils: Fine to medium-textured alluvial soils, generally of the Wehadkee series (Typic Fluvaquent).

Hydrology: Palustrine, seasonally to frequently flooded. May be flooded for relatively long periods.

Vegetation: Canopy dominated by mixtures of flood-tolerant species, such as Liquidambar styraciflua, Ulmus americana, Quercus phellos, Q. lyrata, Q. pagoda (falcata var. pagadaefolia), Q. michauxii, Acer rubrum, Salix nigra, Populus heterophylla, and Fraxinus pennsylvanica. Understory absent, or of species such as Ulmus alata, Ilex decidua, Ilex ambigua, and Carpinus caroliniana. Woody vines, primarily Toxicodendron (Rhus) radicans, Bignonia (Anisostichus) capreolata, and Smilax spp., are frequently prominent. Herbs generally are sparse. Typical species include Saururus cernuus, Carex spp., Impatiens capensis, Boehmeria cylindrica, Dulichium arundinaceum, Zephyranthes atamasco, and Galium obtusum.

Dynamics: These communities are flooded for long periods in many years. Sediment deposition is generally less than on the levees and of finer texture. The periodic input of nutrients makes these sites fertile, but growth is limited by flooding. Physical disturbance by flowing water is unlikely to be a significant disturbance, but prolonged flooding may stress or kill trees.

A number of swamp forests have been diked to make green tree reservoirs. The effect of this on the community is not known, but dynamics, structure, and composition are likely to be affected in the long term.

Range: Potentially throughout the Piedmont, but well developed only in the Durham and Wadesboro Triassic basins. Probably rare or absent in the Blue Ridge.

Associations: Grades into Piedmont/Mountain Levee Forest toward the channel. May grade to Piedmont/Mountain Bottomland Forest or to various mesic, dry-mesic, or dry terrestrial communities.

Distinguishing Features: Piedmont/Mountain Swamp Forests are distinguished from Levee Forests and Bottomland Forests by their occurrence in lower parts of the floodplain which are flooded for long periods, and by the resulting vegetational differences. Swamp Forests have lower diversity, containing only the species from the wettest end of the water tolerance spectrum. In contrast to the Levee and Bottomland Forest, the herb layer is generally sparse.

Swamp Forests may be distinguished from Floodplain Pools by the presence of a closed or potentially closed canopy rooted within the community. They are distinguished from Semipermanent Impoundments by the lack of semi-permanent impounded water. Semipermanent Impoundments also generally lack a closed canopy.

Variation: Varies locally and from site to site with depth and duration of flooding.

Comments: Because of the relatively steep gradients and narrow floodplains in the Piedmont and especially in the Blue Ridge, rivers with fluvial landforms large enough to allow recognition of levee, swamp, and bottomland are less common than in the Coastal Plain. Substantial Swamp Forests appear to be particularly rare. They are confined to the Triassic basins, and large acreages have been destroyed by reservoir construction.

This type occupies topographic positions equivalent to the Cypress--Gum Swamp communities of the Coastal Plain. Because of steeper gradients and shorter floods however, it supports forest more similar to that of the Coastal Plain Bottomland Hardwoods communities.

Rare Plant Species: Vascular -- Asclepias purpurascens, Quercus palustris, Smilax hugeri.

Synonyms:
Swamp Forest (Moore 1973, Moore and Wood 1976).
SAF 92: Cottonwood, Sweetgum-Willow Oak.

Examples:
Brown's Creek Floodplain, Pee Dee National Wildlife Refuge, Anson County.
Big Oak Woods, Mason Farm, N.C. Botanical Garden, Orange County (Sather and Hall 1988).
New Hope Creek Bottomland and other creeks at the upper end of Jordan Reservoir, Durham County (Sutter, Harrison, and Pettig 1987).

References: Moore (1973), Moore and Wood (1976), Sather and Hall (1988), Sutter, Harrison, and Rettig (1987).

Sample Plant Communities:
Mixed bottomland hardwoods/Mixed herbs.
Quercus michauxii-Ulmus americana.
Liquidambar styraciflua-Quercus phellos.

PIEDMONT/MOUNTAIN BOTTOMLAND FOREST

Sites: Floodplain ridges and terraces other than active levees adjacent to the river channel.

Soils: Various alluvial soils, probably generally Chewacla (Fluvaquentic Dyrstochrepts) and Congaree (Typic Udifluvents).

Hydrology: Palustrine, intermittently flooded.

Vegetation: Canopy dominated by various bottomland trees such as Liriodendron tulipifera, Liquidambar styraciflua, Quercus pagoda (falcata var. pagodaefolia), Q. michauxii, Ulmus americana, Celtis laevigata, Fraxinus pennsylvanica, Pinus taeda, Carya ovata, and Carya cordiformis. Understory trees include Carpinus caroliniana, Acer floridanum, Acer rubrum, Cornus florida, Ilex opaca, and Asimina triloba. Shrubs include species such as Aesculus sylvatica, and Evonymus americana. Arundinaria gigantea may form dense thickets. Vines are frequently prominent, including Toxicodendron (Rhus) radicans, Parthenocissus quinquefolia, Bignonia (Anisostichus) capreolata, Smilax spp., Menispermum canadense, and Vitis spp. Herbs include Boehmeria cylindrica, Polystichum acrostichoides, Carex spp., Cryptotaenia canadensis, Polygonum (Tovara) virginianum, Arisaema triphyllum, Viola spp., Senecio aureus, Elymus virginicus, Solidago caesia, Aster divaricatus, Chasmanthium (Uniola) latifolium, and Chasmanthium (Uniola) laxum. Some places are heavily invaded by Lonicera japonica and Microstegium vimineum, and the native herbs are suppressed.

Dynamics: These communities are flooded, at least occasionally. Unlike the Levee Forest they are seldom disturbed by flowing water. They receive less sediment deposition than the Levee Forest but still receive significant input of nutrients through it.

Bottomland Forests are believed to form a stable climax forest, having an uneven-aged canopy with primarily gap phase regeneration, although the possibility of unusually deep and prolonged flooding may make widespread mortality more likely than in uplands. Areas that have been cleared or heavily logged in the past may have abundant or dominant disturbance species such as Pinus taeda, Acer rubrum, Liquidambar styraciflua, or Platanus occidentalis.

Range: Throughout the Piedmont and lower parts of the Blue Ridge.

Associations: Grades into Levee Forest or Swamp Forest within the floodplain. May grade to various mesic, dry-mesic, or dry forest communities.

Distinguishing Features: Piedmont/Mountain Bottomland Forests are distinguished from Levee Forests by not occurring on active levee deposits adjacent to the river. The presence of Platanus occidentalis and Betula nigra usually indicates a levee, but these species may sometimes invade cleared bottomlands. Bottomland Forests are distinguished from Swamp Forests by occurring in higher and better drained parts of the floodplain, which is reflected in vegetational differences. Bottomland Forests are more diverse and usually have a well developed herb layer.

The boundary with upland forests occurs where flooding ceases to have a significant effect on the vegetation and flood-intolerant species such as Fagus grandifolia become a significant component of the community.

Variation: This type contains a broad range of wetness, related to height of ridges or terraces. Sites may vary due to different alluvial material and its effect on soil fertility. Substantial regional variation may also exist but information is not sufficient to recognize variants.

Comments: Because of the relatively steep gradients and narrow floodplains in the Piedmont and especially in the Blue Ridge, rivers with fluvial landforms large enough to allow recognition of levee, swamp, and bottomland are less common than in the Coastal Plain. Even large river floodplains may contain alternating stretches of narrow and broad floodplain.

This type occupies topographic positions equivalent to the Bottomland Hardwoods communities of the Coastal Plain. Because of the steeper gradients and shorter floods it supports different vegetation.

The fertility and infrequent flooding in these sites have made them excellent farm lands. Very few bottomlands of any significant size remain. While many bottomlands exist as successional forests grown up in abandoned fields, intact Bottomland Forests are among the rarest of communities in North Carolina.

Rare Plant Species: Vascular -- Cardamine douglassii, Carex cherokeensis, Carex granularis, Cirsium carolinianum, Dryopteris carthusiana, Panax trifolius, Phacelia ranunculacea, Silphium perfoliatum ssp. connatum.

Synonyms:
Alluvial Forest (Peet and Christensen 1981, Moore 1973, Moore and Wood 1976) (in part).

Examples:
Brown's Creek Floodplain, Pee Dee National Wildlife Refuge, Anson County.
Dan River, Stokes and Rockingham counties (Weakley and Dickerson 1979).

References: Moore (1973), Moore and Wood (1976), Peet and Christensen (1980), Weakley and Dickerson (1979).

Sample Plant Communities:
Mixed bottomland hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
Mixed bottomland hardwoods/Arundinaria gigantea.

FLOODPLAIN POOL

Sites: Depressions in abandoned river channels on floodplains in the Mountain and Piedmont regions, holding standing water much or all of the year.

Soils: The soils of these small areas are not distinguished in soil surveys. They probably represent inclusions in the general floodplain soil units.

Hydrology: Palustrine, permanently to semipermanently flooded.

Vegetation: Central parts may lack higher plants, or may contain aquatics. Edges may have zoned aquatic and wetland vegetation, with species such as Osmunda regalis var. spectabilis, Carex folliculata, C. crinita, C. debilis, C. alata, Boehmeria cylindrica, Polygonum cespitosum, Ludwigia palustris, and Sphagnum spp. Shrubs such as Alnus serrulata may occur on the edge. Pools that are permanently flooded may support fish. Those that dry out fairly frequently will lack fish but may be important breeding sites for amphibians. Several species are largely dependent on these pools, including the salamanders Ambystoma opacum, A. maculatum, A. talpoideum, Hemidactylium scutatum, and the turtle Clemmys guttata.

Dynamics: Not well known. Determined by the frequency of drying out, which determines the nature of aquatic or amphibian animal communities. Major floods may flush the pools or alter their shape. In the absence of floods, pools probably slowly fill and succeed to other floodplain communities or to boggy vegetation.

Range: Widespread but generally small and uncommon in the Piedmont and probably upper Coastal Plain. Extremely rare in the mountains.

Associations: Generally surrounded by Piedmont/Low Mountain Alluvial Forest or Bottomland Forest, potentially by Swamp Forest or Levee Forest. Can possibly be bordered by upland slopes on one side.

Distinguishing Features: Floodplain Pools are distinguished from surrounding floodplain communities by having permanent or semi-permanent standing water. Generally few or no trees are rooted in the pools. Floodplain Pools are distinguished from Semipermanent Impoundments by occurring in depressions rather than impounded areas. They generally are older and more permanent, since thay are not dependent on upkeep of a dam. Their water levels are likely to be more regularly seasonal.

Floodplain Pools differ from the Oxbow Lake type of the Coastal Plain due to the topographic and flooding dynamic differences between the meandering Coastal Plain rivers and the higher gradient Piedmont and Mountain rivers. Climatic and biogeographic differences are significant between the regions. The boundary is tentatively placed at the eastern edge of the Fall Zone. No examples are yet known in this transition area to provide information on the suitability of this boundary.

Floodplain Pools are distinguished from Swamp Forest-Bog Complexes, which also may contain wet depressions, by having standing water and generally muddy bottoms, rather than being filled with organic material and boggy vegetation.

Variation: The primary source of variation is the frequency of drying out, which is determined by depth and connection to groundwater. Pools that never dry out can develop permanent aquatic communities; those that do dry out at least every few years will lack fish and other obligate aquatic animals that cannot easily recolonize. Climatic differenes may lead to differences between Mountain and Piedmont examples.

Comments: This community type is somewhat equivalent to the Coastal Plain Oxbow Lake. There is, however, a major difference in topography and flooding dynamics between the meandering Coastal Plain rivers and the higher gradient Piedmont and Mountain rivers. Difference in climate between the regions is an additional factor separating the types.

The Floodplain Pool type grades conceptually into the Swamp Forest-Bog Complex type, which contains shallower, boggy depressions that may be saturated much of the year but don't flood. These depressions are of similar origin and may have originated as floodplain pools.

Well-developed Floodplain Pools appear to be relatively rare, although their true abundance is not known.

Rare Plant Species: None known.

Synonyms: Pond, pool (general usage).

Examples:
Die Bend, Cherokee County (Govus 1985).
Sandy Bottom, Buncombe County (Braswell, pers. comm. 1983).
Nantahala River Woodland Pond, Macon County (Bruce and Holland 1981).
Pilot Mountain State Park--Yadkin River section, Surry County (Braswell, pers. comm.).

References: Braswell (1988), Bruce and Holland (1981), Govus (1985).

Sample Plant Communities:
Open water.
Brasenia schreberi-sedge spp.
Osmunda regalis var. spectabilis.
Carex spp.
Sphagnum spp.

PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT

Sites: Beaver ponds and similar small, old, undisturbed, man-made impoundments. Generally occur in floodplains and valleys with low gradient.

Soils: Soils existing before the impoundment will be modified by flooding and will be gradually covered with clayey or mucky sediment. These soils are generally not distinguished in soil surveys.

Hydrology: Palustrine, permanently flooded in the center, grading outward to the prevailing hydrology of the surrounding area.

Vegetation: Younger ponds are likely to have dead stems of trees that occurred on the site before impoundment. Occasionally, flood-tolerant trees such as Acer rubrum, Quercus lyrata, or Q. phellos may survive or become established in the pond, but in general there is no tree canopy unless the pond is very shallow. Wetland shrubs such as Cephalanthus occidentalis, Alnus serrulata, Salix spp., and Rosa palustris may become established on old stumps and at the edge. Herbs in similar sites include Scirpus cyperinus, Juncus spp., Saururus cernuus, Carex spp., Hibiscus moscheutos, and Ludwigia spp. In deeper water, aquatic plants such as Peltandra virginica, Nuphar lutea, and Lemna perpusilla may occur. Amphibian and aquatic animal communities may be significant.

Dynamics: These communities may be subject to severe perturbations at irregular intervals. Since they are located on floodplains, flooding may bring in nutrients and sediment. Damage or deterioration may break the dam and temporarily or permanently drain the pond. Beavers may raise the water level, dig channels, and cut trees. In the absence of such disturbance, the ponds slowly fill with clayey or mucky sediment and are invaded by trees.

Range: Potentially throughout the Piedmont and Mountain regions, particularly in areas, such as Triassic basins, where large floodplains or flat valleys occur. Fairly common in the Piedmont, probably fairly rare in the Mountains.

Associations: Grades to stream or river floodplain communities at the upper end. Borders similar communities below the dam. May border either upland or floodplain communities on the sides. In the Mountains, they may be associated with sites of Swamp Forest-Bog Complex, Marsh-Bog Complex, or Southern Appalachian Bog.

Distinguishing Features: Piedmont/Mountain Semipermanent Impoundments are separated from surrounding floodplain communities by the occurrence of permanent or semi-permanent standing water. They are distinguished from Floodplain Pools by being flooded by impounded water rather than occurring in depressions. They generally are younger and are likely to be suddenly drained. Floodplain Pools are usually older and have more regular seasonal fluctuation of water levels.

Piedmont/Mountain Semipermanent Impoundments are generally separated from Coastal Plain Semipermanent Impoundments by physiographic province. Sites near the fall zone should be classified according to vegetation.

Man-made ponds are considered part of this category if they are in small to large floodplains, are of the same size scale as natural beaver ponds, have been established a long time, and have not had the site significantly modified other than by the flooding.

Variation: Variation is not well known. Important factors causing variation are geographic location, age of impoundment, depth of water, and disturbance history. The isolation of ponds may make accidents of dispersal important factors in the flora and fauna present.

Comments: This category is unusual in that some artificial ponds as well as natural beaver ponds are allowed. Unlike most natural communities, beaver ponds result from relatively recent modification of other community types; thus there is the potential for human action to mimic them effectively. In both, the biota consist of species surviving from before impoundment and species that are able to colonize in relatively short times. It is likely that only relatively few man-made ponds meet the criteria for inclusion.

This category may need to be split as more information becomes available. Mountain examples are particularly poorly known, and may be distinct from Piedmont examples. In the mountains, the rare bog community types are often subject to

beaver activity. Beaver ponds may play a role in the formation of such bogs.

In the Second Approximation, only one Semipermanent Impoundment type was included, and the description of it was for the Coastal Plain. The Piedmont/Mountain type differs from the Coastal Plain in climate, flora, and probably flooding dynamics. The general lack of flood tolerant trees such as Taxodium distichum and Nyssa spp. means that Piedmont/Mountain ponds will seldom have a significant tree component. A number of wetland and aquatic herb species are restricted to the Coastal Plain, and the Piedmont/Mountain impoundments have lower potential species diversity.

Rare Plant Species: None known.

Synonyms:
Beaver pond, mill pond (general usage).

Examples:
Beaverdam Creek above Beaverdam Reservoir, Wake and Granville counties PeeDee Gabbro Slopes, Richmond County.
Thoroughfare Creek, Pee Dee National Wildlife Refuge, Anson County Knap of Reeds Creek, Granville County (LeGrand and Dalton 1987).
Panthertown Valley, Jackson County.
Third Creek Swamp, at upper end of Jordan Reservoir, Durham County.

References: LeGrand and Dalton (1987), Moore (1973), Moore and Wood (1976).

Sample Plant Communities: None listed.

PIEDMONT/LOW MOUNTAIN ALLUVIAL FOREST

Sites: River and stream floodplains in which separate fluvial landforms and associated vegetation zones are too small to distinguish, in the Piedmont and lower elevation Mountain valleys.

Soils: Various alluvial soil, most typically Chewacla (Fluvaquentic Dystrochrept) or Congaree (Typic Udifluvent).

Hydrology: Palustrine, seasonally or intermittently flooded.

Vegetation: Forest with open to dense understory or shrub layer and sparse to dense diverse herb layer. Canopy a mixture of bottomland and mesophytic trees, including Betula nigra, Platanus occidentalis, Liquidambar styraciflua, Liriodendron tulipifera, Ulmus americana, Celtis laevigata, Juglans nigra, Fraxinus pennsylvanica, Carya cordiformis, Carya ovata, Quercus imbricaria, Acer rubrum, and in the west, Fraxinus americana and Halesia tetraptera (carolina). Understory trees include Acer negundo, Acer floridanum, Acer rubrum, Asimina triloba, Ilex opaca, and Carpinus caroliniana. Shrubs may include Lindera benzoin, Evonymus americana, Aesculus sylvatica, Leucothoe recurva, Corylus cornuta, and Cornus amomum. Vines are frequently prominent, including Toxicodendron (Rhus) radicans, Parthenocissus quinquefolia, Bignonia (Anisostichus) capreolata, Vitis spp., Menispermum canadense, and Smilax spp. The herb layer is generally lush and diverse. Species include Erythronium umbilicatum ssp. umbilicatum, Claytonia virginica, Stellaria pubera, Solidago caesia, Aster divaricatus, Carex laxiflora, Dichanthelium (Panicum) dichotomum, Elymus virginicus, Polystichum acrostichoides, Botrychium virginianum, Uvularia sessilifolia, Boehmeria cylindrica, Elymus hystrix (Hystrix patula), Chasmanthium (Uniola) latifolium, Chasmanthium (Uniola) laxum, Sedum ternatum, Geum canadense, Polygonum (Tovara) virginianum, Verbesina alternifolia, Impatiens capensis, Corydalis flavula, Cryptotaenia canadensis, Viola spp, Arisaema triphyllum, and Senecio aureus. Many places are heavily invaded by Lonicera japonica and Microstegium vimineum at the expense of native herbs.

Dynamics: Flood-carried sediment provides nutrient input to these communities, as well as serving as a natural disturbance factor. Small parts of forests may be eroded or disturbed by catastrophic floods, though this is less likely than in Mountain Alluvial Forests. Beavers may occasionally create impoundments. Areas that have been cultivated or clearcut are generally dominated by Liriodendron tulipifera or Liquidambar styraciflua.

Range: Throughout the Piedmont and lower Blue Ridge valleys.

Associations: May grade into various mesic, dry-mesic, or dry upland forests, or to cliff communities. Borders river channel, Rocky Bar and Shore, or Sand and Mud Bar.

Distinguishing Features: Piedmont/Low Mountain Alluvial Forests may be distinguished from mesic communities by location in a floodplain and by the presence of alluvial species such as Platanus occidentalis, Betula nigra, and Acer negundo. These species may be almost lacking in small, marginal, Liriodendron- dominated bottoms.

Piedmont/Low Mountain Alluvial Forests are distinguished from communities of larger floodplains, Piedmont/Mountain Levee Forest, Swamp Forest, and Bottomland Forest, by the absence or poor development of the depositional fluvial landforms which determine vegetation. Levees, sloughs, and ridges may be visible in parts of Alluvial Forest communities but they are generally small, often on the same size scale as individual trees.

Piedmont Alluvial Forests may be distinguished from Montane Alluvial Forests by the presence of low elevation alluvial species such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata, and by the lack or unimportance of montane species such as Tsuga canadensis, Betula alleghaniensis (lutea), and Betula lenta. They may be distinguished from Coastal Plain Small Stream Swamps by location and the lack of typical Coastal Plain species such as Taxodium distichum, Nyssa aquatica, and Nyssa biflora.

Variation: Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility but almost all alluvial sites are more fertile than surrounding uplands. Soils may be especially rich if adjacent uplands are on a mafic rock substrate. Species composition varies somewhat between Piedmont sites and low elevation Mountain sites.

Comments: These communities are distinguished from the communities of larger floodplains partly for convenience but mainly because of differences in the ecosystems. In smaller floodplains the relief and size of the fluvial landforms, which differentiate the communities in large floodplains, become smaller. If the watershed is smaller, the flooding regime will also be more variable. These factors reduce the ecological differences between the different fluvial landforms; this apparently results in a highly variable mixture of the species of the communities of larger river floodplains. While these can in some senses be regarded as simply fine-scale mosaics of Levee, Swamp, and Bottomland communities, the patches are too small to be classified individually. In many cases they may contain only a few trees, and most individual trees may interact with trees in other patches. Thus a combination of level of resolution and somewhat different environment support the idea of a separate category for small stream floodplains. It is not clear at this time at what size of river the individual fluvial communities become indistinguishable.

This type is the Piedmont equivalent of the Coastal Plain's Small Stream Swamps. It is distinguished from them because of the differences in gradient and hydrology between the regions, and corresponding differences in species composition and dominance.

The small size and heterogeneous nature of small floodplains compared to the larger floodplains may in some cases make them less likely to be deliberately disturbed by activities such as agriculture or forestry. But it also makes them vulnerable to indirect damage by actions on adjacent lands. In addition, many small streams have been channelized, which is very destructive to the floodplain communities.

Rare Plant Species: Vascular -- Aster mirabilis, Botrychium jenmanii, Bromus latiglumis, Cacalia suaveolens, Cardamine dissecta, Cardamine douglassii, Carex impressinervia, Carex projecta, Crataegus calpodendron, Dirca palustris, Echinocystis lobata, Elymus riparius, Evonymus atropurpurea, Hexastylis lewisii, Humulus lupulus, Mertensia virginica, Panax trifolius, Phacelia ranunculacea, Polemonium reptans, Ptelea trifoliata, Quercus bicolor, Quercus imbricaria, Quercus muehlenbergii, Scutellaria nervosa, Scutellaria parvula var. australis, Silphium perfoliatum ssp. connatum, Spiraea virginiana, Trillium pusillum var. 1; nonvascular -- Fissidens exilis, Plagiochila columbiana.

Synonyms:
Bottomland, floodplain (general usage).
Alluvial Forest (Peet and Christensen 1981, Moore 1973, Moore and Wood 1976) (in part).
Type I (Nehmeth 1968).
SAF 61,91, 92, 93, and 94: River Birch-Sycamore, Swamp Chestnut Oak-Cherrybark Oak, Sweetgum-Willow Oak, Sugarberry-American Elm-Green Ash, and Sycamore-Sweetgum-
American Elm (in part).

Examples:
Eno River State Park, Orange and Durham County.
New Hope Creek, Duke Forest, Orange County.
Dan River, Stokes and Rockingham counties (Weakley and Dickerson 1979).
Cody Cliffs, Huff Island, and other sites on the French Broad River, Madison County. (Wickland and Horton 1975).

References: LeGrand and Dalton (1987), Moore (1973), Moore and Wood (1976), Morgan (1962), Peet and Christensen (1980), Sather (1982), Sather and Hall (1988), Sutter, Harrison, and Rettig (1987), Weakley and Dickerson (1979), Wickland and Horton (1977), Wolfe and Pittillo (1977).

Sample Plant Communities:
Acer saccharum-Mixed bottomland hardwoods/Mixed subcanopy/Mixed herbs//Lonicera japonica.
Betula nigra/Mixed subcanopy hardwoods/Mixed tall herbs.
B. nigra-Juglans nigra/Acer negundo/Lindera benzoin/Mixed tall herbs.
B. nigra-Platanus occidentalis/Acer negundo/Lindera benzoin/Mixed tall herbs.
B. nigra-Platanus occidentalis/Mixed tall herbs.
B. nigra-Mixed floodplain hardwoods/Carpinus caroliniana/Mixed tall herbs.
Carya cordiformis-Mixed mesic hardwoods/Mixed subcanopy hardwoods/Mixed herbs/Lonicera japonica.
Fraxinus americana-Betula nigra/Asimina triloba/Mixed herbs.
Liriodendron tulipifera/Mixed subcanopy/Lindera benzoin.

Mixed alluvial hardwoods/Carpinus caroliniana/Mixed shrubs/Mixed herbs//Mixed vines.
Mixed alluvial hardwoods/Carpinus caroliniana/Mixed tall herbs.
Mixed alluvial hardwoods/Mixed subcanopy hardwoods/Mixed herbs.
Mixed alluvial hardwoods/Mixed shrubs/Mixed herbs.
Mixed alluvial hardwoods//Lonicera japonica.
Mixed alluvial hardwoods/Carex grayi-Mixed herbs.
Mixed alluvial hardwoods/Mixed herbs-Viola sp.

MONTANE ALLUVIAL FOREST

Sites: Stream and river floodplains at moderate to high elevations.

Soils: Alluvial soils. Limited soil mapping and limited knowledge of this type make determination of typical soils difficult. Likely series include Toxaway (Cumulic Humaquept), Rosman (Fluventic Haplumbrept), and Tusquitee (Humic Hapludult).

Hydrology: Palustrine, intermittently flooded.

Vegetation: Forest with open to dense shrub and sparse to dense herb layer. Canopy a mixture of bottomland and mesophytic tree species, usually Tsuga canadensis and Platanus occidentalis, but also Betula alleghaniensis (lutea), Quercus alba, Acer rubrum, Liriodendron tulipifera, and Betula nigra. Typical understory species are Carpinus caroliniana, Hamamelis virginiana, and Salix nigra. The most typical shrubs are Rhododendron maximum, Alnus serrulata, and Leucothoe fontanesiana (axillaris var. editorum). The herb layer may be quite variable from site to site. Some potentially present species include Senecio aureus, Glyceria melicaria, Polygonum punctatum, Claytonia virginica, Conium maculatum, Solidago spp., Trillium spp., Arisaema triphyllum, Chamaelirium luteum, and Viola spp.

Dynamics: Flood-carried sediment undoubtedly provides some nutrient input to these communities, as well as serving as a natural disturbance factor. Forests may be eroded or disturbed by catastrophic floods, sometimes frequently enough to remain in early succession. Beavers may create impoundments which will give way to successional forest.

Range: Throughout the mountain region except in the lower valleys.

Associations: May grade to Rich or Acidic Cove Forest in unflooded areas, or to Montane Oak-Hickory Forest or other communities on drier slopes. May grade to Swamp Forest-Bog Complex or Southern Appalachian Bog on more poorly drained sites.

Distinguishing Features: Montane Alluvial Forests may be distinguished from Piedmont/Low Mountain Alluvial Forests in the Mountain region by their relatively high elevation and differences in species composition. Montane Alluvial Forests lack, or almost lack, characteristic Piedmont alluvial trees such as Liquidambar styraciflua, Acer negundo, Fraxinus pennsylvanica, Ulmus americana, and Ulmus alata. Many of the typical dominants are characteristically montane species such as Tsuga canadensis, Betula alleghaniensis, and Betula lenta. They frequently have a dense ericaceous shrub layer of Rhododendron maximum or Leucothoe fontanesiana. The ideal place for the boundary between the Montane and Piedmont/Low Mountain Alluvial Forest types is not clear. Many sites on the French Broad River appear to be intermediate, with some of both montane and piedmontane elements.

Montane Alluvial Forests may be distinguished from Acidic Cove Forests by the occurrence of flooding and by the significant presence of alluvial species such as Platanus occidentalis, Betula nigra, Carpinus caroliniana, Salix spp., and Alnus serrulata.

Montane Alluvial Forests may be distinguished from Swamp Forest-Bog Complexes by the lack of boggy openings containing Sphagnum and bog herb species.

Variation: Elevation, flooding frequency, and drainage are the factors most likely determining variation within and among sites.

Comments: This type and the Piedmont/Low Mountain Alluvial Forest type were included in a single Piedmont/Mountain Alluvial Forest type in the Second Approximation. They are separated based on the climatic differences related to elevation and the difference in species that results from it. The steeper gradients and higher rainfall of montane areas also results in different flooding regimes, with more intense but shorter-duration floods. Rivers in the larger, lower valleys and basins of the mountain region appear to be more similar to those in the Piedmont and are included in the Piedmont/Low Mountain Alluvial Forest type. Many sites on the French Broad, and possibly other large mountain rivers, appear to be somewhat intermediate. Montane Alluvial Forests are also closely related floristically to the Acidic Cove Forest type.

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 were generally the first areas to be cleared for farming and to become sites for houses, towns, highways, and reservoirs.

Rare Plant Species: None known.

Synonyms:
Bottomland, floodplain (general usage).
Piedmont/Mountain Alluvial Forest (Second Approximation).

Examples:
Broad River Natural Area, Buncombe County (Heiman and Smith in prep.).
Celo Community Natural Area, Yancey County (McLeod 1988; McLeod, pers. comm. 1989).
Upper Cane River, Yancey County (McLeod, pers. comm. 1989).
Sandy Bottom Natural Area, French Broad River, Buncombe County.

References: Heiman and Smith (in prep.), McLeod (1988).

Sample Plant Communities: None listed.

SWAMP FOREST-BOG COMPLEX (Typic Subtype)

Sites: Poorly drained bottomlands, generally with visible microtopography of ridges and sloughs or depressions.

Soils: Alluvial soils. Generally mapped as Toxoway (Cumulic Humaquept) or Wehadkee (Typic Fluvaquent).

Hydrology: Palustrine, seasonally to semipermanently saturated. Flooding frequency is unknown. Seepage is sometimes present.

Vegetation: Forest with closed or open canopy and open or dense shrub layer, interspersed with small boggy openings in depressions. Tsuga canadensis or Acer rubrum are usually the dominant trees. Other trees include Salix nigra, Betula lenta, B. alleghaniensis (lutea), Quercus alba, Pinus strobus, and various other alluvial species. The dominant shrubs are usually Rhododendron maximum, Kalmia latifolia, and Leucothoe fontanesiana (axillaris var. editorum). Other common shrubs include Salix sericea, Alnus serrulata, Ilex montana, Cornus amomum, Viburnum nudum var. cassinoides, and Toxicodendron (Rhus) vernix. Herbs in boggy openings include Solidago patula, Aster novae-angliae, Dalibarda repens, Osmunda cinnamomea, Carex folliculata, C. gynandra, C. scabrata, C. leptalea, C. stricta, Sarracenia purpurea, Sagittaria latifolia var. pubescens, and Leersia virginica. Herbs in the forest include Glyceria melicaria, Lycopodium obscurum, Onoclea sensibilis, Maianthemum canadense, Thelypteris noveboracensis, and Osmunda regalis var. spectabilis.

Dynamics: The factors responsible for creating and maintaining these communities are not well known. Gaddy (1981) suggested they were caused by paludification following tree blowdown or logging in wet alluvial forests. However, some examples appear to be very old, and most logged bottomlands do not contain boggy vegetation. The boggy openings are generally associated with small depressions. They may be successional remnants of once more extensive bog areas. As in Southern Appalachian Bogs, beaver activities may be a significant factor in these communities.

The frequency and role of flooding in these communities is not known. They often occur near streams and undoubtedly are periodically flooded. Some occur near the outer edge of floodplains and also receive seepage water. Others may receive seepage water flowing through Southern Appalachian Bogs.

Range: Scattered throughout the Mountains.

Associations: Sometimes associated with Southern Appalachian Bog (either subtype). May grade to Montane Alluvial Forest, Acidic Cove Forest, or various upland forests.

Distinguishing Features: Swamp Forest-Bog Complexes are distinguished from Southern Appalachian Bogs by their structure, which consists primarily of forested thickets with only small boggy openings. Boggy areas are less than one acre in size. Swamp Forest-Bog Complexes are distinguished from Montane Alluvial Forests and Acidic Cove Forests by being wetter, having open boggy vegetation in small depressions, and having scattered Sphagnum mats. The Floodplain Pool type occurs in deeper bottomland depressions, containing standing water for much or all of the year, and lacking dense boggy vegetation.

The Typic Subtype may be distinguished from the Spruce Subtype by the composition of the forest canopy, which consists of Tsuga canadensis, Acer rubrum, and other lower elevation trees but not of Picea rubens.

Variation: Examples vary with elevation and hydrology. Sites may especially be expected to vary in the relative amounts of closed forest, shrubby openings, and boggy openings. Dominance by Acer rubrum vs. Tsuga canadensis may indicate significant environmental and community differences.

Comments: The classification of mountain boggy wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. Inventory work currently in progress may provide additional information on the variety of these communities.

Because of the scarcity of flat, wet sites in the mountains, these communities are inherently rare. Their occurrence in accessible, low elevation sites that have long been subject to draining, impoundment, and clearing for pasture, has made them extremely rare.

Rare Plant Species: Vascular -- Caltha palustris, Carex bullata, Carex cristatella, Dalibarda repens, Dryopteris carthusiana, Dryopteris cristata, Galium asprellum, Helonias bullata, Listera australis, Platanthera peramoena, Rhododendron vaseyi, Sagittaria fasciculata, Thalictrum macrostylum.

Synonyms:
Forest Gap Bog Complex (Gaddy 1981).
Bog, swamp (general usage).

Examples:
Ochlawaha Bog, Henderson County.
Panthertown Valley, Nantahala National Forest, Jackson County.
Nantahala and Big Indian Creek Bogs, Nantahala National Forest, Macon County (Gaddy 1981).
Tulula Bog, Graham County (Gaddy 1981).
Etowah Swamp, Henderson County (Wickland and Horton 1978).

References: Boufford and Wood (1975), Gaddy (1981), Govus (1985), Pittillo (1974), Sutter (1979), Wickland and Horton (1977).

Sample Plant Communities:
Tsuga canadensis-Acer rubrum/Maianthemum canadense.
Acer rubrum/Mixed shrubs/Mixed herbs.
Tsuga canadensis-Acer rubrum/Rhododendron maximum.
Betula lenta-Tsuga canadensis/Rhododendron maximum.
Mixed bog sedges/Sphagnum spp.
Mixed bog herbs/Sphagnum spp.
Carex folliculata/Sphagnum spp.
Glyceria spp.

SWAMP FOREST-BOG COMPLEX (Spruce Subtype)

Sites: Poorly drained bottomlands at high elevation.

Soils: Wet alluvial soils. Mapped as the Toxaway series (Cumulic Humaquept).

Hydrology: Palustrine. Seasonally to semipermanently saturated. Flooding frequency is not known. Some areas may receive groundwater seepage.

Vegetation: Forest with closed or open canopy and open or dense shrub layer, interspersed with small, open, boggy patches in slight depressions. Picea rubens is the dominant tree, with Tsuga canadensis, Betula alleghaniensis (lutea), Acer rubrum, Amelanchier arborea, and other species sometimes present. A dense shrub layer of Rhododendron maximum and Kalmia latifolia is usually present. Other shrubs may include Ilex verticillata, Ilex collina, Taxus canadensis, Viburnum nudum var. cassinoides, Aronia (Sorbus) melanocarpa, and Vaccinium spp. Herbs are generally sparse under the canopy but may be dense in openings. Species include Glyceria melicaria, Osmunda cinnamomea, O. regalis var. spectabilis, Maianthemum canadense, and various species of the Southern Appalachian Bog type. Sphagnum patches may occur scattered beneath the canopy as well as in small depressions.

Dynamics: The factors responsible for creating and maintaining these communities are not well known. Occurrence of spruce at unusually low elevations and the occurrence of northern disjunct species suggests that they are relicts from the Pleistocene glacial period, persisting in specialized environments. They may, however, represent a late stage of primary succession from more extensive open bogs.

Range: Several examples scattered in the Mountains.

Associations: Associated with Southern Appalachian Bog, Swamp Forest-Bog Complex (Typic Subtype), and upland communities, particularly Northern Hardwood Forest (Typic Subtype).

Distinguishing Features: Swamp Forest-Bog Complexes are distinguished from Southern Appalachian Bogs by their structure, which consists primarily of forested thickets with only small boggy openings. Boggy areas are less than one acre in size. They are distinguished from Red Spruce Forests by being wetter and having boggy openings and scattered Sphagnum mats. They also are generally at somewhat lower elevation than Red Spruce Forest. The Spruce subtype may be distinguished from the Typic Subtype by the composition of the forest, with Picea rubens as the dominant tree.

Variation: Not known.

Comments: This subtype is newly distinguished from the typic subtype, because of the unusual northern and high elevation disjunct species. It is extremely rare.

The classification of mountain boggy wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. Inventory work currently in progress by Smith (In prep.) may provide additional information on the variety of these communities.

Rare Plant Species: Vascular -- Carex trisperma, Ilex collina, Taxus canadensis.

Synonyms:
Spruce swamp.

Examples:
Long Hope Valley, Ashe and Watauga counties (Weakley in prep.) (an extensive, well-developed example).
Alarka Laurel (Govus 1986) (a small, apparently marginal example).

References: Govus (1985), Weakley (in prep.).

Sample Plant Communities:
Picea rubens/Rhododendron maximum.
Picea rubens/Rhododendron maximum/Taxus canadensis.
Picea rubens/Kalmia latifolia-Rhododendron maximum.

SOUTHERN APPALACHIAN BOG (Northern Subtype)

Sites: Flat or gently sloping areas, generally in valley bottoms that are not subject to flooding.

Soils: Wet organic or mucky mineral soils, very acidic. Most bog soils are mapped as the Toxaway (Cumulic Humaquept), Wehadkee (Typic Fluvaquent), or Hatboro (Typic Fluvaquent) series.

Hydrology: Palustrine, permanently saturated to intermittently dry. Generally fed by seepage water.

Vegetation: A mosaic or zoned pattern of shrub thickets and herb dominated areas, much of it underlain by Sphagnum mats. Trees such as Acer rubrum, Pinus strobus, Tsuga canadensis, Pinus rigida, and Picea rubens may be scattered throughout or may dominate on the edges. Shrubs may include Alnus serrulata, Rosa palustris, Salix sericea, Aronia (Sorbus) arbutifolia, Rhododendron maximum, Rhododendron viscosum, Kalmia latifolia, Kalmia carolina, Hypericum densiflorum, Lyonia ligustrina, Ilex verticillata, Ilex collina, Spiraea tomentosa, Spiraea alba, and Menziesia pilosa. The herb layer may include Carex leptalea, C. folliculata, C. gynandra, C. atlantica, C. echinata, Rhynchospora alba, R. capitellata, Scirpus expansus, S. cyperinus, Osmunda cinnamomea, O. regalis var. spectabilis, Solidago patula, Senecio aureus, Thelypteris palustris, Juncus effusus, Juncus subcaudatus, Lilium grayi, Lysimachia terrestris, Vaccinium macrocarpon, Eriophorum virginianum, Parnassia asarifolia, Saxifraga pensylvanica, Sagittaria latifolia var. pubescens, and Orontium aquaticum. Sphagnum species include S. palustre, S. imbricatum, S. bartlettianum, S. recurvum, and, rarely, northern disjuncts such as S. warnstorfii, S. fallax, S. russowii, S. subsecundum sensu stricto, S. angustifolium, S. subtile, and S. flexuosum. Other important bryophytes include Polytrichum commune, Mnium appalachianum, Aulacomnium palustre, and Bazzania trilobata.

Dynamics: The factors responsible for creating and maintaining these communities are not well known. Grazing has been nearly universal in bogs, and few examples exist in pristine condition. Most examples are experiencing invasion or increase of shrubs or trees at the expense of herbaceous zones. This invasion threatens to completely close the bogs and eliminate many of the herbaceous species. While bogs may be undergoing primary succession that will eventually lead to a forest community, there is no reason to expect this process to proceed so rapidly in recent decades after much longer periods of continued existence. The tendency toward rapid succession suggests that some form of periodic or chronic natural disturbance, now disrupted, may have kept the bogs open. Potential disturbances include flooding by beavers, grazing by herds of large mammals, fire, and clearing by Indians. An alternative hypothesis is that the unfavorable environment and competition from established herbaceous vegetation originally limited tree and shrub establishment, but recent modification has changed these conditions. Modifications of potential importance include heavy grazing, ground water pumping, and increased nutrient input.

Range: Scattered in the Mountains north of the Asheville basin. In addition, a few high elevation sites south of the Asheville Basin are included in this subtype.

Associations: Often associated with Swamp Forest-Bog Complex, with the Swamp Forest-Bog Complex occurring nearer the stream and the Southern Appalachian Bog farther away. May grade to Montane Alluvial Forest, Acidic Cove Forest, or various upland forests.

Distinguishing Features: Southern Appalachian Bogs are distinguished from Swamp Forest-Bog Complex by their structure. Southern Appalachian Bogs are concentrically or patchily zoned, with herbs or shrubs dominating in the interior. Swamp Forest-Bog Complexes contain small areas of boggy vegetation in a matrix of forest. When both types occur together, Sphagnum-dominated areas greater than one acre in size should be considered Southern Appalachian Bogs.

The Southern Appalachian Bog type is distinguished from the Southern Appalachian Fen type by species composition, which is correlated with pH. Distinguishing species include several northern fen indicators such as Muhlenbergia glomerata, Tofieldia glutinosa, and Sphagnum subsecundum (sensu stricto). As defined, the only known Southern Appalachian Fen is at Bluff Mountain. A few bogs, occurring over hornblende-rich rocks, have fen-like zones in the center, but the bulk of the area is bog-like.

The distinction between Southern Appalachian Bogs and High Elevation Seeps is not well defined. In general, High Elevation Seeps occur on upper slopes or ridgetops, while Southern Appalachian Bogs occur on non-flooded bottomlands or

slope bases. Southern Appalachian Bogs tend to be larger, to have well developed Sphagnum mats, and to have a definite organic layer. Seeps tend to be more dominated by forbs, rather than by graminoids and shrubs.

The Northern Subtype is distinguished from the Southern Subtype by floristic differences that correlate with geography. The geographic boundary is generally at the Asheville Basin, although a few high elevation examples farther south are of the Northern Subtype. The Northern Subtype has a number of northern disjunct species, while the Southern Subtype often contains species typical of the Coastal Plain. Species which occur in the Northern Subtype but are absent in the Southern include Carex trisperma, C. buxbaumii, Rhynchospora alba, Vaccinium macrocarpon, Saxifraga pensylvanica, and Species which occur in the Southern subtype but are absent in the north include Sarracenia jonesii, Sarracenia purpurea, Sarracenia oreophila, Smilax laurifolia, Viburnum nudum var. nudum, Rhododendron arborescens, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Woodwardia virginica, and Woodwardia areolata.

Variation: Varies with wetness and amount of organic matter accumulation, both within and among sites. Open areas tend to be more diverse than shrub-dominated areas. Some high elevation sites have northern bog species such as Vaccinium macrocarpon and the northern Sphagnum species listed above. Nutrient status also modifies species composition and aspect, with some bogs (such as Celo Bog and some of the Long Hope Valley bogs) approaching the Southern Appalachian Fen category in nutrients and species composition.

Comments: In many classifications of mires, this type would be considered a poor fen, because it generally receives groundwater seepage. It has here been called a "bog" to conform to common usage and to suggest its strongly acid, Sphagnum-dominated vegetation, in opposition to the Southern Appalachian Fen, which is higher in pH and nutrient status, and has a predominance of sedges and a poor Sphagnum flora.

The classification of mountain boggy wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. Inventory work currently in progress by Smith (In prep.) may provide additional information on the variety of these communities.

Because of the scarcity of flat, wet sites in the mountains, these communities are inherently rare. Their occurrence in accessible, low elevation sites that have long been subject to draining, impoundment, and clearing for pasture, have made them extremely rare.

The Marsh-Bog Complex of the Second Approximation has been combined with the Southern Appalachian Bog type here. The two categories have proved difficult to use, and a number of areas initially classified as Marsh-Bog Complex have been reclassified as Southern Appalachian Bog. Although much remains unknown about these communities, it appears that many of the characteristics which distinguish the Marsh-Bog Complex type result from disturbances such as intensive grazing.

Rare Plant Species: Vascular -- Arethusa bulbosa, Arisaema triphyllum ssp. stewardsonii, Botrychium oneidense, Caltha palustris, Campanula aparinoides, Carex baileyi, Carex bromoides, Carex bullata, Carex buxbaumii, Carex echinata ssp. echinata, Carex oligosperma, Carex projecta, Carex ruthii, Carex trisperma, Chelone cuthbertii, Cladium mariscoides, Dryopteris carthusiana, Dryopteris cristata, Epilobium ciliatum, Epilobium leptophyllum, Eriophorum virginicum, Filipendula rubra, Galium asprellum, Geum aleppicum, Geum laciniatum, Glyceria laxa, Hierochloe odorata, Hypericum frondosum, Ilex collina, Juncus gymnocarpus, Lilium canadense var. canadense, Lilium canadense var. editorum, Lilium grayi, Lonicera canadensis, Lonicera dioica, Lycopodiella inundata, Lygodium palmatum, Menyanthes trifoliata, Parnassia asarifolia, Platanthera grandiflora, Poa paludigena, Rhynchospora alba, Sanguisorba canadensis, Saxifraga pensylvanica, Spiraea alba var. alba, Spiraea alba var. latifolia, Taxus canadensis, Thelypteris simulata, Tofieldia glutinosa, Utricularia cornuta, Utricularia minor, Veronicastrum virginicum; nonvascular -- Dicranum undulatum, Sphagnum angustifolium, Sphagnum fallax, Sphagnum flexuosum, Sphagnum subsecundum var. subsecundum, Sphagnum warnstorfii, Splachnum pennsylvanicum.

Synonyms:
Poor fen.

Examples:
Long Hope Valley bogs, Watauga and Ashe counties (Phillips 1975, Weakley in prep.) (extensive complex of 20-30 bogs).
Invershiel (Linville Gap) Bog, Avery County (Scott).

Pineola Bog, Avery County.
Celo Bog, Yancey County (McLeod 1983, McLeod and Croom 1983, McLeod 1988).
Flat Laurel Gap Bog, Blue Ridge Parkway, Haywood County (Horton and Hotaling 1981, Shafer 1984, Shafer 1986).
Boone Fork Bog, Hoot Camp Branch Bog, Sims Creek Bog, Blue Ridge Parkway, Watauga County.
Sparta Bog, Alleghany County (Smith in prep.).
Beech Creek Bog, Watauga County.
Sugar Mountain Bogs, Avery County.

References: Horton and Hotaling (1981), McLeod (1983), McLeod (1988), McLeod and Croom (1983), Scott (n.d.), Shafer (1984), Shafer (1986), Smith (in prep.), Weakley (in prep.).

Sample Plant Communities (zones):
Acer rubrum/Alnus serrulata-mixed shrubs/Glyceria melicaria-Carex intumescens/feather mosses.
Mixed shrubs/Osmunda cinnamomea/Juncus gymnocarpus/feather mosses.
Hypericum densiflorum/Sanguisorba canadensis/Carex folliculata-mixed sedges/Sphagnum spp.
Osmunda cinnamomea/Filipendula rubra-Aconitum uncinatum/Chelone spp./feather mosses.
Osmunda regalis var. spectabilis/Solidago patula/Dichanthelium (Panicum) dichotomum/Sphagnum spp.
Solidago patula/Rubus hispidus/Sphagnum spp.
Mixed sedges-Vaccinium macrocarpon/Sphagnum spp.
Vaccinium macrocarpon/Sphagnum spp.
Mixed heath shrubs/Mixed sedges and forbs/Sphagnum spp.
Mixed bog shrubs.
Rhynchospora capitellata.
Rhododendron maximum.

SOUTHERN APPALACHIAN BOG (Southern Subtype)

Sites: Flat or gently sloping areas, generally in valley bottoms that are not subject to flooding.

Soils: Wet organic or mucky mineral soils, very acidic. Most bog soils are mapped as the Toxaway (Cumulic Humaquept), Wehadkee (Typic Fluvaquent), or Hatboro (Typic Fluvaquent) series.

Hydrology: Palustrine, permanently saturated to intermittently dry. Generally fed by seepage water.

Vegetation: A mosaic or zoned pattern of shrub thickets and herb dominated areas, much of it underlain by Sphagnum mats. Trees such as Acer rubrum, Pinus strobus, Tsuga canadensis, and Pinus rigida, may be scattered throughout or may dominate on the edges. Shrubs may include Alnus serrulata, Rosa palustris, Salix sericea, Aronia (Sorbus) arbutifolia, Rhododendron maximum, R. viscosum, R. arborescens, Viburnum nudum var. nudum, V. nudum var. cassinoides, Kalmia latifolia, Kalmiz carolina, Hypericum densiflorum, Lyonia ligustrina, Ilex verticillata, Spiraea tomentosa, Spiraea alba, and Menziesia pilosa. The herb layer may include Carex leptalea, C. echinata, C. folliculata, C. gynandra, Scirpus polyphyllus, S. cyperinus, Osmunda cinnamomea, O. regalis var. spectabilis, Solidago patula, Senecio aureus, Thelypteris palustris var. pubescens, Juncus effusus, Drosera rotundifolia, Woodwardia virginica, Woodwardia areolata, Dulichium arundinaceum, Sarracenia purpurea, Eriophorum virginianum, and Parnassia asarifolia. Sphagnum species include S. palustre, S. imbricatum, S. bartlettianum, and S. recurvum.

Dynamics: The factors responsible for creating and maintaining these communities are not well known. Grazing has been nearly universal in bogs, and few examples exist in pristine condition. Most examples are experiencing invasion or increase of shrubs or trees at the expense of herbaceous zones. This invasion threatens to completely close the bogs and eliminate many of the herbaceous species. While bogs may be undergoing primary succession that will eventually lead to a forest community, there is no reason to expect this process to proceed so rapidly in recent decades after much longer periods of continued existence. The tendency toward rapid succession suggests that some form of periodic or chronic natural disturbance, now disrupted, may have kept the bogs open. Potential disturbances include flooding by beavers, grazing by herds of large mammals, fire, and clearing by Indians. An alternative hypothesis is that the unfavorable environment and competition from established herbaceous vegetation originally limited tree and shrub establishment, but recent modification has changed these conditions. Modifications of potential importance include heavy grazing, ground water pumping, and increased nutrient input.

Range: Scattered in the mountains south of the Asheville basin. The greatest concentration is in Henderson County.

Associations: Often associated with Swamp Forest-Bog Complex, with the Swamp Forest-Bog Complex occurring nearer the stream and the Southern Appalachian Bog farther away. May grade to Montane Alluvial Forest, Acidic Cove Forest, or various upland forests.

Distinguishing Features: Southern Appalachian Bogs are distinguished from Swamp Forest-Bog Complex by their structure. Southern Appalachian Bogs are concentrically or patchily zoned, with herbs or shrubs dominating in the interior. Swamp Forest-Bog Complexes contain small areas of boggy vegetation in a matrix of forest. When both types occur together, Sphagnum-dominated areas greater than one acre in size should be considered Southern Appalachian Bogs.

The Southern Appalachian Bog type is distinguished from the Southern Appalachian Fen type by species composition, which is correlated with pH. Distinguishing species include several northern fen indicators such as Muhlenbergia glomerata, Tofieldia glutinosa, and Sphagnum subsecundum (sensu stricto). As defined, the only known Southern Appalachian Fen is at Bluff Mountain. A few bogs, occurring over hornblende-rich rocks, have fen-like zones in the center, but the bulk of the area is bog-like.

The distinction between Southern Appalachian Bogs and High Elevation Seeps is not well defined. In general, High Elevation Seeps occur on upper slopes or ridgetops, while Southern Appalachian Bogs occur on non-flooded bottomlands or slope bases. Southern Appalachian Bogs tend to be larger, to have well developed Sphagnum mats, and to have a definite organic layer. Seeps tend to be more dominated by forbs, rather than by graminoids and shrubs.

The Southern Subtype is distinguished from the Northern Subtype by floristic differences that correlate with geography.

The geopgraphic boundary is generally at the Asheville Basin, although several high elevation examples farther south are of the Northern Subtype. The Northern Subtype has a number of northern disjunct species, while the Southern Subtype often contains species typical of the Coastal Plain. Species which occur in the Northern Subtype but are absent in the Southern include Carex trisperma, C. buxbaumii, Rhynchospora alba, Vaccinium macrocarpon, and Saxifraga pensylvanica. Species which occur in the Southern Subtype but are absent in the north include Sarracenia jonesii, Sarracenia purpurea, Sarracenia oreophila, Smilax laurifolia, Viburnum nudum var. nudum, Rhododendron arborescens, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Woodwardia virginica, and Woodwardia areolata.

Variation: Varies with wetness, amount of organic matter accumulation, elevation, and nutrient status, both within and among sites. Open areas will tend to be more diverse than shrub-dominated areas.

Comments: In many classifications of mires, this type would be considered a poor fen, because it generally receives groundwater seepage. It has here been called a "bog" to conform to common usage and to suggest its strongly acid, Sphagnum-dominated vegetation, in opposition to the Southern Appalachian Fen, which is higher in pH and nutrient status, and has a predominance of sedges and a poor Sphagnum flora.

The classification of mountain boggy wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. Inventory work currently in progress by SMith (In prep.) may provide additional information on the variety of these communities.

Because of the scarcity of flat, wet sites in the mountains, these communities are inherently rare. Their occurrence in accessible, low elevation sites that have long been subject to draining, impoundment, and and clearing for pasture, have made them extremely rare.

The Marsh-Bog Complex of the Second Approximation has been combined with the Southern Appalachian Bog type here. The two categories have proved difficult to use, and a number of areas initially classified as Marsh-Bog Complex have been reclassified as Southern Appalachian Bog. Although much remains unknown about these communities, it appears that many of the characteristics which distinguish the Marsh-Bog Complex type result from disturbances such as intensive grazing.

Rare Plant Species: Vascular -- Arethusa bulbosa, Arisaema triphyllum ssp. stewardsonii, Campanula aparinoides, Carex barrattii, Carex bullata, Carex collinsii, Carex echinata ssp. echinata, Carex ruthii, Carex schweinitzii, Chelone cuthbertii, Coreopsis gladiata, Dryopteris cristata, Epilobium ciliatum, Epilobium leptophyllum, Eriophorum virginicum, Galium asprellum, Glyceria laxa, Helenium brevifolium, Helonias bullata, Juncus gymnocarpus, Juncus torreyi, Lilium canadense var. editorum, Lygodium palmatum, Marshallia grandiflora, Myrica gale, Narthecium americanum, Oenothera perennis, Parnassia asarifolia, Pedicularis lanceolata, Platanthera flava var. herbiola, Platanthera integrilabia, Platanthera peramoena, Sagittaria fasciculata, Sanguisorba canadensis, Sarracenia jonesii, Sarracenia oreophila, Scleria minor, Scleria reticularis var. reticularis, Stachys eplingii, Thalictrum macrostylum; nonvascular -- Schlotheimia lancifolia, Splachnum pennsylvanicum.

Synonyms:
Poor fen.

Examples:
Etowah Bog and other bog remnants near Hendersonville, Henderson County (Gaddy 1981c, Lynch 1980).
Dulany Bog, Jackson County (Floyd 1974).
Panthertown Valley bogs, Nantahala National Forest, Jackson County.
Whiteoak Bottom and Hurricane Creek Bog, Nantahala National Forest, Macon County.

References: Boufford and Wood (1975), Floyd (1974), Gaddy (1981c), Lynch (1980), Sutter (1979).

Sample Plant Communities (zones):
Mixed grasses and sedges/Sphagnum spp.
Mixed sedges/Sphagnum spp.
Carex spp./Sphagnum spp.
Osmunda cinnamomea.

Rhododendron maximum.
Mixed heath shrubs.
Salix sericea.
Alnus serrulata-Rosa palustris/Sphagnum spp.

SOUTHERN APPALACHIAN FEN

Sites: Flat or gently sloping areas that are not subject to flooding and are fed by flow of mineral rich circumneutral or only mildly acidic water.

Soils: Mucky soil over shallow bedrock. Mapped as Toxaway (Cumulic Humaquept) but almost certainly a different, undefined series.

Hydrology: Palustrine, semipermanently to permanently saturated, fed by seepage water of relatively high pH.

Vegetation: A complex of zones of herbaceous wetland vegetation depending on small variations in hydrology and substrate. Species dominant in one or more of the zones include: Rhynchospora alba, R. capitellata, Juncus subcaudatus, Cladium mariscoides, Carex stricta, Helenium autumnale, Schizachyrium (Andropogon) scoparium, Sanguisorba canadensis, and Solidago glomerata. Other characteristic species include Huperzia (Lycopodium) selago, Solidago uliginosa, Eriophorum virginicum, Houstonia caerulea, Utricularia cornuta, Osmunda cinnamomea, Osmunda regalis var. spectabilis, Liatris aspera, Muhlenbergia glomerata, Tofieldia glutinosa, Carex conoidea, Carex buxbaumii, and Parnassia grandifolia. Occasional Alnus serrulata and other wetland shrubs occur. Characteristic bryophytes include Sphagnum subsecundum (sensu stricto), Rhytidium rugosum, Hypnum pratense, Campylium stellatum, Calliergon cordifolium, and Calliergonella cuspidata.

Dynamics: Because of the complex zonation, small changes in drainage or water supply could cause major shifts in vegetation. The natural factors that prevent succession to woody cover are not known. Shrubs appear to be invading the northwest margin of the fen on Bluff Mountain.

Range: The only known well-developed example is on Bluff Mountain.

Associations: The known example is associated with High Elevation Mafic Glade, High Elevation Red Oak Forest, and Northern Hardwood Forest (Typic Subtype).

Distinguishing Features: The Southern Appalachian Fen type is distinguished from the Southern Appalachian Bog type by species composition, which is apparently correlated with pH. Distinguishing species include several northern fen indicators: Muhlenbergia glomerata, Tofieldia glutinosa, and Sphagnum subsecundum (sensu stricto). As defined, the only known Southern Appalachian Fen is at Bluff Mountain. A few bogs, occurring over hornblende-rich rocks, have fen- like zones in the center, but the bulk of the area is bog-like.

Variation: Complex vegetation zonation, as described above.

Comments: Southern Appalachian Fens are caused by the seepage of nutrient-rich, circumneutral waters, a situation rare in North Carolina. In many classifications of mires, all or almost all Southern Appalachian Bogs would also be considered poor fens because they receive groundwater seepage. However, because of the acidity of the prevailing Southern Appalachian rocks, most are strongly acid, Sphagnum-dominated, and contain primarily bog species.

Bluff Mountain is the only well developed Southern Appalachian Fen, but several other sites, particularly some of the bogs in Long Hope Valley and Celo Bog, show partial relationship to the Bluff Mountain Fen in nutrient status and species composition. Undiscovered small fens may exist but none as large as Bluff Mountain are likely. Fens in other parts of the United States may be similar in some ways but should not be considered the same natural community type because of their different climate and different origins.

Rare Plant Species: Vascular -- Carex buxbaumii, Carex conoidea, Carex oligosperma, Cladium mariscoides, Eriophorum virginicum, Huperzia selago, Laiatris aspera, Lilium grayi, Muhlenbergia glomerata, Parnassia grandifolia, Rhynchospora alba, Sanguisorba canadensis, Senecio pauperculus, Solidago uliginosa, Tofieldia glutinosa, Utricularia cornuta; nonvascular -- Campylium stellatum, Cephaloziella hampeana, Cladonia psoromica, Sphagnum subsecundum var. subsecundum.

Synonyms:

None known.

Examples:
Bluff Mountain Preserve (Weakley, Mehrhoff, and Mansberg 1979, Tucker 1967) (the only known example, though a few other bog sites show transition toward this type).

References: Mowbray and Schlesinger (1988), Tucker (1967), Weakley, Mehrhoff, and Mansberg (1979).

Sample Plant Communities:
Schizachyrium (Andropogon) scoparium/Mixed mosses.
Carex stricta.
Cladium mariscoides.
Cladium mariscoides/Carex stricta.
Helenium autumnale-Schizachyrium scoparium-Carex stricta.
Juncus subcaudatus/Rhynchospora capitellata/Rhynchospora alba.
Osmunda regalis var spectabilis.
Oxypolis rigidior-Liatris aspera/Houstonia caerulea-Mixed mosses.
Rhynchospora alba.
Sanguisorba canadensis.
Sanguisorba canadensis/Carex stricta.
Sanguisorba canadensis/Eleocharis tenuis.
Sanguisorba canadensis-Solidago glomerata/Rhynchospora capitellata-Sedge sp.

HIGH ELEVATION SEEP

Sites: High elevation sites, generally sloping, receiving nearly constant (or at least, regular) seepage.

Soils: Rocky, gravelly, or mucky soils. Generally too small to be distinguished on soil surveys.

Hydrology: Palustrine, permanently saturated to intermittently dry.

Vegetation: Generally an open to dense bed of wetland herbs. Seeps are often small enough that they may be substantially shaded by trees rooted in adjacent communities, but some are extensive and open. Herbs include Chelone lyonii, Chelone cuthbertii, Veronica americana, Diphylleia cymosa, Saxifraga micranthidifolia, Saxifraga careyana, Cardamine clematitis, Parnassia asarifolia, Helenium autumnale, Chrysosplenium americanum, Boykinia aconitifolia, Polygonum sagittatum, Drosera rotundifolia, Cicuta maculata, Rhynchospora capitellata, Juncus subcaudatus, Carex leptalea, Carex gynandra, Houstonia serpyllifolia, Aster novae-angliae, Aster puniceus, Impatiens pallida, Impatiens capensis, Hypericum prolificum, H. buckleyi, H. mitchellianum, H. graveolens, Viola cucullata, Viola macloskeyi ssp. pallens, Hydrocotyle americana, Aconitum reclinatum, Hydrophyllum canadense, Monarda didyma, Solidago patula, Lycopus uniflorus, Rudbeckia laciniata, Houstonia serpyllifolia, Veratrum viride, Lilium grayi, Aconitum reclinatum, Thalictrum clavatum, Thalictrum dioicum, and Trautvetteria carolinensis. Sphagnum is often present and may occasionally have significant cover. Woody species include Rhododendron maximum, Kalmia latifolia, Viburnum nudum var. cassinoides, Lyonia ligustrina, and Acer rubrum.

Dynamics: Apparently generally fairly stable, although variations in flow from year to year may cause temporary fluctuations in species dominance.

Range: Scattered in small occurrences throughout the mountains at high elevations; fairly common, but never extensive. Presence is related to strike and dip of metamorphic foliation or fractures in the rocks.

Associations: Grades to various high elevation terrestrial communities.

Distinguishing Features: High Elevation Seeps are distinguished from Boulderfield Forest and other upland communities by being wet enough to lack a closed tree canopy rooted in the community.

The distinction between Southern Appalachian Bogs and High Elevation Seeps is not well defined. In general, High Elevation Seeps occur on upper slopes or ridgetops, while Southern Appalachian Bogs occur on non-flooded bottomlands or slope bases. Southern Appalachian Bogs tend to be larger, to have well developed Sphagnum mats, and to have a definite organic layer. Seeps tend to be more dominated by forbs, rather than by graminoids and shrubs.

High Elevation Seeps are best distinguished from Low Elevation Seeps by the plant species present. Examples are often much more extensive than Low Elevation Seeps, and sometimes have a more bog-like component in them. Only extensive well-developed examples should be considered element occurrences.

Variation: This is currently a very diverse grouping, including a wide variety of small upland wetlands occurring within high elevation mountain communities. Division into subtypes is probably desirable, but further study will be required. Examples vary with underlying rock, topographic position, regularity and amount of seepage, elevation (climate), and soil development. Some examples show gradation to Southern Appalachian Bog.

Comments: The classification of mountain wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. High Elevation Seeps and Southern Appalachian Bogs grade conceptually into each other, although they are seldom associated in the same site.

Rare Plant Species: Vascular -- Aconitum reclinatum, Cardamine clematitis, Carex baileyi, Carex echinata ssp. echinata, Carex oligosperma, Carex ruthii, Chrysosplenium americanum, Conioselinum chinense, Geum geniculatum, Huperzia selago, Juncus gymnocarpus, Lilium grayi, Lycopodiella inundata, Parnassia asarifolia, Parnassia grandifolia, Platanthera flava var. herbiola, Platanthera grandiflora, Platanthera peramoena, Sanguisorba canadensis, Solidago uliginosa, Stellaria corei, Veronica americana, Veronica anagallis-aquatica; nonvascular -- Dicranum undulatum, Sphagnum squarrosum.

Synonyms:
Bog, spring.

Examples:
Roan Mountain, Mitchell County.
Big Yellow Mountain, Avery County (Weakley 1980b).
Hump Mountain, Avery County.
Grandfather Mountain, Avery and Watauga County.
Bluff Mountain, Ashe County.
Andrews Bald, Great Smoky Mountains National Park, Swain County.
Long Hope Valley, Ashe and Watauga counties.
Ivestor Gap Cranberry Seep, Pisgah National Forest, Haywood County.
Fork Ridge Balds and Seeps, Blue Ridge Parkway and Pisgah National Forest, Haywood County (Gaddy 1981b).

References: Gaddy (1981b), Govus (1985), Weakley (1980).

Sample Plant Communities:
Aconitum reclinatum.
Impatiens pallida.
Diphylleia cymosa.
Rudbeckia laciniata.
Sphagnum spp.
Mixed seepage herbs.
Mixed sedges and grasses/Sphagnum.

SPRAY CLIFF

Sites: Vertical to gently sloping rock faces, constantly wet from the spray of waterfalls.

Soils: Small pockets or mats of mineral or organic matter interspersed with bare rock.

Hydrology: Palustrine, permanently saturated by spray, with or without seepage water.

Vegetation: A variable collection of mosses, liverworts, algae, vascular herbs, and occasional shrubs, most of them requiring constantly moist substrate and very high relative humidity. Many of the typical species of this community are bryophytes and ferns disjunct from tropical regions. There are also many endemic bryophytes. Vascular species include Huperzia (Lycopodium) porophila, Asplenium montanum, A. trichomanes, A. rhizophyllum, A. monanthes, Cystopteris protrusa, Polypodium virginianum, Trichomanes boschianum, Grammitis nimbata, Vittaria sp. (gametophyte only), Hymenophyllum (Sphaerocionium) sp. (gametophyte only), Trichomanes sp. (gametophyte only), Phegopteris connectilis (Thelypteris phegopteris), Adiantum pedatum, Saxifraga careyana, S. caroliniana, Heuchera parviflora, Circaea alpina, Impatiens capensis, Houstonia serpyllifolia, Hydrocotyle americana, Thalictrum spp., Oxalis acetosella, Cymophyllus fraseri, Carex biltmoreana, Galax urceolata (aphylla), Tsuga canadensis, Rhododendron maximum, and Kalmia latifolia. Bryophyte species, many of them nearly or entirely limited to this community, include Sphagnum quinquefarium, S. girgensohnii, Mnium carolinianum, M. affine, M. marginatum, Isopterygium distichaceum, Bryocrumia vivicolor (andersonii), Hookeria acutifolia, Thamnobryum alleghaniense, Oncophorus raui, Hyophila involuta, Dichodontium pellucidum, Radula spp., Plagiochila sharpii, P. caduciloba, P. sullivantii, P. austinii, Fissidens osmundioides, Bazzania denudata, Conocephalum conicum, Pellia epiphylla, P. neesiana, and Riccardia multifida.

Dynamics: These communities occur in unusually stable and equitable environments. The humidity is high and moisture supply is essentially constant. Temperatures are moderated by water, rock, and sheltering from sun and wind, resulting in only rare freezes or high temperatures. Potential disturbances include extreme droughts or freezes that may result in some die-off of sensitive species. Floods or rock falls may damage some parts, but in general Spray Cliffs are well sheltered from physical disturbance. They may undergo slow primary succession to forested communities.

Range: Scattered throughout the mountains, rare in the upper Piedmont. Most frequent and best-developed in the southern Blue Ridge Escarpment region of Transylvania and Jackson counties.

Associations: Grades to various cliff and forested upland communities laterally and upslope. Grades to the river or stream below.

Distinguishing Features: Spray Cliffs are distinguished from other cliff communities by their association with waterfalls and their constant or near constant wetness. Other cliff communities may have seepage areas, but the cliff as a whole is dry, is not subject to spray, and is often exposed to low humidty. Spray Cliffs are distinguished from forest communities by being steep, rocky, or wet enough to lack a closed tree canopy.

Variation: Examples vary considerably, depending on amount and dependability of spray, elevation, rock type, orientation of rocks, degree of shading, and past and present climate. Some examples have well developed herb or bryophyte mats, while others are nearly barren. The most diverse Spray Cliffs are found in the Blue Ridge Escarpment gorges of Transylvania, Jackson, and Macon counties.

Comments: This community type is considered distinct from other cliff communities (even those wetted by seepage), because of the very distinctive flora, featuring many endemic or tropically disjunct pteridophytes and bryophytes. Spray Cliffs differ from cliffs with seepage in having a more constant water supply, higher humidity in the air, and a more strongly moderated climate.

Rare Plant Species: Vascular -- Asplenium monanthes, Carex biltmoreana, Grammitis nimbata, Heuchera parviflora, Huperzia porophila, Juncus gymnocarpus, Phegopteris connectilis, Saxifraga caroliniana, Spartina pectinata, Trichomanes

boschianum, Trichomanes petersii; nonvascular -- Acrobolbus ciliatus, Bartramidula cernua, Brachythecium rotaeanum, Bryocrumia vivicolor, Bryoxiphium norvegicum, Bryum riparium, Calypogeia peruviana, Cheilolejeunea evansii, Cirriphyllum piliferum, Dichodontium pellucidum, Drepanocladus fluitans, Drepanolejeunea appalachiana, Encalypta procera, Entodon compressus, Entodon sullivantii, Eurhynchium pringlei, Gymnoderma lineare, Homalia trichomanoides, Homaliadelphus sharpii, Lejeunea blomquistii, Lejeunea cavifolia, Lophocolea appalachiana, Mnium carolinianum, Mylia taylorii, Nardia lescurii, Plagiochila austini, Plagiochila caduciloba, Plagiochila virginica var. caroliniana, Plagiochila virginica var. euryphylla, Porella appalachiana, Sphagnum squarrosum, Taxiphyllum alternans.

Synonyms:
None.

Examples:
Upper Whitewater Falls, Whitewater River, Nantahala National Forest, Jackson and Transylvania counties.
Rainbow Falls and Windy Falls, Horsepasture River, Transylvania County.
Bearwallow Creek Falls, Transylvania County.
Toxaway Creek Falls, Transylvania County.
Rock Creek Falls, Transylvania County.
Auger Fork Falls, Transylvania County.
Dry Falls and Cullasaja Falls, Cullasaja River, Nantahala National Forest, Macon County.
Crow Creek Falls, Cullasaja River gorge, Macon County.
Falls of Joe Bryson Branch, Nantahala National Forest, Macon County.
Camp Branch Falls, Nantahala National Forest, Macon County.
Gorge of the Chattooga River, Nantahala National Forest, Macon and Jackson counties.
Bonas Defeat Gorge, , Nantahala National Forest, Jackson County.
Schoolhouse Falls, Panthertown Valley, Nantahala National Forest, Jackson County.
Tuckasegee Gorge, Jackson County.
Scotsman Creek Falls, Jackson County.
Linville Falls, Blue Ridge Parkway, Burke County.
Upper and Lower Cascade Falls, Hanging Rock State Park, Stokes County.

References: Anderson and Zander (1973), Billings and Anderson (1966), Bruce, Hicks, Van Voorhees, and Yurkovich (n.d.), Dumond (1969), Farrar (1967), Pittillo (1974), Pittillo (1976), Pittillo, Wagner, Farrar, and Leonard (1975), Wagner and Sharp (1963).

Sample Plant Communities: None listed.

UPLAND POOL

Sites: Small upland depressions, in the Piedmont and Mountain regions, where water is ponded by an impermeable substrate.

Soils: These areas are too small to be distinguished in soil mapping and most occur in areas that have not been mapped. The soils generally have a mucky surface layer and have a shallow clay hardpan or rock layer that prevents drainage.

Hydrology: Palustrine, seasonally to semipermanently flooded. Rainfall is apparently the main source of water, although some have small watersheds.

Vegetation: Dominated by various wetland shrubs and herbs. Trees such as Nyssa sylvatica, Quercus phellos, Acer rubrum, and Liquidambar styraciflua may be present on the edge or scattered in the center. Shrub species include Cephalanthus occidentalis, Vaccinium spp., Leucothoe racemosa, and in some areas Cyrilla racemiflora. Herbs include Osmunda regalis, various Carex species, Juncus effusus, and a variety of Sphagnum species, including S. cuspidatum, S. palustre, and S. recurvum.

Dynamics: Apparently stable over long periods, but presumably slowly fill with sediment or organic matter. They may tend to succeed to Upland Depression Swamp Forest in time. An ephemeral drawdown community may occur when water levels drop. Extended droughts may be necessary for establishment of some species.

Range: Known only from very few scattered sites in the Piedmont and Mountains.

Associations: May grade to various upland communities. Sometimes associated with Upland Depression Swamp Forest.

Distinguishing Features: Upland Pools differ from Low Elevation Seeps and Hillside Seepage Bogs by having standing water for significant parts of the year and by being kept wet by poor drainage of rainwater and local runoff rather than by seepage. They usually have a pronounced seasonal fluctuation in water level, filling in the winter and often drying completely in the summer. Although Sphagnum may be present, Upland Pools lack the peaty mats and associated bog species found in Hillside Seepage Bogs. Upland Pools are distinguished from Upland Depression Swamp Forests by a longer hydroperiod and by the lack of a closed or mostly closed tree canopy. Upland Pools near the fall line may share a number of species with the Coastal Plain Small Depression Pond type. In the absence of better knowledge of similarities and differences, the two types are arbitrarily divided at the physiographic province boundary.

Variation: As presently defined this is a heterogeneous and somewhat discordant category which includes a variety of shrub- and herb-dominated "upland wetlands." Factors affecting variation include depth of water, clay or rock substrate, and geographic location. Sites in the Uwharrie Mountains have a number of typically Coastal Plain species, but other sites, including the mountain ones, may also have disjunct Coastal Plain species.

Comments: This type was called Piedmont Hardpan Bog in the Second Approximation. The new name reflects expanded knowledge and greater understanding of these communities. New examples, similar to those on hardpan soils, have been discovered on hard rock substrates. Also, examples have been found in the Blue Ridge. These communities are bog-like only in the sense of being shrubby or open wetlands. They do not have well-developed organic mats and lack most bog species.

This is an extremely rare type, with only a few known examples. These communities are often important breeding habitats for amphibians.

Rare Plant Species: Nonvascular -- Sphagnum pylaesii.

Synonyms:
Piedmont Hardpan Bog (Second Approximation).

Examples:
Donnelley Bog, Chatham County (Weakley 1985).
Pleasant Grove Bog and Roberdo Bog, Uwharrie National Forest, Montgomery County (Matthews 1979).
Linville Mountain Pond, Pisgah National Forest, Burke County.
Shortoff Mountain Pond, Pisgah National Forest, Burke County.
North Fork Watershed Pond, Buncombe County (Heiman and Smith in prep.).

References: Heiman and Smith (in prep.), Matthews (1979), Weakley (1985),

Sample Plant Communities:
Cephalanthus occidentalis/Carex joorii.
Osmunda regalis var. spectabilis.
Dulichium arundinaceum-Polygonum hydropiperoides/Sphagnum lescurii.
Mixed wetland shrubs.
Viburnum nudum var. nudum-Leucothoe racemosa.

UPLAND DEPRESSION SWAMP FOREST

Sites: Poorly drained upland flats or depressions. Usually on broad upland flats but occasionally on high ridge tops.

Soils: Various soils with drainage hindered by a clay hardpan or by shallow rock. Typical series are Iredell (Typic Hapludalt), Misenheimer (Aquic Dystrochrept), Kirksey (Aquic Hapludult), Leaksville (Typic Albaqualf), and Picture (Abruptic Argiaquoll).

Hydrology: Palustrine, seasonally to intermittently flooded or saturated. During dry periods water may be unavailable to plants because of restricted rooting depth and because the impermeable layer has kept the subsoil dry.

Vegetation: Forest canopy usually dominated by Quercus phellos or Q. lyrata. Other trees may be present, including Q. michauxii, Liquidambar styraciflua, Acer rubrum, Liriodendron tulipifera, Nyssa biflora, Quercus bicolor, Carya ovata, and occasional upland trees, particularly Quercus stellata and Carya carolinae-septentrionalis. Shrubs are usually sparse. Species may include Vaccinium fuscatum (atrococcum), V. corymbosum, Cephalanthus occidentalis, Ilex decidua, and Viburnum dentatum. Herbs are usually sparse, with Carex species being most typical. Other species include Glyceria septentrionalis, Juncus effusus, Selaginella apoda, Spiranthes cernua, Eleocharis tenuis, and various bottomland spring ephemerals such as Claytonia virginica. The mosses Climacium americanum and Sphagnum lescurii are often abundant. In disturbed areas, vines, primarily Lonicera japonica, Toxicodendron (Rhus) radicans, Campsis radicans, and Vitis rotundifolia, may proliferate.

Dynamics: These communities are generally stable climaxes, maintained by their hydrology. They may be susceptible to disturbance caused by unusually prolonged flooding or by drought.

Range: Scattered throughout the eastern and central Piedmont and possibly the upper Coastal Plain.

Associations: Typically associated with Xeric Hardpan Forest and Basic Oak-- Hickory Forest but may grade into other upland forest types. Sometimes occurs with Upland Pools.

Distinguishing Features: Upland Depression Swamp Forests are distinguished from Upland Pools by having a closed tree canopy and a shorter hydroperiod. They are distinguished from Hillside Seepage Bogs and Low Elevation Seeps by having ponded rain and runoff water rather than seepage, as well as by different species composition. The boundary with surrounding upland communities is the point at which upland plant species become dominant over wetland species. There are sometimes substantial zones of mixed dominance.

Variation: The canopy dominants are relatively constant but sites may vary in associated species and in the lower strata. Differences in soils, particularly between acidic and circumneutral types, are probably important in determining composition, as is hydroperiod. Frye (1989), however, found no effect of soil chemistry on sites on Iredell soils. He noted that the surface horizons were acidic and that bases in the subsoil were unavailable because of the dryness there caused by low permeability.

Comments: Sites which hold enough standing water seasonally may be important breeding sites for amphibians.

Upland Depression Swamp Forests are part of a characteristic suite of communities on mafic igneous or metamorphic rock, along with Xeric Hardpan Forest and Basic Oak--Hickory Forest. The high base levels in mafic rocks contribute to the formation of montmorillonite clays which inhibit drainage. Upland Depression Swamp Forests also form over acidic shales, and occasionally on harder rocks.

Rare Plant Species: Vascular -- Quercus bicolor.

Synonyms:
Gabbro Depression.
Bottomland hardwoods (in part).

Examples:
Frogsboro Upland Depression Forest, Caswell Game Land, Caswell County.
Providence Flats Swamp, Mecklenburg County.
Badin Upland Depression Swamps, Uwharrie National Forest, Montgomery County (Matthews 1979, Wells 1974).
Uwharrie Mafic Rock Area, Uwharrie National Forest, Montgomery County.
South Butner Diabase Swamp, Granville County.
Goshen Gabbro Forest, Granville County (LeGrand 1986).
Donnelley Bog site, Chatham County (Weakley 1985).
Meadow Flats, Duke Forest, Orange County (Ohmann 1980).

References: Frye (1989), LeGrand (1986), Matthews (1979), Ohmann (1980), Weakley (1985), Wells (1974).

Sample Plant Communities:
Quercus phellos.
Quercus phellos-Q. lyrata.
Q. lyrata.
Carya ovata-Quercus bicolor.
Quercus phellos-Q. bicolor.
Quercus phellos/Sphagnum lescurii.

HILLSIDE SEEPAGE BOG

Sites: Piedmont areas which are constantly saturated by seepage. Small areas on slopes or edges of bottomlands.

Soils: Wet mucky soils. Soils are mapped as Cecil (Typic Hapludult), Colfax (Aquic Fragiudult), and "mixed alluvial" but undoubtedly represent inclusions in these map units.

Hydrology: Palustrine, permanently saturated to intermittently dry.

Vegetation: Often zoned, with an open interior and a forested outer edge. The interior typically has a moderately dense to dense herb layer, dominated by various bog graminoids, forbs, and Sphagnum. Important or notable species include Carex crinita, Carex leptalea, Eriocaulon sp., Sarracenia flava, S. purpurea, Calopogon tuberosus (pulchellus), Osmunda cinnamomea, Oxypolis rigidior, Helenium brevifolium, Senecio aureus, and Orontium aquaticum. Sphagnum species include S. imbricatum, S. lescurii, S. palustre, and S. bartlettianum. Woody plants such as Smilax laurifolia, Alnus serrulata, Viburnum nudum var. nudum, Vaccinium corymbosum, Aronia (Sorbus) arbutifolia, Acer rubrum, and Liriodendron tulipifera are usually present and may become dense. The outer zone is typically dominated by trees such as Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, and Nyssa sylvatica. Herbs there include Osmunda regalis var. spectabilis, Woodwardia virginica, and Mitchella repens, as well as various species from the interior.

Dynamics: Very poorly known. All known bogs are experiencing rapid proliferation of shrubs in the open portions, and many have become so dense as to seriously suppress the herb layer. It is not known what kept the bogs open originally and why they are now succeeding. While many of the plants are fire tolerant and fire undoubtedly occurred more frequently in presettlement times than at present, the wet bog sites do not seem to be particularly fire-prone. All bogs were grazed in the past and it is not known what role this had in creating the present vegetation structure.

Range: Examples are known only from Iredell County and Montgomery County.

Associations: May grade to various upland or bottomland communities. Often occupies sites on the lower slope, between upland and bottomland.

Distinguishing Features: Hillside Seepage Bogs are distinguished from Upland Pools and Upland Depression Swamps by being wetted by seepage; they seemingly vary little in wetness, allowing accumulation of organic matter and plants adapted to such a substrate. They are distinguished from Low Elevation Seeps by the presence of well-developed Sphagnum mats and the importance of bog species. The differences in sites or hydrology that lead to these vegetational differences are not known.

Variation: There are significant differences between bogs in the two counties where they occur. The Montgomery County examples contain more Coastal Plain elements while those in Iredell County contain more mountain elements. There is substantial variation among sites in the same county, but it is not known how much is due to past disturbance history and successional state.

Comments: Hillside Seepage Bogs are a rare and very poorly known community type. The lack of sites in undisturbed condition and the apparent instability of known sites makes these communities difficult to interpret.

We have followed the local tradition of calling these communities bogs although they might more properly be called fens or seeps.

Rare Plant Species: Vascular -- Helenium brevifolium, Xyris baldwiniana.

Synonyms:
Pitcher plant bog.

Examples:
Link (Sloan) Bog, Iredell County (Radford and Martin 1975).
Siceloff Bog, Iredell County (Radford and Martin 1975).

Barnett Hollow (901) Bog, Iredell County (Radford and Martin 1975).
Abner Bog, Uwharrie National Forest, Montgomery County (Matthews 1981).
Black Ankle Bog, Montgomery County (Matthews 1981).

References: Matthews (1981), Radford and Martin (1975).

Sample Plant Communities:
Alnus serrulata/mixed bog herbs/Sphagnum spp.
Mixed bog herbs/Sphagnum spp.
Acer rubrum-Liriodendron tulipifera.

LOW ELEVATION SEEP

Sites: Seepages and springs at bases of slopes or edges of floodplains.

Soils: Saturated, usually mucky, soils. Occurrences are too small to be distinguished in soil surveys.

Hydrology: Palustrine, permanently saturated.

Vegetation: Areas are generally small enough to be partially shaded by canopies of trees rooted in adjacent communities. Occasional wetland trees such as Acer rubrum and Quercus phellos may be rooted in the seep. A variety of wetland herbs occur, including Saururus cernuus, Impatiens capensis, Osmunda cinnamomea, Osmunda regalis, Boehmeria cylindrica, Rudbeckia laciniata, Ranunculus recurvatus, Chelone glabra, Juncus spp., and Saxifraga micranthidifolia. Despite a lack of much standing water, these communities are important breeding as well as foraging sites for amphibians. They are used by species such as the salamanders Eurycea quadridigitata, Pseudotriton ruber, Pseudotriton montanus, and Hemidactylium scutatum and the frogs Hyla crucifer, and Pseudacris triseriata (Alvin Braswell, N.C. Museum of Natural Science, pers. comm.).

Dynamics: Not known. Probably stable over long periods, but respond to changes in groundwater levels resulting from drought.

Range: Fairly common in the Piedmont, lower Mountains, and upper Coastal Plain.

Associations: Grades into floodplain communities such as Piedmont/Mountain Alluvial and Bottomland Forest, or into slope forests such as Mesic Mixed Hardwood Forest.

Distinguishing Features: Well-developed Low Elevation Seeps contrast sharply with adjacent floodplain or upland communities in their vegetation and soils. They are distinguished from Hillside Seepage Bogs by the lack of the assemblage of bog species and from High Elevation Seeps by the lack of significant numbers of high elevation plants. While Sphagnum may be present in Low Elevation Seeps, it is not dominant as it may be in the other two types.

Variation: Not known.

Comments: The communities tend to be small, often being shaded by the canopy of the adjacent communities. They are distinguished because they contrast sharply with the surrounding communities, have distinctive species assemblages, and are repeated in the landscape. Only the larger, well-developed examples should be considered element occurrences.

Rare Plant Species: Vascular -- Cardamine micranthera, Carex oklahomensis, Platanthera peramoena, Saxifraga pensylvanica.

Synonyms:
Spring, seep

Examples:
Little Peters Creek Bittercress Site, Stokes County.
Shallowford Road Bluffs, Yadkin County.
Stony Creek Four-toed Salamander Spring, Duke Forest, Orange County (Sather and Hall 1988).
Poplar Ridge Slopes and Bottom (Sather and Hall 1988).
Examples appear to be fairly frequent but are seldom documented.

References: Baranski (1985), Sather and Hall (1988).

Sample Plant Communities: None listed.

WET MARL FOREST

Sites: Flat or gently sloping poorly drained upland areas with marl or limestone near the surface.

Soils: Wet, relatively high in base saturation. Known series are Invershiel (Albaquic Hapludalf) and Meggett (Typic Albaqualf).

Hydrology: Seasonally to intermittently flooded. Water table perched by clay and marl near the surface and flat topography. Duration of flooding varies with microtopography.

Vegetation: Closed canopy forest of mesic and wetland hardwoods, including Ulmus americana, Morus rubra, Tilia americana var. caroliniana, Carya myristiciformis, Quercus shumardii, Q, alba, Q. lyrata, Q. michauxii, Q. nigra, Q. phellos, Carya aquatica, C. cordiformis, C. glabra, Liquidambar styraciflua, Acer floridanum, A. rubrum, and A. negundo. The subcanopy includes Cercis canadensis, Cornus florida, Asimina triloba, Ostrya virginiana, and Carpinus caroliniana. Shrubs include Cornus asperifolia, Sabal minor, Aesculus pavia, A. sylvatica, Cornus stricta, Viburnum nudum var. nudum, V. prunifolium, and V. recognitum. Typical herbs are Cardamine bulbosa, Dryopteris ludoviciana, Geranium maculatum, Arisaema triphyllum, Asarum canadense, Aristolochia serpentaria, Anemone virginiana, Geum canadense, Polystichum acrostichoides, Phryma leptostachya, Circaea lutetiana ssp. canadensis, Cryptotaenia canadensis, Melica mutica, Sanicula canadensis, S. marilandica, Silphium asteriscus, and Boehmeria cylindrica.

Dynamics: Unknown. Probably similar to Nonriverine Wet Hardwood Forest. Fires are undoubtedly absent or extremely rare.

Range: Very rare. Presently known only from southern Pender County, although it may exist elsewhere in the marl outcrop area of the southern part of the North Carolina Coastal Plain. Similar communities may occur in South Carolina.

Associations: Unknown.

Distinguishing Features: Wet Marl Forests may be distinguished from Nonriverine Wet Hardwood Forests by the marl-derived, high pH soils, and by the presence of calciphytes. They are distinguished from Coastal Plain Marl Outcrops by the flat topography and poor drainage.

Variation: The site described by Leonard and Davis (1981) has considerable local heterogeneity, ranging from periodically flooded depressions to mesic rises.

Comments: This community type is known in North Carolina only in Pender County. Its affinities with marl substrate community types of the deep South are shown by the presence of species such as Carya myristiciformis, Cornus asperifolia, Carex willdenowii var. megarrhyncha, Scirpus lineatus, Sabal minor, Dryopteris ludoviciana, and Cocculus carolinus. It also has affinities with mesic, eutrophic sites in the Piedmont, with disjunct or at least unusual occurrences in the Coastal Plain of Asarum canadense, Anemone virginiana, Silphium asteriscus, Cryptotaenia canadensis, Circaea lutetiana ssp. canadensis, Sanicula marilandica, Aesculus sylvatica, and other species. The topographic and hydrologic environment makes the Wet Marl Forest type analogous to the Nonriverine Wet Hardwood Forest type.

Rare Plant Species: Vascular -- Carex granularis, Carex willdenowii var. megarrhyncha, Carya myristiciformis, Cornus asperifolia, Listera australis, Ruellia strepens, Scirpus lineatus, Tilia americana var. caroliniana.

Synonyms:
Marl Forest (Leonard and Davis 1981).

Examples:
Rocky Point Marl Forest, Pender County (Leonard and Davis 1981) (only known example in North Carolina).

References: Leonard and Davis (1981).
Sample Plant Communities:
Mixed hardwoods/Sabal minor.

NONRIVERINE WET HARDWOOD FOREST

Sites: Poorly drained interstream flats with fine-textured mineral soils, not associated with rivers or estuaries. Typically on the margins of large peatland areas.

Soils: Poorly drained loamy or clayey mineral soils. Series include Arapahoe (Typic Humaquept), Argent (Typic Ochraqualf), Roanoke (Typic Ochraquult), Stockade (Typic Umbraqualf), Brookman (Typic Umbraqualf), Deloss (Typic Umbraquult), Pantego (Umbric Paleaquult), and Masontown (Cumulic Humaquept).

Hydrology: Palustrine. Seasonally saturated or flooded by high water tables, poor drainage, and perhaps by sheet flow from adjacent pocosins.

Vegetation: Forest dominated by various hardwood trees typical of bottomlands. Typical species include Quercus michauxii, Q. laurifolia, Q. pagoda (falcata var. pagodaefolia), Liriodendron tulipifera, Liquidambar styraciflua, Ulmus americana, Acer rubrum, and Nyssa biflora. The understory includes species such as Carpinus caroliniana, Acer rubrum, Ilex opaca, and Asimina triloba. The shrub layer is generally sparse to moderate but may be dense. Species include Lindera benzoin, Persea palustris, Leucothoe axillaris, Clethra alnifolia, Vaccinium corymbosum, Myrica cerifera, Arundinaria gigantea, Sabal minor, and Callicarpa americana. Vines such as Bignonia (Anisostichus) capreolata, Toxicodendron (Rhus) radicans, Campsis radicans, Berchemia scandens, and Vitis spp. may be common. The herb layer may include Carex spp., Saururus cernuus, Boehmeria cylindrica, Woodwardia areolata, Athyrium filix-femina var. asplenioides, and Mitchella repens.

Dynamics: These communities appear to be stable climaxes when hydrology is not too altered. They seem unlikely to carry fire even if adjacent areas burn. However, some sites may have once supported understories of Arundinaria gigantea, which would have been highly flammable. Hughes (1952) described extensive, frequently burned canebrakes, with dense cane and sparse trees. Some such cane occurred with "lowland hardwoods." Some of these canebrakes may have succeeded to Nonriverine Wet Hardwood Forest vegetation when frequent fire was suppressed.

Range: Primarily in the outer parts of the embayed section of the Coastal Plain, potentially scattered farther inland and farther south.

Associations: These communities often occur on the margins of large peatlands, grading into Pond Pine Woodland or other pocosin communities on one side and better drained upland communities such as Mesic Mixed Hardwoods Forest or Dry-Mesic Oak--Hickory on the other side. They may grade to Small Stream Swamp at the head of drainages. They may also occur on smaller upland flats.

Distinguishing Features: Nonriverine Wet Hardwood Forests are distinguished by the combination of bottomland oak or mixed hardwood vegetation with location on flats not flooded by rivers or tidal waters. They are distinguished from Wet Marl Forest by the lack of marl-derived soils (though they may occur on Alfisols) and substantial occurrence of calciphilic plants. They are distinguished from Nonriverine Swamp Forest by drier conditions and by the predominance of bottomland hardwood species over Taxodium distichum, Nyssa biflora, and other swamp species. They may be distinguished from Mesic Mixed Hardwoods Forests by the dominance of bottomland trees as listed above. If upland mesic species such as Fagus grandifolia and Quercus alba are present, they are a minor component and are confined to the highest microtopography. The Upland Flat Variant of the Mesic Mixed Hardwood Forest (Coastal Plain Subtype) may contain significant numbers of Quercus michauxii and Q. pagoda, but has a less wet vegetational composition overall.

Variation: Occurrences vary with soil texture, drainage, microtopography. The occurrence of small hummocks and depressions with varying hydroperiod often produces fairly heterogeneous vegetation. The most obvious difference between occurrences is between dominance by oak and by soft hardwoods such as Liquidambar. The latter may reflect wetter conditions, transitional to Nonriverine Swamp Forest, or perhaps a different site history.

Comments: Because these sites are easy to drain and make excellent farmland, very few of these communities are left. They

apparently were once fairly common in some areas. Ashe and Pinchot (1897) described this type as occupying a quarter of the swamp area of the Coastal Plain. Peacock and Lynch (1982a) call this type one of the most threatened community types on the Coastal Plain.

Rare Plant Species: Vascular -- Listera australis, Trillium pusillum var. pusillum; nonvascular -- Cheilolejeunea rigidula.

Synonyms:
SAF 91: Swamp Chestnut Oak-Cherrybark Oak (but in a different habitat from described).
Oak Flats (Ashe and Pinchot 1897).
Bottomland hardwoods (general usage).

Examples:
Scranton Hardwoods, Hyde County (Lynch and Peacock 1982a).
Federal Paper Natural Area, Pamlico County (Peacock and Lynch 1982b).
Stonewall Natural Area, Pamlico County (Peacock and Lynch 1982b).
Merritt Natural Area, Pamlico County (Peacock and Lynch 1982b).
Northwest Backwoods, Currituck County (Frost, LeGrand, and Schneider 1990).
Gibbs Woods, Currituck County (Frost, LeGrand, and Schneider 1990).
Troublesome Point Oak Flats and Marsh, Currituck County (Frost, LeGrand, and Schneider 1990).
Little Flatty Creek and Big Flatty Creek Forests and Marsh, Pasquotank County (Frost, LeGrand, and Schneider 1990).

References: Ashe and Pinchot (1897), Frost, LeGrand, and Schneider (1990), Hughes (1957), Lynch and Peacock (1982a), Peacock and Lynch (1982b).

Sample Plant Communities:
Mixed hydric oaks-Pinus taeda/Carpinus caroliniana/Carex spp.
Mixed hydric oaks-Pinus taeda/Carpinus caroliniana/Saururus cernuus.
Quercus michauxii-Q. laurifolia/Carpinus caroliniana-mixed hardwoods/mixed shrubs/Woodwardia areolata-mixed herbs//mixed clambering vines.
Mixed hydric oaks-mixed hardwoods/Ilex opaca/Woodwardia areolata.
Quercus michauxii-Q. pagoda (falcata var. pagodaefolia)/Carpinus caroliniana/mixed herbs.
Mixed hydric hardwoods/mixed tall shrubs/Leucothoe axillaris/mixed ferns.

NONRIVERINE SWAMP FOREST

Sites: Wet, very poorly drained upland flats and peat deposits with rare mineral influx from overland or tidal flooding.

Soils: Mucky mineral soils or organic soils such as Typic or Terric Medisaprists.

Hydrology: Palustrine. Seasonally or frequently saturated or shallowly flooded by high water table.

Vegetation: Canopy of varying mixtures of Taxodium distichum, Taxodium ascendens, Nyssa biflora, Pinus taeda, Chamaecyparis thyoides, P. serotina, Liriodendron tulipifera, and Acer rubrum. Understory of open to dense Magnolia virginiana, Persea palustris, Cyrilla racemiflora, Lyonia lucida, Clethra alnifolia, Vaccinium spp., and Smilax laurifolia. Typical herbs include Woodwardia virginica, Woodwardia areolata, Carex spp., and Sphagnum spp.

Dynamics: The origin and dynamics of these communities are not well known. They apparently were once more strongly dominated by large trees, particularly bald cypress, and had open to sparse shrub layers. Small stands of large virgin cypress in nonriverine swamp environments are known. Early logging reduced most examples to the current condition of relatively small gum and red maple, often with dense shrubs. Levy and Walker (1979) suggested that similar forests were originally Atlantic White Cedar Forests from which the cedar was cut.

Natural fires were probably rare, but might have occurred in drought periods. Stand killing fires under certain circumstances may lead lead to development of an Atlantic White Cedar Forest community. Areas susceptible to more frequent fire probably supported pocosin communities rather than swamp. Nonriverine Swamp Forest and Atlantic White Cedar Forest may have existed in a shifting mosaic of fire-determined patches on some large peatlands; however, it seems likely that most Nonriverine Swamp Forests occurred primarily in environments which had more nutrient influx or were more permanently wet and protected from fire.

Peacock and Lynch (1982a) suggest that rare flooding by wind tides, bringing some subsidy of mineral nutrients, may be responsible for the occurrence of swamp forest rather than pocosin on peatlands near the Alligator River.

Range: Outer Coastal Plain, primarily in the Embayed Region. Occasionally elsewhere in flat or shallowly depressed areas.

Associations: Grades to Pond Pine Woodland, Atlantic White Cedar Forest, or pocosin types with decreasing flood frequency and mineral input and increasing fire. Grades to Tidal Cypress--Gum Swamp in some embayed river mouths. Less poorly drained upland areas may grade to Nonriverine Wet Hardwood Forest.

Distinguishing Features: Nonriverine Swamp Forests can be distinguished from other peatland communities by the dominance of swamp trees such as Nyssa biflora, and Taxodium distichum. Disturbed exampled dominated by species such as Acer rubrum and Liquidambar styraciflua may often be recognized by remnant Taxodium. Nonriverine Swamp Forests can be distinguished from riverine and tidal cypress-gum swamps by topographic position and source of water. They are wetted by high groundwater rather than by flowing or backed-up water. Swamps at the head of outlet streams from large peatlands are difficult to classify, and may represent intermediates.

Variation: Little information but presumably varies with peat depth, mineral influx, and amount of disturbance. Some examples have abundant pine in them, while others are more purely cypress and gum.

Comments: This community type is poorly understood. It is thought that the shrubby nature is a result of logging. The environment is in some senses intermediate between that of pocosin and that of riverine swamp forests. The sites generally have deep organic deposits. They are not regularly flooded by rivers or tides, but apparently receive some mineral input from adjacent higher lands.

Rare Plant Species: Vascular -- Listera australis.

Synonyms:
SAF 102, 103, and 104: Baldcypress-Tupelo, Water Tupelo-Swamp Tupelo, and Sweetbay-Swamp Tupelo-Red Bay.

Examples:
Alligator River National Wildlife Refuge, Dare and Hyde counties (Peacock and Lynch 1982a).
Van Swamp, Washington County (Lynch and Peacock 1982b).
East Dismal Swamp, Washington County (Lynch and Peacock 1982b).
Bull Neck Swamp, Washington County (Lynch and Peacock 1982b, Frost, LeGrand, and Schneider 1989).
Dismal Swamp Wildlife Refuge, Gates and Camden counties (Frost 1982).
Swanquarter National Wildlife Refuge, Hyde County (an isolated, reportedly virgin cypress stand).

References: Carter and Gammon (1976), Frost (1982), Frost, LeGrand, and Schneider (1990), Levy and Walker (1979), Lynch (1981), Lynch and Peacock (1982b), Peacock and Lynch (1982a).

Sample Plant Communities:
Taxodium ascendens-Nyssa biflora/Lyonia lucida.
Nyssa biflora-Acer rubrum var. trilobum/Lyonia lucida.
Nyssa biflora-Acer rubrum var. trilobum/Leucothoe axillaris.
Taxodium ascendens-Nyssa biflora/Nyssa biflora.

LOW POCOSIN

Sites: Central, deepest parts of domed peatlands on poorly drained interstream flats, and peat-filled Carolina bays and swales. Peat deposits, greater than 1 meter deep, or shallower and over very oligotrophic wet sands.

Soils: Histosols, most typically Dare (Typic Medisaprist), sometimes Croatan (Terric Medisaprist) or Pamlico (Terric Medisaprist).

Hydrology: Palustrine, seasonally flooded or saturated. 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 few examples, in Carolina bays and swales, occur in low areas that lack mineral input, or in the interior of peat-filled depressions where any nutrients in incoming water are filtered out by peat and vegetation on the periphery. The peat is deep and saturated enough that plant roots never reach mineral soil. Small permanently flooded depressions may occur.

Vegetation: Dense shrub layer, less than 1.5 meters tall. Lyonia lucida, Cyrilla racemiflora, or Zenobia pulverulenta ususally dominate, with frequent Smilax laurifolia. Widely scattered, stunted Pinus serotina, Persea palustris, Gordonia lasianthus and Magnolia virginiana usually occur. Pools or openings, usually small but rarely as large as hundreds of acres, may be dominated by species such as Chamaedaphne (Cassandra) calyculata, Carex striata (walteriana), Woodwardia virginica, Sarracenia flava, Andropogon glomeratus, Sphagnum spp., and rarely, Vaccinium macrocarpon.

Dynamics: These communities are extremely nutrient-poor, with normal nutrient input only from rainfall. Studies have found phosphorus to be strongly limiting to plant production (Wilbur and Christensen 1983).

Under natural conditions severe fires occur periodically, associated with droughts. Such fires may burn into the peat in places, as well as killing much or all above-ground vegetation. Root sprouting and reproduction stimulated by the fire and increased nutrient levels allow quick recovery. Christensen, et al. (1981) reported that a burned pocosin regained 20% of its prefire biomass in the first growing season. 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. Species diversity is generally highest right after a fire, and declines gradually. Where a fire burns holes into the peat, pools may form which refill with peat only slowly.

Range: Primarily on the outer and less commonly the middle Coastal Plain.

Associations: Grades to High Pocosin in slightly drier areas with shallower peat.

Distinguishing Features: Low Pocosins are distinguished from other peatland community types by the persistent low stature of the shrubby vegetation (less than 1.5 meters tall) and the sparse distribution and low stature of the few trees. Pocosin communities over shallower peat can superficially resemble Low Pocosins immediately after a severe fire, but recovery over a period of years reestablishes the visible distinctiveness. Prior to recovery, such "false low pocosins" can often be distinguished from true Low Pocosins by the presence of incompletely burned woody material such as large pond pines.

Variation: Stature of vegetation increases with decreasing peat depth. Dominance, stature, and diversity also vary due to fire cycles. Woodwell (1956) noted geographic variation, with Cyrilla usually dominant in the northeastern and central parts of the state and Lyonia in the southern parts. Other species may rarely dominate in extremely wet examples. Theoretically, differences in hydrology, fire regime, and other site factors between large peatlands and Carolina bays should create differences in low pocosins in these settings, but whether these differences are significant is not known.

Comments: Low Pocosin communities are at the end of a gradient of wetness, nutrient availability, and usually, peat depth. They are the least productive and most stunted communities of this series. However, the relationships of this series of pocosin communities are somewhat complicated by fire. Representing the extreme of peatland development, true Low Pocosins are much rarer than High Pocosins or Pond Pine Woodlands.

Most of the literature on pocosin communities is general and does not distinguish among the types. Thus, it is difficult to tell what information pertains to which types.

Rare Plant Species: Vascular -- Eriophorum virginicum, Kalmia cuneata, Lysimachia asperulifolia, Peltandra sagittifolia, Rhynchospora alba; nonvascular -- Sphagnum fitzgeraldii.

Synonyms:
Shrub Bog (various usages) (in part).
Pine-Ericalean Pocosin (Kologiski 1977) (in part).
Short Pocosin.

Examples:
Croatan Pocosins, Croatan National Forest, Carteret and Craven counties (Snyder 1977, Snyder 1980).
US 264 Pocosin, Dare County (Peacock and Lynch 1982a).
Green Swamp, Brunswick County (Kologiski 1977).
Holly Shelter Swamp, Pender County (Wells 1946).
Angola Bay Swamp, Pender and Duplin counties (Leonard and Davis 1981).
Big Colly and Tatum Millpond Carolina Bays, Bladen Lakes State Forest, Bladen County (Weakley and Scott 1982).
Bushy Lake State Natural Area, Cumberland County.
Mashoes Pocosin, Dare County (Peacock and Lynch 1982a).

References: Ash, McDonald, Kare, and Pories (1983), Christensen (1981), Christensen (1988), Christensen, Burchell, Liggett, and Simms (1981), Christensen, Wilbur, and McLean (1988), Dachnowski and Wells (1929), Kologiski (1977), Leonard and Davis (1981), Otte (1981), Peacock and Lynch (1982a), Sharitz and Gibbons (1982), Snyder (1977), Snyder (1980), Weakley and Scott (1982), Wells (1946), Wells and Whitford (1976), Wilbur and Christensen (1983), Woodwell (1956).

Sample Plant Communities:
Cyrilla racemiflora.
Lyonia lucida.
Zenobia pulverulenta.
Zenobia pulverulenta-Cyrilla racemiflora.
Ilex glabra.
Chamaedaphne (Cassandra) calyculata.
Sarracenia flava.
Carex striata (walteriana).

HIGH POCOSIN

Sites: Central to intermediate parts of domed peatlands on poorly drained interstream flats, and peat-filled Carolina bays and swales. Peat deposits, 1.5 meters deep, or shallower and over very oligotrophic wet sands.

Soils: Histosols, including Dare (Typic Medisaprist), Croatan (Terric Medisaprist), and Pungo (Typic Medisaprist). Occasionally in areas mapped as other series.

Hydrology: Palustrine, seasonally flooded or saturated. High Pocosins occurring in domed peatlands are slightly higher than the surrounding lands and little surface or ground water drains into them, 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. Small, permanently flooded depressions may occur, but are less common than in Low Pocosin.

Vegetation: Dense shrub layer, between 1.5 and 3 meters tall, except when recovering from fire. Usually dominated by Lyonia lucida, Cyrilla racemiflora, and Ilex glabra, with abundant Smilax laurifolia. Arundinaria gigantea may occur. Scattered Pinus serotina, Persea palustris, Gordonia lasianthus, and Magnolia virginiana usually occur. Herbs are usually nearly absent beneath the dense shrub layer. In recently burned sites, species such as Woodwardia virginica and Andropogon glomeratus may be important.

Dynamics: These communities are extremely nutrient-poor, with little normal nutrient input other than from rainfall. Studies have found phosphorus to be strongly limiting to plant production (Wilbur and Christensen 1983).

Under natural conditions severe fires occur periodically, associated with droughts. Such fires may burn into the peat in places, as well as killing much or all above-ground vegetation. Root sprouting and reproduction stimulated by the fire and increased nutrient levels allow quick recovery. Recovery 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. Species diversity is generally highest right after a fire, and declines gradually. Where a fire burns holes into the peat, pools may form which refill with peat only slowly. As with Pond Pine Woodland, some High Pocosin sites may once have been Arundinaria-dominated canebrakes, maintained by a more frequent fire regime.

Range: Primarily on the outer and less commonly the middle Coastal Plain.

Associations: Intermediate between Low Pocosin and Pond Pine Woodland and grades into both. Occasionally grades to drier communities along sharp gradients at the edge of depressions.

Distinguishing Features: High Pocosins are distinguished from other peatland community types by the persistent stature of the shrubby vegetation, intermediate between Low Pocosin and Pond Pine Woodland (1.5 to 3 meters tall) and the sparse distribution and relatively low stature of the few trees. Pond Pine Woodlands may resemble this type immediately after a severe fire, but regrowth over a period of years reestablishes the visible distinctiveness. Prior to this, "false high pocosins" can often be distinguished from true High Pocosins by the presence of incompletely burned woody material such as large pond pines, although the distinction is more difficult for High Pocosins than Low Pocosins. Recently burned High Pocosins may resemble Low Pocosin.

Variation: Stature of vegetation increases with decreasing peat depth. Dominance, stature, and diversity also vary due to fire cycles. Woodwell (1956) noted geographic variation, with Cyrilla usually dominant in the northeastern and central parts of the state and Lyonia in the southern parts. Theoretically, differences in hydrology, fire regime, and other site factors between large peatlands and Carolina bays should create differences in low pocosins in these settings, but whether these differences are significant is not known.

Comments: High Pocosin communities are part of a gradient of wetness, nutrient availability, and (usually) peat depth. They

are intermediate between Low Pocosin and Pond Pine Woodland. However, the relationships of this series of pocosin communities are somewhat complicated by fire. High Pocosins are more common than Low Pocosins but, having shallower peat, are more easily drained and destroyed.

Most of the literature on pocosin communities is general and does not distinguish among the types. Thus, it is difficult to tell what information pertains to which types.

Rare Plant Species: Vascular -- Amphicarpum purshii, Calamovilfa brevipilis, Kalmia cuneata, Lysimachia asperulifolia, Lysimachia loomisii, Peltandra sagittifolia, Pleea tenuifolia; nonvascular -- Sphagnum fitzgeraldii.

Synonyms:
Pine-Ericalean Pocosin (Kologiski 1977) (in part).
Included in the Short Pocosin category of Snyder (1980).
Shrub bog (general usage).

Examples:
Croatan Pocosins, Croatan National Forest, Carteret, Craven, and Jones counties (Snyder 1977, Snyder 1980).
U.S. 264 Pocosin, Dare County (Peacock and Lynch 1982a).
Green Swamp, Brunswick County (Kologiski 1977).
Holly Shelter Swamp, Pender County (Wells 1946).
Angola Bay Swamp, Pender and Duplin counties.
Jones Lake and Salters Lake Carolina Bays, Jones Lake State Park, Bladen County.

References: Ash, McDonald, Kare, and Pories (1983), Christensen (1981), Christensen (1988), Christensen, Burchell, Liggett, and Simms (1981), Christensen, Wilbur, and McLean (1988), Dachnowski and Wells (1929), Frost (1989), Kologiski (1977), Leonard and Davis (1981), Otte (1981), Peacock and Lynch (1982a), Sharitz and Gibbons (1982), Snyder (1977), Snyder (1980), Weakley and Scott (1982), Wells (1946), Wells and Whitford (1976), Wilbur and Christensen (1983), Woodwell (1956).

Sample Plant Communities:
Lyonia lucida-Ilex glabra.
Lyonia lucida-Cyrilla racemiflora.
Pinus serotina/Cyrilla racemiflora-Lyonia lucida.
Ilex coriacea-Lyonia lucida.
Cyrilla racemiflora.
Clethra alnifolia-Ilex glabra.

POND PINE WOODLAND

Sites: Outer parts of domed peatlands on poorly drained interstream flats, and peat-filled Carolina bays and shallow swales. Shallow organic deposits or deeper peats with some input of mineral sediment.

Soils: Shallow Histosols or oligotrophic mineral soils with organic surface layers. Series include Croatan (Typic Medisaprist), Murville (Typic Haplaquod), Lynn Haven (Typic Haplaquod), Torhunta (Typic Humaquept), Ponzer (Terric Medisaprist), Roper (Histic Humaquept), and Pungo (Typic Medisaprist).

Hydrology: Palustrine, temporarily flooded or saturated. Water table drops to underlying mineral sediment during the dry season, allowing plants to root there. These areas may also receive some influx of water with nutrients from adjacent areas.

Vegetation: Open to nearly closed canopy of Pinus serotina, sometimes codominant with Gordonia lasianthus, and with lesser amounts of Magnolia virginiana, Acer rubrum, Pinus taeda, Persea palustris, and Chamaecyparis thyoides. Shrub layer tall and very dense, greater than 5 meters tall except when recently burned. Common shrubs are Cyrilla racemiflora, Lyonia lucida, Lyonia ligustrina, Ilex coriacea, Ilex glabra, Gaylussacia frondosa, Clethra alnifolia, and Persea palustris, Arundinaria gigantea is often present and may even dominate the shrub layer. Smilax laurifolia is usually common. Herbs are generally nearly absent under the dense woody cover, although occasional Woodwardia virginica, W. areolata, and Sphagnum clumps may occur.

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 soils of the Pond Pine Woodland. This ecotonal zone, while too small to be classified as a separate community, often resembles a Pine Savanna, with a high diversity of herbaceous plants absent from both of the adjoining communities. This ecotone is the primary habitat for a number of rare plant species.

Dynamics: These communities are wet and nutrient poor, though less so than Low Pocosin or High Pocosin. As with other peatland communities, Pond Pine Woodlands are susceptible to fires during dry periods. Because water levels are lower, they are susceptible more of the time than the wetter pocosins. The large amount of fuel makes fires extremely intense. The dominant species sprout readily, and only a few years are apparently required for the dense shrub layer to reach its former height. Pinus serotina recovers 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. As in other pocosin communities, species diversity is highest right after a fire and declines gradually.

Where frequent fires have occurred over a long time period, the Pond Pine Woodland understory is dominated by Arundinaria gigantea, with few shrubs. This may have been the natural state for much of the large acreage of Pond Pine Woodland that is now extremely shrubby. 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 can recover more quickly from fire than shrubs, canebrakes, once established, might maintain themselves by promoting more frequent burning. This could only occur, however, if frequent ignition sources existed in the region.

Most Pond Pine Woodlands are thought natural, but some areas are believed to have developed these communities after the logging of Nonriverine Swamp Forests. In some peatlands they may exist with Peatland Atlantic White Cedar Forest, Nonriverine Swamp Forest, and Bay Forest in a mosaic determined by disturbance history.

Range: Throughout the Coastal Plain, but most extensive in the outer parts.

Associations: Grades to High Pocosin, Bay Forest, Nonriverine Swamp Forest, Pine Savanna, or Wet Pine Flatwoods. May occasionally grade to Brackish or Tidal Freshwater Marsh, Estuarine Fringe Loblolly Pine Forest, or Tidal Cypress--Gum Swamp.

Distinguishing Features: Pond Pine Woodlands are distinguished from other peatland communities by the substantial Pinus serotina canopy. Mixed canopy stands are most easily classified by the predominant tree species into Pond Pine Woodland, Bay Forest, Peatland Atlantic White Cedar Forest, or Nonriverine Swamp Forest. The affinities of Pinus taeda dominated

stands are not known. The shrub layer is generally taller than that in High Pocosin. Both the tall shrubs and the pine canopy may be absent for periods of years following severe or frequent fire, but remnant woody debris often remains to offer clues to past vegetation structure. Many sites that are called Low Pocosin or High Pocosin because of low stature of the shrubs are probably successional Pond Pine Woodland.

Variation: This is a fairly broad category, covering a range of environments and vegetation. However, no clear variants are known within it at present. Factors causing variation include depth of peat, influx of external water and mineral sediment, fire, and disturbance history. Occurrences on large peatlands, Carolina bays, and swales may be somewhat distinct from each other.

Comments: This is a widespread community type that occurs in a variety of environments. Less is known about the natural ecology and dynamics of Pond Pine Woodlands than of Low Pocosins and High Pocosins. It is unclear how much of the scientific literature on pocosins applies to them. Because of their drier location and closer association with non-peatland communities, their fire and nutrient dynamics may be different. Because they are usually more accessible and easier to disturb, most examples have been modified more heavily than the wetter pocosin types.

Of particular interest is the role of Arundinaria gigantea in these communities. Hughes (1957), Biswell and Foster (1942), and some earlier writers described vast canebrakes on the wetlands of the Coastal Plain. These dense stands of Arundinaria usually had sparse or no tree canopy, and were maintained by frequent fire. The most common trees listed as associates in the canebrakes were Pinus serotina, with Pinus taeda and lowland hardwoods less common. Such canebrakes may represent a phase of Pond Pine Woodland occurring on sites prone to frequent fire. Alternatively, the pines may have been present because of frequent fire in sites which they do not now occupy. Cane brakes have essentially disappeared from the landscape, with fire suppression and other disturbances, such as open-range livestock. It is not clear what communities have replaced them, but typical Pond Pine Woodland is one of the strongest possibilities.

Rare Plant Species: Vascular -- Hexastylis lewisii, Kalmia cuneata, Lysimachia loomisii, Peltandra sagittifolia; nonvascular --Sphagnum fitzgeraldii.

Synonyms:
Tall Pocosin (Snyder 1980).
Conifer-Hardwood Pocosin (Kologiski 1977) (in part).
SAF 98: Pond Pine (in part).
Includes both the Pond Pine Forest and Pond Pine Woodland of Otte (1981).

Examples:
Alligator River National Wildlife Refuge and Dare Bombing Range, Dare County (Peacock and Lynch 1982a).
Croatan Pocosins, including Pond Pine Research Natural Area, Croatan National Forest, Craven, Carteret, and Jones counties (Snyder 1977, 1980).
Boiling Springs Wetland Complex, Brunswick County (Nifong 1981).
Green Swamp, Brunswick County (Kologiski 1977).
Bladen Lakes State Forest Carolina bays and interbay areas, Bladen County (Weakley and Scott 1982).
Jones Lake and Salters Lake Carolina bays and interbay areas, Jones Lake State Park, Bladen County.
Mill Pond Bay Natural Area, Cumberland and Bladen counties.

References: Ash, McDonald, Kare, and Pories (1983), Bennett and Nelson (1990), Biswell and Foster (1942), Christensen (1981), Christensen (1988), Christensen, Burchell, Liggett, and Simms (1981), Christensen, Wilbur, and McLean (1988), Dachnowski and Wells (1929), Frost (1989), Hughes (1957), Kologiski (1977), Leonard and Davis (1981), Otte (1981), Peacock and Lynch (1982a), Sharitz and Gibbons (1982), Snyder (1977), Snyder (1980), Weakley and Scott (1982), Wells (1946), Wells and Whitford (1976), Wilbur and Christensen (1983), Woodwell (1956).

Sample Plant Communities:
Pinus serotina/Lyonia lucida.
Pinus serotina/Cyrilla racemiflora.

Pinus serotina/Ilex coriacea.
Pinus serotina-Gordonia lasianthus/Lyonia lucida.
Pinus serotina-Gordonia lasianthus/Persea palustris/Lyonia lucida.
Pinus serotina/Arundinaria gigantea.
Pinus serotina/mixed pocosin shrubs.

PEATLAND ATLANTIC WHITE CEDAR FOREST

Sites: Peatlands, Carolina bays, and other depressions or swales with organic deposits and without flowing or seepage water.

Soils: Deep or shallow organic soils, generally Pamlico (Terric Medisaprist), Pungo (Typic Medisaprist), or Dare (Typic Medisaprist).

Hydrology: Intermittently or seasonally saturated.

Vegetation: Canopy dominated by Chamaecyparis thyoides, with or without smaller amounts of other wetland trees such as Pinus serotina, P. taeda, Acer rubrum, Nyssa biflora, and Taxodium ascendens. Understory open to dense, of species such as Gordonia lasianthus, Magnolia virginiana, Persea palustris, Lyonia lucida, Cyrilla racemiflora, Ilex glabra, Lyonia ligustrina, Gaylussacia frondosa, and Ilex coriacea. Herbs are generally sparse. Typical species include Mitchella repens, Woodwardia areolata, and Sphagnum spp.

Dynamics: Peatland Atlantic White Cedar Forests generally exist as a mosaic with Pond Pine Woodland, Bay Forest, Nonriverine Swamp Forest, or other communities in the landscape of large peatlands. Their occurrence is determined by fire history, though hydrology and nutrient status may also be important factors. Peatland Atlantic White Cedar Forests typically occur as even-aged stands, often with a dense canopy. These stands establish after removal of previous vegetation by a crown fire or other disturbance (Buell and Cain 1943; Korstian 1924). Such stand establishment apparently depends on sufficient removal of competing trees and shrubs and presence of seed. Large numbers of seeds accumulate under mature stands, but they may be destroyed if the fire occurs at low water table and burns into the peat.

As even-aged stands mature, dead wood accumulates, making the community more susceptible to a stand-killing fire. In the long absence of fire, white cedar forests are believed to succeed to Bay Forest, Pond Pine Woodland, or maple-gum dominated Nonriverine Swamp Forest (Buell and Cain 1943; Kologiski 1977). The young cedars are, however, very susceptible to even moderate fires, and frequent fire lead to pocosin vegetation. Thus, Peatland Atlantic White Cedar Forests are dependent on a specific fire regime.

Range: Throughout the Coastal Plain, primarily in the great peatlands of the Outer Coastal Plain, also prominent in the Bladen Lakes area of Carolina Bays.

Associations: Usually associated with Nonriverine Swamp Forest, Pond Pine Woodland, or other pocosin communities. May grade to Estuarine Fringe Loblolly Pine Forest, Tidal Cypress--Gum Swamp, or marsh communities along shorelines.

Distinguishing Features: Peatland Atlantic White Cedar Forests are distinguished from Streamhead Atlantic White Cedar Forest by their locations on peat domes or in depressions fed mainly by rainwater, as opposed to streamheads with flowing or seepage water. They are distinguished from all other peatland community types by the dominance of Chamaecyparis thyoides in the canopy. Forests with substantial Chamaecyparis sometimes occur along blackwater rivers. Isolated peat-filled depressions on high relict terraces may be considered to belong to this type, but if they are flooded or influenced by the river they are placed in the Bottomland Hardwoods Forest (Blackwater Subtype).

Variation: Stands vary in structure with age of the stand. There may also be differences in composition, hydrology, and dynamics between examples on large peatlands and those in Carolina bays and other depressions. Communities marginally dominated by Chamaecyparis mixed with other trees may include cedars of mixed age and represent a distinct variant with different dynamics.

Comments: This type was included together with the Streamhead Atlantic White Cedar Forest in the more general Atlantic White Cedar Forest type of the Second Approximation. The new distinction 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.

This type differs from most natural community types included in this classification in that it occurs on sites similar to those of other types, occurring as the result of a particular fire history. It is regarded as a distinct natural community type

because of its very distinctive vegetational composition and structure, and dynamics. The fire regime that creates these communities is part of the natural environment of the peatlands. With fire control and fragmentation of the large peatlands, fires suitable for creating patches of Peatland Atlantic White Cedar Forest have become extremely rare. With the loss of natural fire regime and with widespread logging and drainage, these communities, which were once abundant, have become very rare.

Rare Plant Species: None known.

Synonyms:
Atlantic White Cedar Forest (Second Approximation) (in part).
SAF 97: Atlantic White Cedar (in part).

Examples:
Alligator River National Wildlife Refuge, Dare and Hyde counties (Lynch and Peacock 1982a, Moore and Carter 1987).
Green Swamp, Brunswick County (Kologiski 1977).
Bull's Neck Swamp, Hyde County (Lynch and Peacock 1982a, Moore and Carter 1987).
Nellie Bell Pond Marsh and Cedar Swamp, Northwest River, Currituck County (Frost, LeGrand, and Schneider 1989).
Jones Lake Carolina Bay, Jones Lake State Park, Bladen County.

References: Ashe and Pinchot (1897), Buell and Cain (1943), Christensen (1981), Christensen (1988), Frost (1982), Frost (1989), Frost, LeGrand, and Schneider (1990), Kologiski (1977), Korstian (1924), Laderman (1989), Lynch and Peacock (1982a), Lynch and Peacock (1982b), Moore and Carter (1987), Wells (1942).

Sample Plant Communities:
Chamaecyparis thyoides.
Chamaecyparis thyoides/Lyonia lucida.
Chamaecyparis thyoides/Lyonia lucida-Ilex coriacea.

BAY FOREST

Sites: Outer parts of domed peatlands on poorly drained interstream flats, and peat-filled Carolina bays and shallow swales. Shallow organic deposits or deeper peats with some input of mineral sediment.

Soils: Shallow Histosols or oligotrophic mineral soils with organic surface layers. Series include Croatan (Typic Medisaprist), Pamlico (Terric Medisaprist), Dorovan (Typic Medisaprist), and undoubtedly others.

Hydrology: Palustrine, seasonally saturated or flooded. It is unclear if hydrology differs from that of Pond Pine Woodland and Peatland Atlantic White Cedar Forest.

Vegetation: Dominated by combinations of Gordonia lasianthus, Magnolia virginiana, and Persea palustris. Pinus serotina, Nyssa biflora, Acer rubrum, Pinus taeda, and Chamaecyparis thyoides may be significant components. The shrub layer is dense to somewhat open, consisting of species such as Lyonia lucida, Cyrilla racemiflora, Lyonia ligustrina, Ilex coriacea, and Ilex cassine.

Dynamics: Like other peatland communities, Bay Forests are wet and nutrient poor, though probably less so than Low Pocosins or High Pocosins.

Bay forests are usually considered a late successional community, replacing Peatland Atlantic White Cedar Forest or Pond Pine Woodland after long absence of fire (Buell and Cain 1943; Kologiski 1977). In large peatlands they may exist with these communities in a mosaic defined by disturbance history, or they may occupy distinct sites which protect them from fire.

Fires may be be expected to be intense in the dense vegetation. Christensen (1988) suggests that shallow peat burns may allow Chamaecyparis or Pinus serotina establishment. However, Bay Forest dominants sprout readily, and in less severe burns may be expected to recover.

Range: Outer and middle Coastal Plain.

Associations: Grades to Pond Pine Woodland, Nonriverine Swamp Forest, Peatland Atlantic White Cedar Forest, or High Pocosin.

Distinguishing Features: Bay Forests are distinguished from Pond Pine Woodland, Peatland Atlantic White Cedar Forest, and Nonriverine Swamp Forest by a canopy dominated by the three bay species. Persea palustris-dominated areas in sandhill streamheads or seepage slopes, small depressions, or barrier islands are not considered Bay Forests but are classified as Streamhead Pocosin, Small Depression Pocosin, and Maritime Shrub Swamp respectively.

Variation: Not well known but presumably varies with wetness, fire, and disturbance history.

Comments: This is a poorly defined, poorly known community type. The name "bay" is applied to many kinds of vegetation, only some of which fit into this type. This makes it difficult to determine what literature applies to this type, and whether applicable studies are really studying the same phenomena.

The environmental associations and successional relationships between this community type and other peatland types are not well known. Bay Forests may be solely a product of fire suppression, or there may be sites which naturally supported them. Snyder (1980) found examples associated with the beginning of stream drainage on the edge of large peat domes. In the absence of definite knowledge, it seems best to consider Bay Forests a community type and to protect them for further study.

Rare Plant Species: None known.

Synonyms:
Evergreen Bay (Kologiski 1977).
SAF 104: Sweetbay-Swamp Tupelo-Redbay.

Bay pocosin (Snyder 1980).
Examples:
Green Swamp, Brunswick and Columbus counties (Kologiski 1977).
Croatan National Forest, Carteret Craven, and Jones counties (Snyder 1980).
Big Colly Bay, Bladen Lakes State Forest, Bladen County.
Salters Lake Carolina Bay, Bladen County.

References: Bennett and Nelson (1990), Christensen (1988), Kologiski (1977), Snyder (1980), Wells and Whitford (1976).

Sample Plant Communities:
Gordonia lasianthus-Persea palustris-Magnolia virginiana/Cyrilla racemiflora-Lyonia lucida/Woodwardia virginica.
Gordonia lasianthus-Acer rubrum/Persea palustris/mixed pocosin shrubs.

STREAMHEAD POCOSIN

Sites: Headwaters of small streams in sandhill areas, on flat bottoms, and sometimes extending up adjacent seepage slopes (particularly in fire-suppressed conditions).

Soils: Wet, acidic soils with an organic layer overlying or interbedded with clay or sand, or wet seepy sands underlain with clay. Examples are mapped as Johnston (Cumulic Humaquept), Blaney (Arenic Hapludult), Bibb (Typic Fluvaquent), and "alluvium."

Hydrology: Palustrine, seasonally to semipermanently saturated. Receives oligotrophic runoff and some seepage from pocosin or sandhill areas.

Vegetation: Dense shrub layer dominated by species such as Cyrilla racemiflora, Lyonia lucida, Ilex glabra, I. coriacea, Lyonia mariana, Persea palustris, Clethra alnifolia, Toxicodendron (Rhus) vernix, Kalmia cuneata, Vaccinium corymbosum, Leucothoe racemosa, and Gaylussacia frondosa, often with abundant Smilax laurifolia. The canopy contains scattered to fairly dense trees, primarily Pinus serotina, Acer rubrum, Liriodendron tulipifera, and Nyssa biflora, also including Chamaecyparis thyoides, Pinus taeda, Magnolia virginiana, and Liquidambar styraciflua. Herbs are generally sparse, with Woodwardia areolata, Osmunda cinnamomea, Carex lonchocarpa (folliculata var. australis), and other Carex species typical.

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 Pond Pine Woodland. 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 absent from both of the adjoining communities. This ecotone is the primary habitat for a number of rare plant species.

Dynamics: Because of their long, narrow shape, Streamhead Pocosins are subject to influence from fire on adjacent uplands. Even though the pocosins are usually too wet to carry fire and fires burning into them go out, the fires disturb the edges. In addition, some of the nutrients released by burning in adjacent uplands will also reach the pocosin through runoff or groundwater, making these communities more fertile than peatland pocosins. 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.

The natural successional status of Streamhead Pocosins is not entirely clear. With relatively frequent fire they are dominated by shrubs, with an open to sparse tree canopy. With certain fire regimes a Streamhead Atlantic White Cedar Forest may develop. Some Streamhead Pocosins may succeed to Small Stream Swamps with long enough absence of fire, but others seem to persist. On the upper edges lack of fire allows Streamhead Pocosin to expand up to the beginning of dry upland conditions. With frequent fire it is confined to the lower parts of the streamhead, and an herb-dominated Sandhill Seep or Wet Pine Flatwoods may occur above it.

Range: Primarily in Sandhills region but may occur throughout the upper Coastal Plain. It is not known to occur in the lower Coastal Plain.

Associations: Grades into Sandhill Seep, Mesic Pine Flatwoods, Pine/Scrub Oak Sandhill, or Xeric Sandhill Scrub. Grades downstream to Coastal Plain Small Stream Swamp, Blackwater Subtype.

Distinguishing Features: This type is distinguished from other pocosin types by its occurrence in sandhill streamheads, with flowing or seepage water, rather than on peat domes or in depressions fed mainly by rainwater. It is distinguished from Streamhead Atlantic White Cedar Forests and Small Stream Swamps by the dominance of Pinus serotina, Liriodendron tulipifera, Magnolia virginiana, and Persea palustris over Chamaecyparis or Taxodium and Nyssa. It is distinguished from adjacent Sandhill Seep, flatwoods, and sandhill communities by the strong dominance of shrubs over herbs.

Variation: Vegetation varies greatly with frequency of burning. Other variations have not been studied.

Comments: Many papers mention streamheads as a site for pocosin vegetation, without describing them specifically in detail. 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. They also apparently have a higher species diversity. Of particular note is the importance of Liriodendron tulipifera in many of these communities.

These communities are not rare but sites which have remained under a natural fire regime are nearly nonexistent.

Rare Plant Species: Vascular -- Carex collinsii, Eriophorum virginicum, Hexastylis lewisii, Kalmia cuneata, Lindera subcoriacea, Lycopus cokeri, Lysimachia asperulifolia, Sarracenia rubra.

Synonyms:
SAF 104: Sweetbay-Swamp Tupelo-Red Bay (in part).
Bayhead, bay forest, bayhead, pocosin (general usage).

Examples:
Sandhills Gamelands, Scotland and Richmond counties (numerous examples throughout). Fort Bragg, Hoke and Cumberland counties (numerous examples throughout).

References: Burk (1959), Christensen, Burchell, Liggett, and Simms (1981), North Carolina Vegetation Survey (1989), Otte (1981), Sharitz and Gibbons (1982).

Sample Plant Communities:
Pinus serotina/mixed pocosin shrubs
Pinus serotina-Liriodendron tulipifera/mixed pocosin shrubs.
Pinus serotina/Lyonia lucida.

STREAMHEAD ATLANTIC WHITE CEDAR FOREST

Sites: Along small headwater streams in sandhill areas, on flat bottoms or extending up adjacent seepage slopes.

Soils: Wet, acidic soils with an organic layer overlying or interbedded with clay or sand. Generally on the Torhunta (Typic Humaquept) and Johnston (Cumulic Humaquept) series.

Hydrology: Palustrine, seasonally to intermittently flooded or saturated.

Vegetation: Canopy dominated by Chamaecyparis thyoides, with or without Nyssa biflora, Pinus serotina, Liriodendron tulipifera, and Acer rubrum. Except where the canopy is completely closed, a dense shrub layer occurs, with species such as Magnolia virginiana, Persea palustris, Ilex glabra, Lyonia lucida, Vaccinium corymbosum, Toxicodendron (Rhus) vernix, and Arundinaria gigantea. Smilax laurifolia and S. rotundifolia are often common. The herb layer is poorly developed, with Osmunda cinnamomea the most characteristic species. Patches of Sphagnum are common.

Dynamics: The dynamics of these communities are less well studied than those of Peatland Atlantic White Cedar Forests. They occur in sites similar to Streamhead Pocosin and Small Stream Swamp (Blackwater Subtype), and the locations and relative amounts of these three community types may depend on fire history as well as subtle site variations. Moore and Carter (1987) observed both even-aged and uneven-aged stands of this type. They noted that as stands age, the cedar canopy become 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 frequently; the wetness of the sites prevents most fires from spreading into them from adjacent sandhill communities. The canopy trees are probably periodically killed by hot fires and regenerate on burned sites. With more frequent fire a Streamhead Pocosin may develop on the same site, and with less frequent fire the site may succeed to a shrubby Small Stream Swamp. Moore and Carter (1987) also noted that cedar was able to invade adjacent wet grassy areas when fire was suppressed.

Range: Primarily in the Sandhills region. Occasional examples may occur elsewhere in the Coastal Plain.

Associations: Grades to Streamhead Pocosin or Small Stream Swamp (Blackwater Subtype) along the stream course. Generally grades rather abruptly to Pine/Scrub Oak Sandhill, Xeric Sandhill Scrub, or Wet Pine Flatwoods at the edge of the stream course.

Distinguishing Features: This type is distinguished from Peatland Atlantic White Cedar Forests by its occurrence in sandhill streamheads, with flowing or seepage water, rather than on peat domes or in depressions fed mainly by rainwater. It is distingished from Streamhead Pocosin and Small Stream Swamp (Blackwater Subtype) by the dominance of Chamaecyparis.

Variation: Occurrences may vary in relative amounts of white cedar and hardwoods. A distinctive variant occurs on seepage slopes isolated from bottomlands.

Comments: This type was included with the Peatland Atlantic White Cedar Forest type in the Second Approximation. The new distinction 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.

Rare Plant Species: Vascular -- Carex collinsii.

Synonyms:
SAF 97: Atlantic White Cedar.
Atlantic White Cedar Forest (Second Approximation) (in part).

Examples:

Juniper Springs Church, Lee County.
White Cedar Branch Head, Naked Creek White Cedar Stand, and Millstone Creek Natural Areas, Sandhills Game Land, Richmond and Moore counties.
McPherson Impact Area, Fort Bragg, Hoke County (N.C. Vegetation Survey 1989).
Cedar Swamp Seep, Bladen County.

References: Laderman (1989), Moore and Carter (1987), North Carolina Vegetation Survey (1989).

Sample Plant Communities:
Chamaecyparis thyoides.
Chamaecyparis thyoides/mixed pocosin shrubs.
Chamaecyparis thyoides-Liriodendron tulipifera/mixed pocosin shrubs.

SMALL DEPRESSION POCOSIN

Sites: Limesinks, small Carolina bays, and other small depressions, in upland, usually sandy areas.

Soils: Peaty sands or thicker organic accumulations. The small depressions are seldom distinguished on soil maps. They probably represent inclusions of series similar to those on which Pond Pine Woodlands occur.

Hydrology: Palustrine, seasonally flooded or intermittently exposed. May receive drainage from oligotrophic sandy areas.

Vegetation: Dense to fairly dense shrub layer, with species including Lyonia lucida, Cyrilla racemiflora, Ilex glabra, Ilex coriacea, Clethra alnifolia, Gaylussacia frondosa, Ilex myrtifolia, Vaccinium corymbosum, and Kalmia carolina. The wettest parts may have Zenobia pulverulenta and Chamaedaphne (Cassandra) calyculata. A sparse to fairly dense tree canopy of Pinus serotina, Acer rubrum, or Persea palustris may be present, with associated Magnolia virginiana, Nyssa biflora, Taxodium ascendens, Pinus taeda, Magnolia virginiana, and Gordonia lasianthus. Smilax laurifolia and Smilax glauca may be common. Herbs are generally sparse, but may include Osmunda cinnamomea, Woodwardia virginica, W. areolata, and Carex spp.

A distinctive savanna-like ecotonal zone, as on the edges of Pond Pine Woodlands, may sometimes be present, although in many instances the edge with uplands is abrupt.

Dynamics: Because of their small size, Small Depression Pocosins are subject to influence from adjacent, usually more frequently burned communities. Fires sweeping across uplands may not usually burn all the way across a Small Depression Pocosin, but they will affect a significant portion of it. Some of the nutients released by fires on adjacent areas will also reach the Small Depression Pocosin, even if it does not itself burn. Thus, it is likely that they are somewhat more fertile than other pocosin community types. The combination of more frequent disturbance and greater nutrient input may account for the higher shrub diversity, which includes some species not usually found in other pocosin community types. It also makes them susceptible to indirect disruption when surroundings lands are disturbed or when fire is eliminated.

Range: Throughout the Coastal Plain and Sandhills.

Associations: Small areas, generally surrounded by Pine Savanna, Wet or Dry Pine Flatwoods, or Pine/Scrub Oak Sandhill. Often associated with Vernal Pools and Small Depression Ponds in complexes of limesink depressions.

Distinguishing Features: Small Depression Pocosins are distinguished from upland and flatwoods communities by their dense tall shrubby vegetation. Small Depression Pocosins grade conceptually into Pond Pine Woodlands and High Pocosins that occur in smaller swales, and the boundary is arbitrary. Areas should be classified as Small Depression Pocosin if they occur in depressions less than 10 acres in size and are well isolated from other pocosin communities. Small Depression Ponds may have a dense pocosin-like shrub zone around the edge. For practical reasons, this is considered part of the Small Depression Pond occurrence, even though it is similar to Small Depression Pocosins.

Variation: Very variable in structure and composition, in response to differences in fire history, wetness, and geographic location. No distinct variants have been recognized.

Comments: Little detailed information is available on these communities. Some studies mention them in passing but do not describe them specifically. It is not clear how much of the general information on pocosins applies to them. Their small size and different environment make them distinct from the peatland pocosins. The differences in their dynamics are speculative, since no studies or systematic observations have been done.

In addition to their relationship to other pocosin community types, Small Depression Pocosins also have close ties to Small Depression Ponds, which often have pocosin-like edge zones. The environments of Small Depression Ponds, Vernal Pools, and Small Depression Pocosins appear very similar and are often associated. Differences in hydroperiod seem to be responsible for the different vegetation of the community types. The three types may represent different stages in primary succession, which is proceeding at different rates in different depressions.

Small Depression Pocosins are not extremely rare but potential acreage is very limited. Examples which have had a

natural fire history may be extremely rare.

Rare Plant Species: Vascular -- Eriophorum virginicum, Hypericum adpressum, Lindera melissifolia, Litsea aestivalis.

Synonyms:
Swale, pocosin (general usage).

Examples:
Patsy Pond complex and areas along Millis Road, Croatan National Forest, Carteret County (Snyder 1980).
Neuse River Sand Ridge, Craven County (McDonald, Ash, and Fussell 1981).
Piney Pools, Sandhills Gamelands, Scotland County (N.C. Vegetation Survey 1989).
Carolina Beach State Park and Sunny Point Buffer Zone, New Hanover County.
Lanier Quarry Savanna, Pender County.

References: Bennett and Nelson (1990), Frost (1989), McDonald, Ash, and Fussell (1981), North Carolina Vegetation Survey (1989), Snyder (1980), Woodwell (1956).

Sample Plant Communities:
Pinus serotina/Cyrilla racemiflora.
Pinus serotina/Gaylussacia frondosa.
Acer rubrum-Magnolia virginiana/Persea palustris-Cyrilla racemiflora.
Pinus serotina/mixed pocosin shrubs.
Lyonia lucida-Cyrilla racemiflora.
Pinus serotina-P. taeda/Persea palustris/Ilex glabra.

WET PINE FLATWOODS

Sites: Seasonally wet to usually wet sites, generally on flat or nearly flat Coastal Plain sediments.

Soils: Most commonly wet sandy Spodosols such as Leon (Aeric Haplaquod). Sometimes on wet Ultisols such as Rains (Typic Paleudult), Coxville (Typic Paleudult), Goldsboro (Aquic Paleudult), Lynchburg (Aeric Paleaqult), or Lignum (Aquic Hapludult).

Hydrology: Palustrine, seasonally saturated, but may become quite dry for part of the year.

Vegetation: Open to closed canopy of Pinus palustris, sometimes mixed with P. taeda or P. serotina. Understory absent or may contain invading hardwoods. A low shrub layer of varying density is usually present. Common species may include Ilex glabra, Gaylussacia frondosa, G. dumosa, Kalmia carolina, Lyonia mariana, Magnolia virginiana, Persea palustris (borbonia), and Arundinaria gigantea. Vaccinium crassifolium may form dense mats. The herb layer is generally dominated by Aristida stricta, though Pteridium aquilinum may dominate locally. Other typical herbs include Schizachyrium (Andropogon) scoparium, Andropogon glomeratus, Xyris sp., and Panicum virgatum. Herbaceous diversity is lower than in the Pine Savanna type. Shrub and herb patches often appear randomly intermixed, but they may be strongly zoned near the wet ecotone with adjacent pocosin communities. A number of distinctive species are associated with this ecotone.

Where Wet Pine Flatwoods borders Pond Pine Woodland or other pocosin communities, a distinct ecotonal zone often occurs, where the more frequent fire of the flatwoods 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, with a high diversity of herbaceous plants absent from both of the adjoining communities. This ecotone is the primary habitat for a number of rare plant species.

Dynamics: These communities naturally experienced frequent, low to moderate intensity surface fires which maintained a somewhat open canopy, open to sparse shrub layer, and vigorous herb layer. These fires have been largely eliminated in recent decades, resulting in changes in community structure. In some sites, Pinus taeda and weedy facultative wetland hardwoods invade in the absence of fire, but in other sites they apparently are excluded by some other factor.

Range: Widespread in the outer and middle Coastal Plain, less common in the Sandhills.

Associations: Frequently associated with Pond Pine Woodland and with Pine/Scrub Oak Sandhill, Xeric Sandhill Scrub, or Coastal Fringe Sandhill. Sometimes grades into the rarer Pine Savanna and Mesic Pine Flatwoods types.

Distinguishing Features: Wet Pine Flatwoods are distinguished from Pond Pine Woodland and other pocosin communities by the dominance of herbs and low shrubs such as Ilex glabra, Gaylussacia frondosa, and Kalmia carolina over the taller pocosin shrubs such as Lyonia lucida and Cyrilla racemiflora.

Wet Pine Flatwoods is separated from the new Mesic Pine Flatwoods type at the Terrestrial-Palustrine boundary. However, these two types often grade into each other, and the boundary may be difficult to determine. Some examples may contain fairly even mixtures of facultative, facultative wet, and facultative upland species.

The boundary with Pine Savanna is not well understood. Both types may have a savanna structure, but flatwoods are generally shrubby and have a lower herb diversity, with more upland plant species. Where both occur in the same area, the flatwoods tend to occur on drier sites, but the boundary may shift in response to long term fire regime.

Variation: A very heterogeneous type that may require further subdivision. Several variants are tentatively recognized:

1. Wet Spodosol Variant, the most typical variant, best matching the vegetational description above.

2. Lumbee Variant, known on wet Ultisols in Robeson County, with a mixed pine canopy, some oak understory, and a more diverse herb layer including an abundance of legumes.

3. Leiophyllum Variant, known on wet Spodosols in southeastern Brunswick County, with Leiophyllum buxifolium as a codominant in the shrub layer.

Comments: The Wet Pine Flatwoods type as defined here represents only a subset of the communities that have been called flatwoods. Christensen (1988) notes that the name "flatwoods" has been used for just about any Coastal Plain pine forest with a well-developed woody understory, and it is also occasionally used for communities lacking a woody understory. Some of these communities have also been given the name savanna. Unfortunately, there seems to be no concise name for this type that does not carry such confusion with it.

The Wet Pine Flatwoods and Mesic Pine Flatwoods types represent a new splitting of the Pine Flatwoods type of the Second Approximation. The split was done both to have separate wetland and upland types and to reduce the range of variation in this broad category. Despite the split, Wet Pine Flatwoods remains a heterogeneous category that may require future splitting.

The relationships of Wet Pine Flatwoods, Mesic Pine Flatwoods and Pine Savanna are somewhat unclear. Where Wet Pine Flatwoods co-occurs with Pine Savanna, the flatwoods appears to occur in slightly drier sites. Differences in soil type may also play a role. In other situations Wet Pine Flatwoods appear to have developed successionally by loss of herb diversity and increase of shrubs in Pine Savanna sites where fire had long been excluded. Thus, it appears that Pine Savannas and Wet Pine Flatwoods have different but overlapping environmental ranges, with the boundary between the two determined by fire history. The complex interaction of hydrology, soil type, and fire make sorting out and classifying the communities difficult. The confusion on classification and naming makes it difficult to know what knowledge on community function is applicable to which types.

Rare Plant Species: Vascular -- Dionaea muscipula, Hypericum adpressum, Lysimachia asperulifolia, Pleea tenuifolia, Syngonanthus flavidulus, Tofieldia glabra, Xyris baldwiniana.

Synonyms:
Pine Flatwoods (Second Approximation and general usage) (in part).

Examples:

Wet Spodosol variant:
Salters Lake, Jones Lake State Park, Bladen County.
Bladen Lakes State Forest, Bladen County (several natural areas).
Atlantic Natural Area, Carteret County (Fussell and Wilson 1983).
Little Road Longleaf Savannas, Croatan National Forest, Carteret County (McDonald, Ash, and Fussell, 1981).
James Tract, Pender County.
Beaver Dam Creek-Little Muddy Creek Natural Area, Sandhills Game Land, Scotland County.
Lumber River-Drowning Creek Flatwoods, Sandhills Game Land, Scotland County.

Lumbee Variant:
Moss Neck Savanna, Robeson County.

Leiophyllum Variant:
Boiling Spring Lakes Wetland Complex, Brunswick County (Nifong 1981)
Military Ocean Terminal at Sunny Point, Brunswick County.

References: Christensen (1977), Christensen (1988), Fussell and Wilson (1983), Hartshorn (1972), Leonard and Davis (1981), McDonald, Ash, and Fussell (1981), Nifong (1981), Peacock and Lynch (1982b), Schneider (1990).

Sample Plant Communities:
Pinus palustris/Aristida stricta.
Pinus palustris/Aristida stricta-Pteridium aquilinum.
Pinus palustris/Arundinaria gigantea.
Pinus palustris/Ilex glabra.
Pinus palustris/Gaylussacia frondosa.

Pinus palustris/Vaccinium crassifolium.
Pinus palustris/Vaccinium crassifolium-Aristida stricta.
Pinus palustris/Kalmia carolina.
Pinus palustris/Leiophyllum buxifolium.
Pinus palustris/Leiophyllum buxifolium-Ilex glabra.
Pinus palustris-Pinus serotina/Leiophyllum buxifolium-Ilex glabra.
Pinus palustris-Pinus serotina/Ilex glabra.
Pinus palustris-Pinus serotina/Aristida stricta.
Pinus taeda/Ilex glabra.
P. taeda/Arundinaria gigantea.

PINE SAVANNA

Sites: Wet, generally flat areas, and occasionally low "islands" in peatlands or swamps, saturated part of the year, with frequent fire.

Soils: Pine Savannas occur on a variety of wet mineral soils, including Ultisols, Alfisols, and Spodosols. Typical series are Woodington (Typic Paleaquult), Foreston (Aquic Paleudult), Grifton (Typic Ochraqualf), Leon (Aeric Haplaquod), Baymeade (Arenic Hapludult), Pantego (Umbric Paleaquult), and Rimini (Entic Haplohumod).

Hydrology: Palustrine, seasonally saturated by a high or perched water table.

Vegetation: Open to sparse canopy of Pinus palustris, sometimes with P. serotina codominating or dominating. Scattered Ilex glabra, Vaccinium crassifolium, Myrica cerifera, Gaylussacia frondosa, or other shrubs may be present. The herb layer is generally dense, except immedately after a fire, and is very diverse, with grasses, sedges, composites, orchids, and lilies particularly prominent. Graminoids, usually Aristida stricta, Muhlenbergia expansa, Schizachyrium (Andropogon) scoparium, and Ctenium aromaticum, usually dominate. Other frequently encountered species include Rhynchospora cephalantha, Rhynchospora (Dichromena) latifolia, other Rhynchospora species, Scleria spp., Andropogon glomeratus var. glaucopsis, Calopogon pallidus, Calopogon tuberosus (pulchellus), Aletris farinosa, Aletris aurea, Eriocaulon decangulare, Eryngium integrifolium, Fuirena squarrosa, Platanthera (Habenaria) blephariglottis, Platanthera (Habenaria) cristata, Cleistes divaricata, Linum floridanum, Lobelia canbyi, Cirsium (Carduus) virginianum, Cirsium (Carduus) lecontei, Eupatorium spp., Helianthus angustifolius, Helianthus heterophyllus, Liatris spicata, Lilium catesbaei, Xyris caroliniana, Hypoxis spp., Oxypolis filiformis, Marshallia graminifolia, Bigelowia (Chondrophora) nudata, Carphephorus tomentosus, Carphephorus (Trilisa) paniculatus, Erigeron vernus, Chaptalia tomentosus, Pteridium aquilinum, Zigadenus glaberrimus, Zigadenus densus, Tofieldia glabra, Tofieldia racemosa, Lycopodiella (Lycopodium) alopecuroides, Oxypolis ternata, Polygala lutea, P. hookeri, P. cruciata, Rhexia alifanus, and Rhexia lutea. Insectivorous plants such as Dionaea muscipula, Sarracenia flava, Sarracenia purpurea, Drosera capillaris, Drosera brevifolia (leucantha), and Pinguicula caerulea are often common.

Dynamics: These communities naturally experienced frequent, fairly low intensity surface fires. Frequent fire is essential for maintaining the high species diversity and the vegetational structure. Fire also increases primary production in the community (Garren 1943, Christensen 1977, Schneider 1988). In the absence of fire the canopy may become denser and shrubs invade. With longer fire suppression some Pine Savannas may succeed to Wet Pine Flatwoods or Pond Pine Woodland.

The season of burning has also been found to be important in determining vegetation structure and composition. Schneider (1988) found that in general spring and summer fires favored grass dominance while fall fires favored shrubs more.

Range: Lower Coastal Plain.

Associations: Frequently borders Pond Pine Woodland or other pocosin communities, often with a fire-sharpened boundary. May grade to Wet Pine Flatwoods, Mesic Pine Flatwoods, or sandhill communities. May contain depressions with Vernal Pool, Small Depression Pocosin, or Small Depression Pond communities.

Distinguishing Features: Pine Savannas are distinguished from Pond Pine Woodlands and other pocosin communities by the dominance of herbs with little shrub component. The boundary with Wet Pine Flatwoods and Mesic Pine Flatwoods is not well understood. Both may have a savanna structure, but flatwoods are generally shrubby and have a lower herb diversity, with more upland plant species. Where both occur in the same area, the flatwoods tend to occur on drier sites, but the boundary may shift in response to long term fire regime.

Sandhill Seeps may share many characteristics with Pine Savannas, including high herb diversity and low woody cover. They may be distinguished by occurrence on hillsides with seepage rather than on flats with high water tables, and by floristic differences.

Variation: The high species diversity allows for substantial variation in vegetation, which is probably related to soil,

hydrology, microtopography, and fire history. In very wet places Pinus serotina may replace P. palustris as the predominant canopy tree, and even Taxodium ascendens may occasionally be important. Although Aristida stricta is the most common dominant herb, areas may be dominated by Muhlenbergia expansa, Ctenium aromaticum, Arundinaria gigantea ssp. tecta, Pteridium aquilinum, or Sporobolus teretifolius.

Several studies have described subcategories within savannas. Woodwell (1956) recognized three herb unions: 1) Aristida stricta with Polygala lutea and Rhexia alifanus on sandy soils; 2) Muhlenbergia capillaris (expansa?) with Panicum spp., Rhexia alifanus, and Sarracenia flava on clay soils; and 3)
Andropogon glomeratus var. glaucopsis with Schizachyrium scoparium, on both sand and clay. Kologiski (1977), in the Green Swamp, recognized six plant community types in his pine-graminoid, pine-filicalean, and pine-ericalean community classes of pine savannas. Walker and Peet (1983) described dry, mesic, and wet savannas in the Green Swamp. Only the wet and mesic categories fall into the Pine Savanna type as defined here.

Comments: The Pine Savanna type as defined here represents only a subset of communities that have been called savannas. Other community types may also have a savanna vegetational structure, with a dense herb layer, open tree canopy, and little in the middle strata. The Pine Savanna type is intended to include the sites most consistently called savannas in North Carolina -- the extremely high diversity communities on frequently burned wet sites, primarily in the lower Coastal Plain.

The relationship with Wet Pine Flatwoods is somewhat unclear. In sites where it co-occurs with Pine Savanna, it appears to occur in slightly drier sites. Differences in soil type may also play a role. In other situations Wet Pine Flatwoods appear to have developed successionally by loss of herb diversity and increase of shrubs in Pine Savanna sites where fire had long been excluded. Thus, it appears that Pine Savannas and Wet Pine Flatwoods have different but overlapping environmental ranges, with the boundary between the two determined by fire history.

Pine Savannas are notable for their high plant species richness on a small scale (Walker and Peet 1983). Square meter plots with as many as 52 species of vascular plants have been reported from the Green Swamp (Peet, pers. comm.). In plots covering 625 square meters, Walker and Peet (1983) found 70-84 species, making this site one of the richest in temperate North America at that scale. Pine Savannas are of great interest for the theoretical study of the causes of species diversity in communities. Among the large number of species are a great many rare plants, more than associated with any other natural community type in the state.

Rare Plant Species: Vascular -- Agalinis aphylla, Agalinis fasciculata, Agalinis linifolia, Agalinis tenella, Agalinis virgata, Allium sp. 1, Amorpha georgiana var. confusa, Amphicarpum purshii, Andropogon glomeratus var. glaucopsis, Andropogon mohrii, Anthaenantia rufa, Aristida palustris, Asclepias longifolia, Asclepias pedicellata, Balduina atropurpurea, Bartonia verna, Buchnera americana, Cacalia ovata, Calamovilfa brevipilis, Calopogon barbatus, Cirsium lecontei, Cirsium virginianum, Cladium mariscoides, Coreopsis gladiata, Dichanthelium erectifolium, Dionaea muscipula, Drosera filiformis, Gentiana autumnalis, Gratiola aurea, Helenium brevifolium, Helenium pinnatifidum, Helenium vernale, Helianthus heterophyllus, Hibiscus aculeatus, Hypericum adpressum, Hypoxis sessilis, Linum floridanum var. chrysocarpum, Lophiola aurea, Lysimachia asperulifolia, Lysimachia loomisii, Macbridea caroliniana, Oxypolis ternata, Parnassia caroliniana, Pinguicula lutea, Pinguicula pumila, Plantago sparsiflora, Platanthera integra, Platanthera nivea, Pleea tenuifolia, Polygala brevifolia, Polygala hookeri, Psilocarya nitens, Rhexia aristosa, Rhynchospora breviseta, Rhynchospora filifolia, Rhynchospora intermixta, Rhynchospora oligantha, Rhynchospora pallida, Rhynchospora stenophylla, Rhynchospora wrightiana, Sarracenia minor, Sarracenia rubra, Schwalbea americana, Scleria georgiana, Scleria minor, Scleria verticillata, Sisyrinchium rosulatum, Solidago pulchra, Solidago verna, Sphenopholis filiformis, Spiranthes longilabris, Sporobolus teretifolius, Syngonanthus flavidulus, Thalictrum cooleyi, Tofieldia glabra, Trillium pusillum var. pusillum, Xyris baldwiniana, Xyris brevifolia, Xyris difformis var. floridana, Xyris flabelliformis; nonvascular -- Campylopus carolinae, Lophozia capitata, Sphagnum fitzgeraldii.

Synonyms:
Grass-Sedge Bog (Wells and Shunk 1928, Wells 1928).
Sometimes included in the large range of communities called flatwoods in general usage.

Examples:
Green Swamp Preserve, Brunswick County (Kologiski 1977, McIver 1981, Schneider 1988, Walker and Peet 1983).
Lanier Quarry Savanna, Pender County (Leonard and Davis 1981, Weakley 1980a).

Millis Road Savanna, Croatan National Forest, Carteret County (Fussell and Wilson 1983, Snyder 1980) (wetter portions).
Parker Savanna, Pender County.
Schulkens Savanna, Brunswick County.
Holly Shelter Game Land, Pender County.
Nakina Savanna, Columbus County.
Myrtle Head Savanna, Brunswick County.

References: Christensen (1977), Christensen (1981), Fussell and Wilson (1983), Gaddy (1982), Garren (1943), Kologiski (1977), Leonard and Davis (1981), McIver (1981), Nifong (1981), Roberts and Oosting (1958), Schneider (1988), Schneider (1990), Snyder (1980), Walker and Peet (1983), Weakley 1980a, Wells and Shunk (1928), Wells and Whitford (1976).

Sample Plant Communities:
Pinus palustris/Aristida stricta.
P. palustris/Aristida stricta-Liatris graminifolia-Chrysopsis graminifolia.
P. palustris/Gaylussacia dumosa-Aristida stricta.
P. palustris/Mixed sedges.
P. palustris/Muhlenbergia expansa.
P. palustris/Sporobolus teretifolius.
P. palustris/Arundinaria gigantea ssp. tecta.
P. palustris/Aristida stricta-Rhynchospora spp.
P. serotina/Aristida stricta-Rhynchospora spp.
P. serotina/Mixed sedges.

SANDHILL SEEP

Sites: Slopes in sand ridge or sandhill areas where water is forced to the surface by a clay layer.

Soils: Wet sands underlain by clays. Usually mapped as Vaucluse (Typic Hapludult) or Blaney (Arenic Hapludult), but probably represents inclusions in these map units.

Hydrology: Palustrine, seasonally to permanently saturated with oligotrophic waters.

Vegetation: Dense to open growth of various wetland shrubs and herbs, or mixtures of wetland and upland species, with structure determined by fire regime. Common shrubs include Clethra alnifolia, Lyonia lucida, Aronia (Sorbus) arbutifolia, Ilex glabra, Gaylussacia frondosa, Symplocos tinctoria, Myrica heterophylla, and Toxicodendron (Rhus) vernix. A variety of other shrubs may be present in some sites. Arundinaria gigantea ssp. tecta may dominate in places. Trees may be present. Species include Pinus palustris, P. serotina, P. taeda, Acer rubrum, Magnolia virginiana, and Persea palustris. Herbs are sparse under shrub cover but may dominate frequently burned sites. Typical herbs include Osmunda cinnamomea, Xyris caroliniana, Pteridium aquilinum, Woodwardia virginica, Dichanthelium (Panicum) spp., Andropogon glomeratus, Ctenium aromaticum, Sarracenia flava, S. purpurea, S. rubra, Drosera capillaris, Rhexia alifanus, Polygala lutea, Eupatorium pilosum, and Aristida stricta. Sphagnum spp. are common. On frequently burned sites a great diversity of other herbs may also be present.

Dynamics: Community structure is strongly controlled by fire regime. Because of their small size, Sandhill Seeps are subject to fires spreading from adjacent sandhill communities, and under natural fire regimes probably burned more frequently than other similarly wet communities. At least parts of them burned almost as frequently as the adjoining sandhill communities. Under frequent fire Sandhill Seeps are open and herb-dominated, resembling Pine Savannas. In the absence of fire shrubs quickly expand and the vegetation becomes pocosin-like.

The nutrient dynamics of these communities are not known. The presence of clay in the soil may allow greater retention of nutrients than in sandy soils, although the seepage is likely to be very low in nutrients. Like other small communities in sandhill areas, nutrients mobilized by fire may be available to Sandhill Seeps even if they do not themselves burn.

Range: Primarily in the Sandhills region but present in scarps and sand ridges elsewhere in the Coastal Plain.

Associations: Borders or grades into Mesic Pine Flatwoods or Pine/Scrub Oak Sandhill above. May grade into Streamhead Pocosin, Small Stream Swamp, or Wet Pine Flatwoods below.

Distingishing Features: Sandhill Seeps are distinguished by the occurrence of wetland vegetation on seepage slopes. The boundary with Streamhead Pocosin may be difficult to determine in some areas. In frequently burned sites Sandhill Seeps are herb-dominated, while Streamhead Pocosins are shrub-dominated. In infrequently burned areas where both are shrubby, Sandhill Seeps may be recognized by partial or total isolation from a stream system, location on a sharp slope break, or by remnants of the herbaceous vegetation beneath the shrubs. Herb-dominated Sandhill Seeps share many species with Pine Savannas, but may be distinguished by their occurrence on relatively small, sloping, seepage areas in sandhills.

Variation: Sites vary greatly with fire history and wetness, from dense shrub thickets to herb-dominated boggy spots. Changes in structure can occur rapidly with change in fire regime. Sites out of the Sandhills region seem to differ from those in the Sandhills, but too few are known to assess their differences.

Comments: This type was called Seepage Pocosin in the Second Approximation. The new name and description represent new knowledge and a change in our concept of these communities. In most parts of the Sandhills, fire suppression has allowed the Sandhill Seeps to grow up into dense, pocosin-like vegetation, though they often remain more diverse than typical pocosins. In very frequently burned seepage areas on Fort Bragg the N.C. Vegetation Survey (1989) found communities of herbs, sometimes with sparse shrubs. These communities had extremely high species richness, with up to 102 species per 1/100 hectare (10x10 meters), apparently surpassing even the great species richness of Pine Savannas, and the highest known in temperate North America. Those seeps may represent unusually rich examples, but Jay Carter (pers.

comm.) notes that many Sandhill Seeps had fairly diverse herbaceous vegetation that has gradually disappeared with the lack of fire.

It is unclear how common Sandhill Seeps are. They may be fairly widespread in the northern part of the Sandhills region, in Moore and Hoke County, but they have always been of limited acreage. Because they so quickly become overgrown with shrubs, examples in good condition are now extremely rare.

Rare Plant Species: Vascular -- Calamovilfa brevipilis, Carex barrattii, Carex exilis, Carex tetanica, Carex turgescens, Cladium mariscoides, Dionaea muscipula, Eriophorum virginicum, Eupatorium resinosum, Glyceria obtusa, Lilium sp. 1, Parnassia caroliniana, Rhynchospora alba, Rhynchospora pallida, Sagittaria engelmanniana, Sarracenia rubra, Schwalbea americana, Scleria minor, Solidago verna, Tofieldia glabra, Xyris baldwiniana.

Synonyms:
Seepage Pocosin (Second Approximation).
May sometimes be referred to as pine savanna, grass-sedge bog, or pocosin.

Examples:
Fort Bragg, particularly in the McPherson Impact Area, Hoke County (N.C. Vegetation Survey) (the best examples known of frequently burned seeps).
Still Lane Seepage Slopes and Bone Fork natural areas, Sandhills Game Land, Scotland County (small and less frequently burned).
Seeps on Suffolk Scarp, Beaufort County (Hartshorn 1972).
Tate Road Savanna, Onslow County (Schneider 1990).

References: North Carolina Vegetation Survey (1989), Schneider (1990), Walker and Peet (1983).

Sample Plant Communities:
Osmunda cinnamomea-mixed wetland herbs.
Mixed wetland herbs.
Pinus serotia/Lyonia lucida.
Clethra alnifolia.
Pinus palustris/Arundinaria gigantea ssp. tecta.
Mixed pocosin shrubs/Sphagnum spp.

VERNAL POOL

Sites: Small, seasonally flooded depressions, with gently sloping sides, usually in sandy uplands.

Soils: These small areas are not generally distinguished on soil maps, or are indicated by a symbol as "wet spots" or "depressions" without a soil series being named.

Hydrology: Palustrine, seasonally flooded.

Vegetation: Dominated by a dense to sparse herbaceous layer. Species vary among examples. Schizachyrium (Andropogon) scoparium and Panicum spp. are the most common dry-season dominants, although other examples are dominated by Leersia hexandra or by Carex spp. and ferns such as Woodwardia virginica. Many examples have strong zonation of dominants. Commonly associated species include Centella asiatica, Dichanthelium spp., Andropogon spp., Drosera spp., and Sphagnum spp. During the wet season Utricularia spp. and other aquatic plants may be important. A few individual wetland trees or shrubs may be present in the pool interior. A shrub border, as described for the Small Depression Pond type, is sometimes present but is not usually as well developed.

Dynamics: The seasonal fluctuation in water levels and its variation among years is the primary environmental factor in these communities. Significant seasonal variation in presence and activity of species occurs. Some Vernal Pools are wet enough to accumulate muck on the bottom, while others remain sandy. Most have little or no watershed and probably do not receive much runoff or its nutrient input.

When dry, Vernal Pools are subject to fires spreading from adjacent uplands. The importance of fire in these communities is not known, but it may be significant for preventing invasion by woody plants and in nutrient cycling. Season of fire is important since winter fires are unlikely to burn the water- filled pools. In the primary natural fire season, in early to mid summer, most Vernal Pools would probably be able to burn during dry years but not wet years.

Range: Throughout the Coastal Plain and Sandhills, but most common in the outer Coastal Plain from Brunswick to Carteret counties.

Associations: Surrounded by various upland communities, particularly Xeric Sandhill Scrub, Pine/Scrub Oak Sandhill, Coastal Fringe Sandhill, or Mesic Pine Flatwoods. Vernal Pools often occur in complexes of limesinks or other small depressions with Small Depression Pocosins and Small Depression Ponds.

Distinguishing Features: Vernal Pools are distinguished from Small Depression Pocosins by herbaceous rather than shrub or tree dominance. They are distinguished from Small Depression Ponds by drying most or all years. Obligate aquatic plants are absent. Vernal Pools are distinguished from Cypress Savannas by differences in species composition. The most important environmental differences between Vernal Pools and Cypress Savannas are not well known. Seasonally flooded depressional wetlands may occur in the Interdune Pond community types, but these are located on the barrier islands and have maritime influence. Likewise, Upland Pools are seasonally flooded but occur in the Piedmont and Mountains. Both of these distinctions can also be made on floristic and other bases. The wettest parts of Pine Savannas may resemble Vernal Pools, but are flooded less deeply and for shorter duration.

Variation: Vernal Pools are quite variable, depending on depth, length of flooding, substrate, and fire regime. Because they are small and isolated, much variation may also result from accidents of dispersal and establishment of species.

Comments: These communities are often extremely important breeding sites for amphibians. One Vernal Pool was reported to contain 17 species of frogs (Henry Wilbur, pers. comm.).

Little work has been done on the vegetation dynamics of these communities. They are seldom described specifically in detail. It is therefore difficult to tell how rare they are.

Most Vernal Pools occur in complexes of small, circular depressions believed to be limesinks, where surface sands have slumped in response to solution of underlying limestone. The limestone is deep enough to have no effect on the water chemistry of the pools. Vernal Pools may also occur in small Carolina bays, and in round or irregular depressions of

unknown origin. Vernal Pools are often associated with Small Depression Ponds and Small Depression Pocosins in complexes of small depressions.

Rare Plant Species: Vascular -- Helenium pinnatifidum.

Synonyms:
Pond, pool, limesink (general usage).

Examples:
Piney Pools, Sandhills Game Land, Scotland County.
Carolina Beach State Park, New Hanover County.
Bog Hole (Seventeen Frog Pond, Grassy Pond), Sandhills Game Land, Scotland County (an unusually wet example, transitional to Small Depression Pond).

References: North Carolina Vegetation Survey (1989).

Sample Plant Communities:
Schizachyrium (Andropogon) scoparium.
Schizachyrium scoparium-Panicum sp.
Eleocharis melanocarpa.
Leersia hexandra.
Coelorachis (Manisurus) rugosa-Dichanthelium sp.
Woodwardia virginica-Carex bullata.
Panicum hemitomon.

CYPRESS SAVANNA

Sites: Clay-based Carolina bays and possibly other wet clayey depressions.

Soils: Wetland soils with a clay hardpan, generally McColl (Typic Fragiaquult) and Rains (Typic Paleaquult) series.

Hydrology: Palustrine, seasonally to temporarily flooded.

Vegetation: Open to sparse canopy dominated by Taxodium ascendens, with or without Nyssa biflora, Pinus taeda, Pinus serotina, Liquidambar styraciflua, other wetland trees, or shrubs; rarely lacking a canopy. Shrubs include Ilex amelanchier, Leucothoe racemosa, Cyrilla racemiflora, and Lyonia lucida. Important herbs include Panicum hemitomon, Panicum verrucosum, Dichanthelium (Panicum) spp., Erianthus alopecuroides, Carex striata (walteriana), Woodwardia virginica, Rhynchospora inundata, R. tracyi, R. corniculata, other Rhynchospora spp., Scleria reticularis var. pubescens, Andropogon virginicus, Eleocharis melanocarpa, Lachnanthes caroliniana, Leersia hexandra, Boltonia sp., Sagittaria isoetiformis, Utricularia inflata, and Pluchea rosea.

Dynamics: These communities are apparently dependent on a combination of flooding and fire to maintain their open savanna structure. After several years without flooding due to drought, young pine and hardwoods began to invade many sites. It remains to be seen if subsequent flooding in wetter years will eliminate them. Cypress Savannas undoubtedly burned periodically under natural conditions and this would have helped restrict establishment of woody species. The frequency of natural burning is not known. Because the natural fire season was primarily in the summer when bays are often dry, Cypress Savannas may have burned fairly frequently. Peroni (1988) found that physiognomy of Cypress Savannas had remained relatively constant for the past 50 years despite grazing and lack of fire.

Range: Restricted to the region of clay-based Carolina bays on the southern part of the inner Coastal Plain. They are more numerous and widespread in South Carolina (Bennett and Nelson 1990).

Associations: May surround and grade to Small Depression Pond in bays. Upland associates are poorly known, but probably included Mesic Pine Flatwoods, Wet Pine Flatwoods, and Pine/Scrub Oak Sandhill.

Distinguishing Features: Cypress Savannas are distinguished from Pine Savannas by deeper and longer flooding and different species composition. Taxodium ascendens may occasionally occur in Pine Savannas but will be associated with a typical Pine Savanna herb layer. Cypress Savannas are distinguished from Small Depression Ponds with cypress by the herb layer composition and the periodic absence of standing water. They are distinguished from Vernal Pools by differences in species composition. The most important environmental differences between Vernal Pools and Cypress Savannas are not well known. Cypress Savannas are distinguished from Small Depression Ponds by lacking permanent water (drying up many summers), and by having different species composition and having an open canopy of Taxodium.

Variation: Two variants are recognized:

1. Typic Variant, resembling most closely the description given above, and typically having an open canopy of Taxodium ascendens.

2. Depression Meadow Variant, having at most a few scattered Taxodium ascendens, but occurring in clay-based Carolina bays and with herbaceous flora generally similar to the Typic Variant. This variant is recognized in South Carolina by Bennett and Nelson (1990) as "Depression Meadow." The absence of trees is apparently natural, but it is not clear what ecological dynamics prevent pondcypress from occupying these sites. Some examples (Tunstall's Bay) appear to be wetter than typical Cypress Savannas, while others (State-line Prairie Bay and Cutgrass Bay) do not appear to be notably wetter. This variant is related to Small Depression Ponds and Vernal Pools, and shares some characteristics with each, but its flora and geographic position relate it more closely to Cypress Savannas.

Vegetation also varies in the composition of the herb layer and in the density of cypress and shrubs. Near the margins, there

is often distinct zonality of species composition. Fluctuations in water level from year to year produce dramatic changes in herbaceous dominance. Fires also cause great changes in dominance of shrubs and herbs.

Comments: Little is known about the variation in this type from place to place and year to year. It is a very rare community type in North Carolina. It is somewhat more abundant, but still rare, in South Carolina.

Rare Plant Species: Vascular -- Amphicarpum floridanum, Drosera filiformis, Echinodorus parvulus, Eleocharis atropurpurea, Eleocharis melanocarpa, Gratiola ramosa, Ilex amelanchier, Iva microcephala, Lobelia boykinii, Muhlenbergia torreyana, Oldenlandia boscii, Oxypolis canbyi, Rhexia aristosa, Rhynchospora filifolia, Rhynchospora inundata, Rhynchospora tracyi, Sagittaria isoetiformis, Scleria reticularis var. reticularis, Sclerolepis uniflora, Utricularia cornuta.

Synonyms: Clay-based Carolina bay (general usage).
Pond Cypress Savanna (Bennett and Nelson 1990).

Examples (all from Nifong 1982 and Carter 1978):

Typic Variant:
Antioch Carolina Bay, Hoke County.
Goose Pond Carolina Bay, Robeson County.
McIntosh Bays, Scotland County.
Pretty Pond Carolina Bay, Robeson County.

Depression Meadow Variant:
Tunstall's Bay, Scotland County.
State-line Prairie Bay, Scotland County.
Cutgrass Bay, Sampson County.

References: Bennett and Nelson (1990), Bryant (1964), Carter (1978), Harrison (1983), Nifong (1982), Peroni (1988).

Sample Plant communities:
Taxodium ascendens/Andropogon virginicus-mixed graminoids.
T. ascendens/Liquidambar styraciflua/Dichanthelium sp.
T. ascendens/Pluchea rosea/Dichanthelium sp.
T. ascendens-Nyssa biflora/Liquidambar styraciflua.
T. ascendens-Pinus taeda/Leucothoe racemosa.
T. ascendens-P. taeda/Liquidambar styraciflua-Quercus laurifolia/Mixed ericaceous shrubs.
T. ascendens-P. taeda/Mixed transgressives/Woodwardia virginica.
T. ascendens/Liquidambar styraciflua/Mixed graminoids.
T. ascendens/Panicum hemitomon.
T. ascendens/Pinus taeda/Sphagnum.
T. ascendens/Rhynchospora tracyi-R. corniculata.
Mixed graminoids.
Panicum hemitomon.
Rhynchospora tracyi.
Lachnanthes caroliniana.

SMALL DEPRESSION POND

Sites: Permanently flooded sinkholes (dolines), Carolina bays, and other upland depressions.

Soils: The soils of ponds are not generally mapped. The surrounding and underlying substrate is generally sandy but the pond may contain clay or organic sediment.

Hydrology: Permanently flooded in center, grading outward to the prevailing hydrology of the surrounding area.

Vegetation: Pond vegetation is a complex of zones, often concentric but sometimes irregular. Both dominant species and species present vary widely among ponds. The deepest parts may be open water or may support aquatic plants such as Nymphaea odorata, Nymphoides aquatica, Nuphar lutea, Proserpinaca pectinata, and various Utricularia species. Shallow water and intermittently exposed edges may contain a variety of emergent and wetland plants, including Panicum hemitomon, other Panicum species, Sacciolepis striata, Eleocharis equisetoides, other Eleocharis species, a number of Rhynchospora species, Centella asiatica, Drosera intermedia, and Woodwardia virginica. Scattered Taxodium ascendens and Nyssa biflora sometimes occur in both deep and shallow water zones. Most ponds are surrounded by a dense zone of shrubs. This zone is often pocosin-like, with species such as Cyrilla racemiflora, Lyonia lucida, Ilex glabra, and Ilex myrtifolia dominating, but it may contain distinctive pond-shore species such as Cephalanthus occidentalis and Litsea aestivalis.

Dynamics: Little is known about the dynamics of these pond communities. Fluctuations in water levels is probably the most important factor, especially for the edge vegetation which is intermittently or seasonally exposed. Most ponds are believed to be very acidic and nutrient poor. Most have little or no watershed and are probably fed by rainfall and groundwater. Since the surrounding soils are generally sandy, acidic, and infertile, both runoff and groundwater are probably nutrient poor.

Range: Scattered throughout the Coastal Plain, but most common in the southern two thirds.

Associations: Usually surrounded by Xeric Sandhills Scrub, Coastal Fringe Sandhill, Mesic Pine Flatwoods, or Wet Pine Flatwoods, but may be surrounded by any upland or wetland community type except floodplain and maritime types. Small Depression Ponds often occur associated with Small Depression Pocosins and Vernal Pools in sinkhole complexes.

Distinguishing Features: Small Depression Ponds are distinguished from the related depressional wetlands, Small Depression Pocosin and Vernal Pool, by the presence of permanent or nearly permanent water in the deeper parts. This is often accompanied by the presence of obligate aquatic plants. The boundary with adjacent upland or wetland communities is taken to be where the regional hydrology predominates over the hydrology of the pond. This will generally be the Terrestrial-Palustrine boundary, but may be wetter if the surrounding community if a wetlands. The pond community is thus defined to include all of the wetland zones, not just the permanently flooded center. Small Depression Ponds are arbitrarily distinguished from lake aquatic communities and Natural Lake Shorelines by an open water acreage less than 8 hectares (20 acres), the Palustrine- Lacustrine boundary used by Cowardin, et al. (1979). They are distinguished from Cypress Savannas by having permanent water (not drying up in most summers) and by having different species composition.

Variation: Ponds are extremely variable among occurrences as well as heterogeneous within individual ponds. Factors likely to be important in determining variation include water depth, water level fluctuation, substrate, slope of sides and bottom, water chemistry, surrounding landscape, geographic location, and accidents of dispersal. The diversity within this type may warrant splitting into several types when further study is done on these communities.

Comments: Small Depression Ponds represent heterogeneous complexes of varying hydrology and vegetational physiognomy. Rather than attempting to separate such zones into many small community types, too small to be handled efficiently, we have kept them together as hydrologic units. Any protection of ponds must be at the level of these hydrologic units. We recognize that particular zones of Small Depression Ponds often are very similar hydrologically and vegetationally to Vernal Pools or Small Depression Pocosins, but believe this to be the best solution to the problem of classifying these complexes.

Small Depression Ponds have a wide range, but occupy very limited acreage and must be considered rare. The

tremendous diversity among examples, and the probability that this type as defined here represents several community types, increases the need for protection of a range of sites.

Most Small Depression Ponds occur in limesink complexes or other clusters of depressions, associated with Small Depression Pocosin and Vernal Pool communities.

Rare Plant Species: Vascular -- Agalinis fasciculata, Coelorachis rugosa, Cyperus lecontei, Drosera filiformis, Eleocharis cellulosa, Eleocharis elongata, Eleocharis melanocarpa, Eleocharis robbinsii, Eleocharis rostellata, Eupatorium leptophyllum, Habenaria repens, Litsea aestivalis, Ludwigia linifolia, Ludwigia peploides ssp. glabrescens, Ludwigia suffruticosa, Myriophyllum laxum, Nymphoides cordata, Polygonum hirsutum, Rhexia aristosa, Rhexia cubensis, Rhynchospora alba, Rhynchospora pleiantha, Rhynchospora tracyi, Utricularia cornuta, Utricularia olivacea.

Synonyms: Various zones are named by investigators of specific sites.

Examples:
Military Ocean Terminal Sunny Point Limestone Sinks, Brunswick County (Nifong 1981).
Spring Creek Pond, Brunswick County (Nifong 1981).
Carolina Beach State Park, New Hanover County (Taggart and Dickerson 1980).
Patsy Pond Complex and Nine Foot Road Ponds, Croatan National Forest, Carteret County (Otte and Whetstone 1979).
Boiling Springs Lake Limesink Complex, Brunswick County (Nifong 1981).
Camp Lejeune Limesink Complex, Onslow County.

References: McDonald, Ash, and Fussell (1981), Nifong (1981), Otte and Whetstone (1979), Taggart and Dickerson (1980).

Sample Plant Communities:
Nymphaea odorata.
Nymphaea odorata-Nymphoides aquatica.
Eleocharis equisetoides/Nuphar lutea.
Rhynchospora inundata/Nuphar lutea.
Myriophyllum laxum.
Utricularia olivacea.
Nymphoides cordata.
Nuphar lutea.
Panicum hemitomon.
Sacciolepis striata.
Rhynchospora fascicularis-Sacciolepis striata.
Mixed graminoids.
Xyris jupicai.
Eleocharis vivipara.
Hydrocotyle umbellata.
Taxodium ascendens.
Taxodium ascendens/Nymphaea odorata.
Taxodium ascendens/Nyssa biflora.
Lyonia lucida-Cyrilla racemiflora/Smilax laurifolia.
Vaccinium corymbosum-Ilex glabra.

NATURAL LAKE SHORELINE

Sites: Vegetated shoreline zones of large natural lakes of various origins.
Soils: Not usually distinguished in mapping. Permanently flooded areas are usually mapped as part of the lake and higher areas are mapped the smae as the surrounding lands. Most of North Carolina's natural lakes are in peatland and are bordered by organic soils, but some have sandy beaches or eroded mineral sediments. Shorelines may be either accreting or eroding.

Hydrology: Water levels, movement, and chemistry are controlled by the lake. Although placed in the Palustrine System by Cowardin et al. (1979) because of emergent vegetation, they are more closely related hydrologically and faunally to the Lacustrine System. Hydroperiod ranges from permanently flooded to the prevailing hydrology of the surrounding area.

Vegetation: Generally a complex of zones which may include emergent graminoids and other herbs, shrub thickets, swamps of Taxodium and Nyssa spp., or various bottomland hardwoods species. Typical shrubs include Cephalanthus occidentalis, Itea virginica, Cyrilla racemiflora, Ilex laevigata, Myrica cerifera, and Lyonia lucida. Herb species may include Panicum hemitomon, Pontederia cordata, Peltandra sagittifolia, Nuphar lutea ssp. lutea, Nuphar lutea ssp. sagittifolia, Nymphaea odorata, Typha latifolia, Juncus effusus, Mayaca aubletii, Myriophyllum tenellum, Scirpus cyperinus, S. americanus, Saururus cernuus, Sagittaria isoetiformis, and Eriocaulon aquaticum.

Dynamics: May be gradually extended by sedimentation or reduced by erosion. Drier zones at edge may be affected by fires from surrounding communities. Nutrient levels and hydroperiod are determined by lake levels and chemistry.

Range: Large natural lakes occur in the Pamlimarle Peninsula, in the Croatan National Forest, in the Bladen Lakes area, and in Columbus County.

Associations: Frequently surrounded by peatland communities but may be surrounded by various upland communities. Grades into blackwater floodplain communities along inlet and outlet streams.

Distinguishing Features: This type includes all palustrine wetlands bordering lacustrine systems. The boundary with the aquatic lake community is at the limit of persistent emergent plants. The boundary with surrounding communities is at the upland boundary or where the lake-controlled hydrology gives way to the prevailing hydrology of the surrounding area. This boundary may be very gradual in some wetland areas. Natural Lake Shorelines are distinguished from Small Depression Ponds by their association with an open water body larger than 8 hectares (20 acres) in size, the Palustrine-Lacustrine boundary defined by Cowardin, et al. (1979).

Variation: This is a very heterogeneous type that will proably be further divided in the future. Important factors determining variation include erosion or accretion of the shoreline, substrate, and water chemistry. Variants that can be recognized include narrow erosional peat shorelines dominated by overhanging shrubs, eroding organic or mineral shorelines with remnant islands of cypress trees, broad accreting or stable shorelines with marshy beds of emergent graminoids, and low bottomland hardwood-dominated areas. These variants are distinctive when well developed, but many shorelines are intermediate or are complex mixtures of several.

Comments: Natural Lake Shorelines represent heterogeneous complexes of varying hydrology and vegetational physiognomy. Rather than attempting to separate such zones into many small community types, too small to be handled efficiently, we have kept them together as hydrologic units separated only along wetland system boundaries. Any protection of a lake must be at the level of the whole lake or at least of the whole segment of shoreline rather than of individual zones.

This type will likely be further divided when more information is available. It is unsatisfyingly heterogeneous and difficult to characterize, because of variability from site to site and presence of complex zonation. Zones of a given species or assemblage may be quite small or narrow.

Rare Plant Species: Vascular -- Bacopa rotundifolia, Epidendrum conopseum, Luziola fluitans, Myriophyllum laxum, Myriophyllum tenellum, Nelumbo lutea, Nuphar lutea ssp. sagittifolia, Sagittaria calycina, Scirpus acutus, Utricularia olivacea, Utricularia resupinata.

Synonyms: None known.

Examples:
Phelps Lake, North Carolina State Parks, Washington County (Lynch and Peacock 1982b).
Catfish Lake, Croatan National Forest, Craven County.
Great Lake, Croatan National Forest, Craven County (Taggart and Fussell 1981).
Lake Ellis Simon, Craven and Carteret counties.
Jones and Salters Lakes, Jones Lake State Park, Bladen County.
Alligator and Swan Lake, Alligator River National Wildlife Refuge, Dare County.

References: Brown (1911), Lynch and Peacock (1982b), Taggart and Fussell (1981).

Sample Plant Communities:
Taxodium distichum.
Taxodium distichum/Asimina triloba/mixed herbs.
Taxodium distichum-mixed bottomland hardwoods.
Liquidambar styraciflua-Nyssa biflora/Persea palustris.
Cyrilla racemiflora-Lyonia lucida.
Panicum hemitomon/mixed aquatic herbs.

MARITIME WET GRASSLAND

Sites: Dune swales and sand flats with water table normally just below the surface, old overwash terraces, and sand-filled marshes.

Soils: Wet sandy soils. Usually mapped as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent).

Hydrology: Palustrine, seasonally or permanently saturated, freshwater. Overwash seldom to moderately frequent.

Vegetation: Dense herbaceous vegetation, with a mixture of wetland and mesic species making for high diversity. Generally dominated by Spartina patens, Fimbristylis spp., or Muhlenbergia filipes. Other species include Rhynchospora (Dichromena) colorata, Scirpus americanus, Andropogon virginicus, Setaria geniculata, Juncus roemerianus, Diodia virginica, Sabatia stellaris, Phyla (Lippia) nodiflora, Hydrocotyle bonariensis, H. umbellata, Bacopa monnieri, Aster tenuifolius, Gaura angustifolia, Lactuca canadensis, Paspalum spp., Panicum spp., Oenothera fruticosa, Mikania scandens, Cynanchum angustifolium (palustre), Xyris jupicai, Vulpia (Festuca) octoflora, Hypericum hypericoides, Centella asiatica, Rhexia mariana, and Eustachys (Chloris) petraea.

Dynamics: As with other barrier island communities, Maritime Wet Grasslands occur in a dynamic environment. Occurrences on low sand flats are overwashed by salt water during severe storms. Overwash may kill species that are not very salt-tolerant, and may temporarily bury the vegetation under new sand deposits. The major species are able to recover from such disturbance if it is not too frequent. If enough sand is deposited the community will be replaced by a Maritime Dry Grassland (Godfrey and Godfrey 1976). Occurrences in dune swales are better protected from overwash, but may be filled by blowing sand.

Most Maritime Wet Grasslands are subject to some salt spray, and this, along with occasional overwash, appears to be significant in preventing succession. With the artificial building of continuous dunes on many islands, many of these communities have been invaded by shrubs and are succeeding to Maritime Shrub or Maritime Shrub Swamp. A similar succession may occur if natural dune growth or beach accretion increase protection from overwash.

Range: Barrier islands.

Associations: Grades into Dune Grass, Maritime Dry Grassland, Maritime Shrub, Brackish or Salt Marsh. Mosaics of Maritime Dry and Wet Grassland often exist on large flats.

Distinguishing Features: Maritime Wet Grasslands are distinguished from Interdune Ponds by the lack of standing water for all or much of the year. They are distinguished from Maritime Dry Grasslands by their high diversity and occurrence on wetter sites. The boundary is at the Terrestrial-Palustrine boundary, where upland species begin to outweigh wetland species.

Maritime Wet Grasslands are separated from Tidal Freshwater Marsh, Brackish Marsh, and Salt Marsh where tidal flooding ceases except during rare severe storms. The vegetational nature of this boundary is not known.

Variation: Examples vary with hydroperiod and degree of protection from overwash and salt spray. The wettest areas approach freshwater marsh and may be quite diverse. Tyndall and Levy (1978), in southern Virginia, recognized several herb associations based on ordination: Scirpus americanus-Hydrocotyle umbellata, Spartina patens-Scirpus americanus, Spartina patens, Andropogon virginicus, Centella asiatica-Juncus elliotii, and Spartina patens-Centella asiatica. These associations were largely controlled by moisture.

Comments: This type is apparently not naturally extremely rare, but like all barrier island communities, it is limited in extent and threatened by recreational and commercial development and modification of the salt spray and overwash environment. It is often not distinguished from Maritime Dry Grassland, and the relative abundance of the two types is not known. The nature of the transition to marsh and upland communities needs further investigation.

Rare Plant Species: Vascular -- Eleocharis cellulosa, Ludwigia alata, Rhynchospora odorata.

Synonyms:
Dune Slack, Mesic Meadow (subsets, Godfrey and Godfrey 1976).
Dune Marsh (Au 1974).
Closed Grassland, Mesic Meadow (Snow and Godfrey 1978).

Examples:
Shackleford Banks and Core Banks, Cape Lookout National Seashore, Carteret County (Au 1974, Godfrey and Godfrey 1976, Snow and Godfrey 1978).
Pine Island Audubon Sanctuary, Currituck County (Parnell, et al. 1987).
Ocracoke Island, Cape Hatteras National Seashore, Hyde County.
Hutaff Island, Pender County (Weakley 1980a).

References: Au (1974), Godfrey and Godfrey (1976), Hosier and Cleary (1979), Parnell, Hosier, Sieren, Webster, and Cooper (1987), Snow and Godfrey (1978), Tyndall and Levy (1978), U.S. Fish and Wildlife Service (1980), Weakley (1980a).

Sample Plant Communities:
Spartina patens.
Spartina patens-Fimbristylis sp.
Fimbristylis sp.-Muhlenbergia filipes.
Mixed wetland herbs.

MARITIME SWAMP FOREST

Sites: Wet areas in well-protected swales, edges of relict dunes, and edges of freshwater sounds.

Soils: Wet mucky or sandy soils, of the Conaby (Histic Humaquept) or Duckston (Typic Psammaquent) series.

Hydrology: Palustrine, seasonally or intermittently flooded or saturated, to intermittently exposed.

Vegetation: Forest dominated by various wetland trees such as Nyssa biflora, Acer rubrum, Liquidambar styraciflua, Fraxinus americana, Taxodium distichum, Pinus taeda, Quercus nigra, or Q. michauxii. Understory trees and shrubs may include Carpinus caroliniana, Persea palustris, Myrica cerifera, Cornus stricta, Magnolia virginiana, Vaccinium fuscatum (atrococcum), and V. corymbosum. Arundinaria gigantea may be common. Common vines include Berchemia scandens, Toxicodendron (Rhus) radicans, and Vitis rotundifolia. The usually sparse herb layer may include Woodwardia virginica, W. areolata, Osmunda cinnamomea, O. regalis var. spectabilis, Boehmeria cylindrica, Saururus cernuus, Mitchella repens, and Carex spp.

Dynamics: The specific dynamics of these communities are not well known. Like all barrier island communities they have the potential for disturbance by storm winds, salt spray, and migrating sand dunes. Acer rubrum may function as an early successional species, eventually giving way, at least partially, to other hardwoods in the absence of severe disturbance. Extensive young Acer-Nyssa forests on the sound side of Currituck Banks may be developing since the adjacent marshes turned from brackish to fresh with the closing of inlets in the banks.

Range: Several scattered locations on the barrier islands.

Associations: Grades to Maritime Forest or Maritime Mesophytic Forest, occurring as inclusions within them or between them and marsh.

Distinguishing Features: This type is distinguished by its occurrence in nontidal maritime wetlands and its dominance by wetland trees other than Persea palustris.

Variation: This type is heterogeneous in vegetation, with several very different canopy compositions occurring at the several isolated sites. Wentworth, et al. (1989) identified four general variants, with Taxodium-dominated, Fraxinus-dominated, Acer-dominated, and mixed Acer-Nyssa-Liquidambar-dominated canopies. Some of these variants may reflect different site conditions, but others may simply be accidents of dispersal to the isolated island locations.

Comments: The Maritime Shrub Swamp type is newly distinguished from the Maritime Swamp Forest. The present boundary between the two types is somewhat arbitrary and may be refined with further study.

This is a very rare type. While less threatened by development than most maritime communities, it may be destroyed by impoundment, ditching, and by lowering of the water table resulting from extensive well pumping.

Rare Plant Species: Vascular -- Corallorhiza wisteriana, Dryopteris ludoviciana, Listera australis, Malaxis spicata.

Synonyms:
Swamp forest (general usage).

Examples (from N.C. Vegetation Survey 1988; Lopazanski, Evans, and Shaw 1988; and references cited):
Kitty Hawk Woods, Dare County.
Southern Shores Cypress Swamp, Dare County.
Nag's Head Woods, Dare County (Atkinson and List 1978).
Theodore Roosevelt State Natural Area, Bogue Banks, Carteret County.
Emerald Isle Woods, Carteret County.
Pine Island Audubon Sanctuary, Currituck County (Parnell, et al. 1987).

References: Atkinson and List (1978), Hosier and Cleary (1979), Lopazanski, Evans, and Shaw (1988), North Carolina Vegetation Survey (1988), Parnell, Hosier, Sieren, Webster, and Cooper (1987), Wentworth, Schafale, Weakley, Peet, White, and Frost (1989).

Sample Plant Communities:
Acer rubrum-Nyssa biflora//Toxicodendron (Rhus) radicans.
Taxodium distichum/Saururus cernuus.
Fraxinus americana.

MARITIME SHRUB SWAMP

Sites: Wet dune swales and depressions on barrier islands.

Soils: Wet, mucky soils of the Conaby series (Histic Humaquept).

Hydrology: Palustrine, seasonally flooded or saturated to intermittently exposed.

Vegetation: Open to dense canopy of shrubs or small trees. Persea palustris is most typically dominant, although some areas are dominated by Cornus stricta. Occasional larger trees such as Pinus taeda or Acer rubrum may be present. Vines, particularly Smilax spp., Toxicodendron (Rhus) radicans, and Berchemia scandens, often form dense tangles above or among the shrubs. The sparse herb layer may contain Osmunda cinnamomea, O. regalis var. spectabillis, Woodwardia virginica, Onoclea sensibilis, or Thelypteris palustris var. pubescens. Clumps of Sphagnum sp. may be common.

Dynamics: The specific dynamics of these communities are not known. Like all barrier island communities, they have the potential for disturbance by storm winds, salt spray, and migrating sand dunes, but they usually occur in the most sheltered barrier island locations. They may represent a stage in primary succession from Interdune Pond or Maritime Wet Grassland to Maritime Swamp Forest, but some apparently are of long standing and do not appear to be invaded by trees.

Range: Known only from the Buxton Woods and Nags Head Woods areas on the Outer Banks.

Associations: Usually surrounded by Maritime Evergreen Forest or Maritime Deciduous Forest. Occasionally may border Dune Grass or marsh communities. At Buxton Woods, it typically grades into Interdune Pond (Freshwater Marsh Variant).

Distinguishing Features: This community type is distinguished by its occurrence in maritime nontidal wetlands and its dominance by wetland shrubs or small trees.

Variations: Two distinctive variants are known:

1. Red Bay Variant, dominated by Persea palustris.

2. Dogwood Variant, dominated by Cornus stricta.

The important environmental factors producing these two variants are not known.

Comments: It is unclear what factors are responsible for the maintenance of shrub dominance. The sites do not appear to be more chronically disturbed than those dominated with trees. Although wetness clearly prevents the invasion of typical upland trees, many Maritime Swamp Forests appear equally wet. It is possible that the soils may contain more organic matter in Maritime Shrub Swamp than in Maritime Swamp Forest, although both are generally mapped on the same series. Difficulty of dispersal for wetland trees among isolated habitats on the islands may also be a factor.

This community type is newly distinguished from Maritime Swamp Forest. The boundary between the two types is somewhat arbitrary and may be refined further with more study. This type remains a heterogeneous category, with the Persea and Cornus dominated examples seeming very different.

This is an extremely rare type. While less threatened by development than most maritime communities, it may be destroyed by impoundment, ditching, or by lowering of the water table resulting from excessive well pumping.

Rare Plant Species: Vascular -- Liparis loeselii.

Synonyms:
Maritime Swamp Forest (Second Approximation) (in part).
Bay Forest (Atkinson and List 1978).

Examples (from N.C. Vegetation Survey 1988; Lopazanski, Evans, and Shaw 1988; and cited references):
Nags Head Woods, Dare County (Atkinson and List 1978).
Buxton Woods, Dare County (Dumond 1977).

References: Atkinson and List (1978), DuMond (1977), Lopazanski, Evans, and Shaw (1988), North Carolina Vegetation Survey (1988), Wentworth, Schafale, Weakley, Peet, White, and Frost (1989).

Sample Plant Communities:
Cornus stricta.
Persea palustris.
Persea palustris-Magnolia virginiana.

INTERDUNE POND

Sites: Depressions in active or relict dune areas on barrier islands.

Soils: The soils of ponds are not generally mapped. The surrounding and underlying substrate is sand or muck.

Hydrology: Permanently flooded to intermittently exposed. Kling (1988) described the ponds at Nag's Head Woods as water table windows, connected to the local groundwater system, but noted that other ponds could be isolated by a layer of organic material, with a perched water table.

Vegetation: Varies with depth of water. Deep water areas may have various floating or submerged aquatic plants, including Azolla caroliniana, Ceratophyllum echinatum, Limnobium spongia, Riccia fluitans, Ricciocarpus natans, Spirodela polyrrhiza, Wolffiella gladiata (floridana), Utricularia gibba (biflora), Lemna gibba, and Hottonia inflata. Shallow water and intermittently exposed areas have various freshwater marsh species, such as Leersia oryzoides, Eleocharis baldwinii, Typha angustifolia, Sacciolepis striata, Setaria magna, Hydrocotyle ranunculoides, Bidens frondosa, Triadenum (Hypericum) walteri, Lycopus rubellus, Boehmeria cylindrica, Thelypteris palustris var. pubescens, Zizaniopsis miliacea, Cladium mariscus ssp. jamaicense, Typha latifolia, Fimbristylis castanea, Juncus spp., and Polygonum spp. Some pond margins have a border of shrubs and trees such as Salix nigra, Acer rubrum, Nyssa biflora, Rosa palustris, Cephalanthus occidentalis, and Decodon verticillatus. Some have been invaded by the aggressively weed Phargmites australis (communis), which now dominates these sites.

Dynamics: Like other barrier island communities, Interdune Ponds may be subject to modification, disturbance, or destruction by processes such as sand dune movement, salt water overwash, and storm erosion. These processes are natural but may by modified by human action. In the absence of such disturbance ponds may undergo primary succession, slowly filling with organic matter and becoming Maritime Shrub Swamp or Maritime Swamp Forest communities.

Short term dynamics are dominated by water level fluctuations. After several drought years most of the ponds at Nag's Head Woods held no standing water for months, but in wetter years they are permanently flooded. During the long drought seedlings of wetland plants, including trees, established in the pond beds. Most will probably be eliminated by later flooding but some may persist.

Nutrient levels are probably higher than in inland Small Depression Ponds, because of salt aerosol input and presence of ions leached from shell fragments in young sand dunes into the ground water. Kling (1986) found that the water chemistry of the Nag's Head Woods ponds was similar to local ground water. Other ponds, however, may receive occasional salt water influence which would produce different chemistry.

Range: Scattered on the barrier islands.

Associations: Small areas, surrounded by Dune Grass, Maritime Wet or Dry Grassland, Maritime Shrub, Maritime Shrub Swamp, Maritime Swamp Forest, Maritime Evergreen Forest, or Maritime Deciduous Forest.

Distinguishing Features: Interdune Ponds are distinguished from Maritime Wet Grasslands by having standing water all or much of the year, and by vegetation. They may be distinguished from the inland Small Depression Ponds by their location on barrier islands. They are distinguished from Tidal Freshwater Marsh by the lack of tidal fluctuation in water levels.

Variation: Ponds vary widely among locations. Two variants are recognized, and more may exist:

1. Open Pond Variant, in shallow swales between discontinuous dunes and on sand flats, subject to periodic or occasional overwash.

2. Deep Pool Variant, in relict dune systems with deep water and steep sides, well sheltered from salt spray. The ponds of Nag's Head Woods are the best example.

3. Freshwater Marsh Variant, in broad, shallow swales, with a mosaic of shallow open water and tall graminoids. These

areas are known as "sedges" in the Buxton Woods area.

Comments: This is a broad category with a great deal of diversity, including both deep and shallow open water and some marshy areas. Despite its breadth, it is a very rare community type. Because most Interdune Ponds are apparently connected to the local water table, they may be disturbed indirectly by lowering or salinization of the water table resulting from excessive pumping of wells.

Rare Plant Species: Vascular -- Azolla caroliniana, Bulbostylis warei, Habenaria repens, Hottonia inflata, Lilaeopsis carolinensis, Ludwigia alata, Ludwigia brevipes, Ludwigia lanceolata, Luziola fluitans, Peltandra sagittifolia.

Synonyms:
Dune Marsh (Au 1974).
Dune Swale (general usage).
Sedge (general usage).

Examples:
Open Pond Variant:
Shackleford Banks, Cape Lookout National Seashore, Carteret County (Au 1974, Snow and Godfrey 1978).
Open Pond, Buxton Woods, Cape Hatteras National Seashore, Dare County (N.C. Vegetation Survey 1988).

Deep Pool Variant:
Nags Head Woods, Dare County (Atkinson and List 1978, Otte, Atkinson, and Atkinson 1984; Davison 1988).
Southern Shores Cypress Swamp, Dare County (N.C. Vegetation Survey 1988).

Freshwater Marsh Variant:
Jennette Sedge, and other sedges in Buxton Woods, Cape Hatteras National Seashore, Dare County (N.C. Vegetation Survey 1988, Lopazanski and Evans 1988).

References: Atkinson and List (1978), Au (1974), Bellis (1988), Braswell (1988), Davison (1988), Kling (1986), List and List (1988), MacPherson (1988), Mayes (1984), North Carolina Vegetation Survey (1988), Odum and Harvey (1988), Otte, Atkinson, and Atkinson (1984), Schwartz (1988), Snow and Godfrey (1978), Wentworth, Schafale, Weakley, Peet, White, and Frost (1989).

Sample Plant Communities:
Open water.
Spirodela polyrrhiza-Azolla caroliniana-Lemna spp.-Wolffia columbiana.
Riccia americana-Ricciocarpus natans.
Spirodela polyrrhiza.
Spirodela polyrrhiza-Lemna spp.-Hydrocotyle ranunculoides.
Limnobium spongia.
Decodon verticillatus/Saururus cernuus-Boehmeria cylindrica.
Sparganium americanum.
Eleocharis baldwinii-Hydrocotyle ranunculoides.
Decodon verticillatus.
Sagittaria latifolia.
Decodon verticillatus/Dulichium arundinaceum-Proserpinaca pectinata.
Eleocharis baldwinii.
Eleocharis baldwinii-Hydrocotyle ranunculoides-Leersia oryzoides-Utricularia spp.
Leersia oryzoides.
Cladium mariscus ssp. jamaicense.
Typha latifolia.
Zizaniopsis miliacea.

Rosa palustris.
Salix nigra.
Nyssa biflora.

ESTUARINE FRINGE LOBLOLLY PINE FOREST

Sites: Margins of estuaries, between marsh and upland or peatland communities.

Soils: Wet organic or mineral soils.

Hydrology: Palustrine, permanently or near permanently saturated, probably rarely flooded.

Vegetation: Canopy dominated by Pinus taeda, sometimes with Acer rubrum, Liquidambar styraciflua, or Nyssa biflora. Understory usually Acer rubrum and Persea palustris. The shrub layer is usually of moderate density, though it may be open if burned regularly. Myrica cerifera is the most typical shrub, with Arundinaria gigantea, Ilex glabra, or other species sometimes occurring. Vines, particularly Smilax spp. may be prominent and dense. The herb layer is usually sparse, although scattered Woodwardia areolata, Osmunda cinnamomea, and O. regalis var. spectabilis may occur. Species from adjacent marshes may occur in low areas.

Dynamics: These communities are dominated almost exclusively by species that tend to establish after severe disturbance but do not do well with chronic stress or disturbance such as frequent fire. The factors that lead to their occurrence and persistence here are not known. These sites are adjacent both to communities that naturally burned and to periodically flooded communities. It may be that occasional flooding, encroachment of killing salt water, and severe fires cause stand death and regeneration, while the lack of their regular occurrence allows the forest to mature and exclude marsh and pocosin species.

Range: Known from the shorelines and islands of the larger estuaries in the northern half of the coastal zone. May extend southward.

Associations: Grades downward to Tidal Freshwater Marsh or Brackish Marsh. Grades upward to peatland or upland communities, probably usually Pond Pine Woodland, Nonriverine Wet Hardwood Forest, and Maritime Forest.

Distinguishing Features: This type is distinguished by its location along estuarine shorelines, between marshes and inland communities, or on marsh islands. Because a wide variety of other community types become dominated by these species if heavily cut or prevented from burning, this natual community type is difficult to distinguish. Only sites in the appropriate setting and which appear to be the result of natural forces should be classified as this type.

Variation: Unknown.

Comments: This is a newly recognized natural community type. Since the wide distribution of disturbance vegetation dominated by the same species makes it difficult to tell examples of this community type, almost no written descriptions exist that clearly appear to fit it. Most of this description is drawn from Frost, Schneider, and LeGrand (1990) and personal communications from Frost and LeGrand.

Rare Plant Species: None known.

Synonyms:
SAF type 81: Loblolly pine.

Examples:
Harbinger Marsh, Currituck County (Frost, LeGrand, and Schneider 1990).
Broad Creek Marshes, Camden County (Frost, LeGrand, and Schneider 1990).
Hunting Creek Pocosin, Camden County (Frost, LeGrand, and Schneider 1990).
Swanquarter National Wildlife Refuge (LeGrand, pers. comm.).
Roanoke Island (LeGrand, pers. comm.).

References: Frost, LeGrand, and Schneider (1990).
Sample Plant Communities:
Pinus taeda/Acer rubrum-Persea palustris/Myrica cerifera.

TIDAL FRESHWATER MARSH

Sites: Margins of estuaries, or drowned rivers and creeks, regularly or irregularly flooded with freshwater tides. Sometimes extensive, covering hundreds of acres, elsewhere in small zonal patches.

Soils: Organic or, less frequently, mineral soils. Series include Currituck (Terric Medisaprist), Dorovan (Typic Medisaprist), Ponzer (Terric Medisaprist), Hobonny (Typic Medisaprist), Yaupon (Aquic Eudorthent), and Chowan (Thaptohistic Fluvaquent).

Hydrology: Palustrine, tidal, regularly or irregularly flooded with freshwater lunar or wind tides. Little or no salinity in the water (0.5 ppt or less).

Vegetation: Dense herbaceous vegetation dominated by species such as Spartina cynosuroides, Cladium mariscus ssp. jamaicense, Typha latifolia, Typha angustifolia, Zizaniopsis miliacea, Zizania aquatica, Scirpus americanus, Eleocharis fallax, E. rostellata, Sagittaria lancifolia (sensu lato), Peltandra virginica, Pontederia cordata, Centella asiatica, and Osmunda regalis var. spectabilis. Other common species include Hibiscus moscheutos, Eleocharis flavescens, Iris virginica, Pluchea foetida, Lythrum lineare, Sium suave, Asclepias incarnata, Thelypteris palustris var. pubescens, Hydrocotyle umbellata, Carex stricta, and Carex alata. Scattered trees and shrubs, particularly Myrica cerifera and Taxodium distichum. Invasive Phragmites australis (communis) clones sometimes form dense patches.

Dynamics: Tidal flooding brings in nutrients derived from seawater and varying amounts of sediment to the community. Regularly flooded marshes are reported to have high productivity, equivalent to salt marshes at the same latitude (Odum, et al. 1984). Irregularly flooded marshes and marshes in areas with little mineral sediment are probably less productive.

Areas with substantial regular daily tides have tidally carried muddy sediment deposited in them, producing tidal mud flats and estuarineward progradation of the marsh (Steve Benton, Division of Coastal Management, pers. comm. 1984). Areas with only irregular tidal flooding have less mineral sedimentation and accumulate organic matter. They lack mud flats, and their estuarine edges are scarped and erosional. As sea level rises, mineral or organic sedimentation causes the marsh surface to rise and the landward edge will migrate landward. Hummocks of plants may grow upward into columns while adjacent channels which do not grow upward become deeper.

Near the gradation to Brackish Marsh, occasional intrusion of salt water may cause significant natural disturbance to the community, killing freshwater species. Such temporary events may not affect the community composition in the long run.

Changes in tidal inlets may cause more permanent change between fresh and brackish marsh or between regularly and irregularly flooded marsh. Much of the Tidal Freshwater Marsh in northeastern North Carolina was brackish until the most recent (to date) Currituck Banks inlet closed in 1828. Most of these areas now are dominated by freshwater species, but some areas remain dominated by brackish species. All of the areas may still be undergoing succession and future changes are not known. In some areas wetland trees appear to be invading these marshes.

Fire was probably a natural component of some of these communities. Frost, Schneider, and LeGrand (1990) suggest that a fire frequency of 3-5 years was likely in marshes adjacent to upland communities that burned, while areas isolated by channels or swamps would seldom, if ever, have burned. Burning appears to reduce dominance by the large species and increase species diversity. Some of the marshes in the northeastern part of the state are regularly burned to improve waterfowl habitat.

Phragmites australis is acting as an aggresive invader in these communities, especially on the lower Cape Fear River. Once established in a new area, it rapidly expands into dense stands, eliminating most other species.

Regularly flooded freshwater marshes in general have a distinct seasonal succession of dominance, from bare mud to fleshy broad-leaved plants to tall graminoids. Similar seasonal succession probably also occurs in irregularly flooded marshes.

Range: Throughout the coastal zone, including barrier islands. Most extensive in the northeast corner of the state.

Associations: Grades upriver to Tidal Cypress--Gum Swamp, to floodplain communities, or to Sand and Mud Bar. Grades seaward to Brackish Marsh. Grades shoreward to Tidal Cypress--Gum Swamp, Estuarine Fringe Loblolly Pine Forest, peatland, or upland communities.

Distinguishing Features: Tidal Freshwater Marsh is distinguished from adjacent swamp forest and upland forests by the lack of a dominant tree or shrub layer.

The boundary with the Brackish Marsh type is taken to be where the above listed species become predominant over more brackish species such as Juncus roemerianus and Spartina spp. This apparently corresponds to the boundary given in Cowardin, et al. (1979) as 0.5 part per thousand of salt. Some common dominant species, such as Cladonia mariscus ssp. jamaicense and Spartina cynosuroides tolerate some salt and may occur in Brackish Marshes, occasionally in large patches. In Tidal Freshwater marshes these species, when present, are generally confined to the outer edges where what salt is present is least diluted by rainwater and fresh groundwater. In Brackish Marshes they are more likely to be in the least salty zones. Relict stands of brackish species in now-fresh water should be considered Tidal Freshwater Marsh.

The boundary with the Sand and Mud Bar type has not been examined, but should be placed where tidal influence begins to predominate over river flow and seasonal flooding.

Variation: Two variants are recognized:

1. Freshwater Variant, occurring in upper tidally-influenced areas, where salt is essentially absent even during the highest tides, typically dominated by a combination of forbs, sedges, rushes, and salt-intolerant grasses.

2. Oligohaline Variant, occurring in areas with salt levels below the 0.5 parts per thousand salt limit, but with slight salt influence. Salt levels may be higher during rare high tide events. These communities are usually dominated by Cladium mariscus ssp. jamaicense, Typha spp., and Spartina cynosuroides, but have a high plant diversity.

Significant variations in nutrient dynamics, sedimentation, and probably vegetation are also believed to occur between examples regularly flooded by lunar tides and those irregularly flooded by wind tides.

Tidal Freshwater Marshes are often very heterogeneous within sites. Regularly flooded marshes generally do not have distinct zones (Odum, et al. 1984). Irregularly flooded marshes, at least of the Oligohaline Variant, often appear to have zonation (Frost, Schneider, and LeGrand 1990). A fringe of tall grasses such as Spartina cynosuroides generally dominates on the outer edge, and more irregular zones of dominants occur in the interior.

Comments: Regularly flooded freshwater marshes, although predominant on the Atlantic Coast as a whole, are rarer than irregularly flooded examples in North Carolina. Odum, et al. (1984) gives an estimate of 3000 acres of regularly flooded freshwater marshes (presumably both variants) for North Carolina, primarily along the Cape Fear River. Irregularly flooded marshes reach their best development in North Carolina, being widespread along Albemarle and Currituck Sound and their tributaries. The Oligohaline Variant is relatively widespread in the northeast part of North Carolina, but the Freshwater Variant is fairly rare in the state.

In contrast to Brackish and Salt Marshes, Tidal Freshwater Marshes are very diverse.

Rare Plant Species: Vascular -- Aeschynomene virginica, Cladium mariscoides, Crinum americanum, Cyperus dentatus, Eleocharis rostellata, Eriocaulon aquaticum, Habenaria repens, Heteranthera multiflora, Hottonia inflata, Isoetes riparia, Lathyrus palustris, Lilaeopsis carolinensis, Limosella australis, Ludwigia alata, Ptilimnium costatum, Ranunculus hederaceus, Spartina pectinata, Zizania aquatica.

Synonyms:
Nontidal freshwater marsh (Odum, et al. 1984)

Examples:
Freshwater Variant:
Bennett's Creek, Catherine Creek, Chowan Swamp, Gates County (Frost 1982, Frost, LeGrand, and Schneider 1990).
Lower Black River (Nifong and Taggart 1981, Burney 1975).
Wiccacon River Freshwater, Hertford County (Frost, LeGrand, and Schneider 1990).

Oligohaline Variant:
North River, Currituck and Camden County (Frost, LeGrand, and Schneider 1990).

Northwest River, Currituck County (Frost, LeGrand, and Schneider 1990).
Currituck Sound (Hosier and Cleary 1979; Perry 1979; Parnell et al. 1987).
Goose Creek State Park, Beaufort County (Corda 1982).
Durant Island, Dare County (Peacock and Lynch 1982a).
Neuse River Floodplain, Craven County (McDonald, Ash, and Fussell 1981).

References: Burney (1975), Corda (1982), Deyle and Smith (1976), Frost (1982), Frost, LeGrand, and Schneider (1990), Hosier and Cleary (1979), McDonald, Ash, and Fussell (1981), Nifong and Taggart (1981), Odum, Smith, Hoover, and McIver (1984), Parnell, Hosier, Sieren, Webster, and Cooper (1987), Peacock and Lynch (1982a), Perry (1979).

Sample Plant Communities:
Spartina cynosuroides-mixed emergents.
Cladium mariscus ssp. jamaicense.
Spartina cynosuroides-Cladium mariscus ssp. jamaicense.
Spartina cynosuroides-Typha angustifolia-Scirpus spp.
Cladium jamaicense/Osmunda regalis var. spectabilis-mixed emergents.
Phragmites australis (communis).
Scirpus americanus-mixed emergents.
Eleocharis rostellata.
Eleocharis rostellata-Centella asiatica.
Eryngium aquaticum-Scirpus americanus.
Sagittaria lancifolia-Osmunda regalis var. spectabilis-mixed aquatic and wetland forbs.
Typha latifolia-Juncus roemerianus.
Juncus roemerianus-Eleocharis obtusa.
Mixed hydrophytic grasses and herbs.

TIDAL CYPRESS--GUM SWAMP

Sites: Margins of freshwater sounds and mouths of both blackwater and brownwater rivers with regular or irregular freshwater tides.

Soils: Generally organic soils such as Dorovan (Typic Medisaprist) and Hobonny (Typic Medisaprist), occasionally mineral soils such as Masontown (Cumulic Humaquept).

Hydrology: Palustrine, regularly to irregularly flooded with freshwater lunar or wind tides. Little or no salinity in the water (0.5 ppt or less).

Vegetation: Canopy dominated by combinations of Taxodium distichum, Nyssa aquatica, and Nyssa biflora, sometimes with Pinus taeda and Acer rubrum. Understory species include Acer rubrum, Nyssa biflora, Persea palustris, Magnolia virginiana, Fraxinus caroliniana, and Juniperus virginiana. The shrub layer may be either open or dense. Typical species include Myrica cerifera, Cyrilla racemiflora, Vaccinium corymbosum, Rosa palustris, and sometimes Sabal minor or Arundinaria gigantea. The herb layer is usually sparse, except in canopy openings. Species include Osmunda regalis var. spectabilis, O. cinnamomea, Woodwardia areolata, Saururus cernuus, Carex stricta, and Peltandra virginica.

Dynamics: Tidal flooding brings seawater-derived nutrients and varying amounts of sediment into the community, probably making these communities more productive than Cypress--Gum Swamp (Blackwater Subtype).

Intrusion by salt water during major storms may cause major disturbance to the community, possibly killing most of the trees. With a long-term rise in sea level, these communities will be replaced by marsh, probably abruptly after the canopy is killed by such a disturbance.

The wet soils, long periods of flooding, and sparse herbaceous layer make these communities unlikely to carry fire.

Range: Throughout the estuarine region of the Coastal Plain.

Associations: Grades away from shore and downriver into Tidal Freshwater Marsh, Estuarine Frings Loblolly Pine Forest, or open water. Grades upstream into blackwater or brownwater river floodplain communities.

Distinguishing Features: Tidal Cypress--Gum Swamp is distinguished from other Cypress--Gum Swamps by having tidal flooding predominating over river flooding, rainfall, and groundwater as the main source of wetness. This may be difficult to judge in some cases. The floristic differences that correspond to this distinction are not well known. The presence of short dead-end tidal creeks may help distinguish tidal areas (J.M. Lynch, pers. comm.), as may the presence of Tidal Freshwater Marsh.

Cypress--Gum Swamps are distinguished from all other communities by the dominance of Taxodium and Nyssa in the canopy. Occasional heavily cut examples may become dominated by Acer rubrum or various understory species.

Variation: Nyssa aquatica generally occurs close to the edge of the water, while Nyssa biflora occurs further back, in areas more stagnant and dominated by organic matter. Along freshwater sounds this community may be a narrow band but on large rivers it may form extensive flats. It is likely that differences exist between these two situations due to the relative amounts of tidal and river influence and the availability of mineral sediment. Differences may also exist between regularly and irregularly flooded examples.

Comments: Tidal swamps are distinguished by flooding caused primarily by regular or irregular tides rather than seasonal river flooding. This situation modifies the water quality of both brownwater and blackwater rivers and produces a different hydrologic regime.

Rare Plant Species: Vascular -- Epidendrum conopseum, Heteranthera multiflora, Lilaeopsis carolinensis, Lilium sp. 2.

Synonyms:
SAF 101, 102, and 103: Baldcypress, Baldcypress-Tupelo, and Water Tupelo-Swamp Tupelo.

Cypress-Gum Flats (Lynch 1981).

Examples:
North River-Deep Creek, Currituck County (Frost, LeGrand, and Schneider 1990).
Northeast Cape Fear River (Leonard and Davis 1981).
Roper Island, Hyde County (Lynch and Peacock 1982a).
Durant Island, Dare County (Peacock and Lynch 1982a).
Dollison's Swamp, Cape Fear River, Brunswick County (Nifong and Taggart 1981).
Goose Creek State Park, Beaufort County.
Holston Creek, Croatan National Forest, Carteret County.

References: Allen (1958), Frost, LeGrand, and Schneider (1990), Leonard and Davis (1981), Lynch (1981), Lynch and Peacock (1982a), Nifong and Taggart (1981).

Sample Plant Communities:
Nyssa biflora/mixed swamp understory.
Taxodium distichum-Nyssa biflora/Fraxinus caroliniana.
Taxodium distichum/Acer rubrum/Myrica cerifera-Lyonia lucida-Rosa palustris.

SALT MARSH

Sites: Margins of sounds and estuaries, backs of barrier islands, and old flood tide deltas near closed inlets, with regular salt water tides.

Soils: Usually mineral soils, most typically Carteret (Typic Psammaquent), Bohicket (Typic Sulfaquent), Hobucken (Typic Hydraquent), and Axis (Typic Sulfaquent).

Hydrology: Estuarine, tidal, regularly flooded, euhaline (30-40 ppt).

Vegetation: Characteristically strongly dominated by Spartina alterniflora. Strong zonation occurs in the higher parts, with zones of Juncus roemerianus, Spartina patens, and sometimes other brackish marsh species.

Dynamics: Organic material is regularly removed and sediment deposited by the tides, making these communities highly productive.

Coupled with rising sea level, tidal sedimentation causes a rise in the marsh surface and landward migration of the marsh. Sediment may also be deposited on the shoreline, causing estuarineward progradation of the marsh. Marshes on the back sides of barrier islands may be subject to episodic burial by sand overwash.

Range: Throughout the coastal part of the state. Best developed in the southern and middle parts of the coast where lunar tidal amplitude is greatest.

Associations: Grades to Brackish Marsh in estuaries, or to estuarine channels lacking emergent vegetation. May grade to Salt Shrub or Salt Flat. Grades through higher zones to Estuarine Fringe Loblolly Pine Forest, or to various upland, peatland, or maritime communities.

Distinguishing Features: Salt Marshes are distinguished from all other community types by the dominance of Spartina alterniflora as well as by their tidal, saltwater environment. Relatively narrow zones of brackish marsh species at the upper edge are considered part of the Salt Marsh, but larger expanses in the heads of creeks and in the interior of large marsh islands are considered separate Brackish Marsh communities.

Variation: The low diversity allows little variation in vegetation other than the zonation in the upper parts. Differences in depth of flooding will produce variation in production.

Comments: Since it occurs over extensive areas, this community type is in no danger of disappearing. However, its role in the function of larger ecosystems makes large areas important. A loss of substantial amounts of it could have serious consequences for nutrient cycling and for reproduction of estuarine and marine organisms.

Rare Plant Species: Vascular -- None.

Synonyms:
Different zones of the salt marsh have been called by a variety of names, including salt, brackish, and fresh marsh, and regularly and irregularly flooded marsh.

Examples:
Hammocks Beach State Park, Onslow County.
Smith Island Complex, Brunswick County (Mayes 1984).
Elizabeth River Marshes, Brunswick County
Masonboro Island, New Hanover Co (Weakley 1980c, Hosier and Cleary 1977).
Shackleford Banks, Carteret County (Au 1974, Godfrey 1976).
Lea Island, Pender County (Weakley 1980a).
Hutaff Island, Pender County (Weakley 1980a).

References: Adams (1963), Au (1974), Godfrey and Godfrey (1976), Hosier and Cleary (1977), Mayes (1984), Nifong (1981), Weakley (1980a).

Sample Plant Communities:

lower zones:

Spartina alterniflora.

higher zones:

Spartina patens.
S. patens-Salicornia virginica.
Juncus roemerianus.
Spartina cynosuroides.
Kosteletskya virginica-Hibiscus moscheutos.
Fimbristylis spadicea-Spartina patens.

BRACKISH MARSH

Sites: Margins of sounds and estuaries somewhat removed from connection with the sea, so that salinity is diluted by freshwater inflow and tidal range is generally less than in Salt Marshes.

Soils: Typically organic soils, primarily Lafitte (Typic Medisaprist), Hobonny (Typic Medisaprist), or Currituck (Terric Medisaprist). Occasionally on mineral soils such as Carteret (Typic Psammaquent).

Hydrology: Estuarine, tidal, regularly or irregularly flooded, mixohaline (0.5 to 30 ppt).

Vegetation: Typically strongly dominated by Juncus roemerianus or Spartina patens, occasionally by Spartina cynosuroides, Cladium mariscus ssp. jamaicense, or other species. Zonation may occur in the higher parts, with zones of various freshwater species.

Dynamics: Areas with substantial regular daily lunar tides have a regular input of nutrients, which makes them highly productive. Areas with only irregular wind tidal flooding have much less nutrient input.

Regularly flooded marshes supplied with abundant sediment may produce tidal mud flats and estuarineward progradation of the marsh. Irregularly flooded marshes have less mineral sedimentation and accumulate relatively more organic matter. They lack mud flats and their estuarine edges are scarped and erosional. As sea level rises, mineral or organic sedimentation causes the marsh surface to rise. The landward edge will migrate landward. Changes in tidal inlets may cause changes in salinity.

Range: Throughout the estuarine parts of the state. Most extensive in the large sounds of the middle and north part of the coast.

Associations: Grades seaward to Salt Marsh to estuarine channels lacking emergent vegetation. Grades up estuary to Tidal Freshwater Marsh. Grades through higher zones to Estuarine Fringe Loblolly Pine Forest or to various upland, peatland, or maritime communities.

Distinguishing Features: Brackish Marsh is distinguished by the brackish tidal environment and usually also by the dominance of Juncus roemerianus. Spartina patens-dominated Brackish Marshes may be distinguished from Maritime Dry or Wet Grasslands by the higher diversity of the latter communities, with other species that do not occur in marshes. The boundary with the Tidal Freshwater Marsh type is taken to be where its characteristic species become predominant over Juncus roemerianus and Spartina patens. This apparently corresponds to the boundary given in Cowardin, et al. (1979) as 0.5 parts per thousand of salt. Some species which are shared, such as Spartina cynosuroides and Cladium mariscus var. jamaicense may form large patches in either type. In Tidal Freshwater Marshes however, these species will generally be confined to the outer edges where what salt is present is least diluted by rainwater and fresh groundwater, while in Brackish Marshes they will occur in the least salty zones in the marsh.

Variation: Variation in species composition and dynamics may occur in response to the salinity gradient. Some nearly fresh water areas may be dominated by different species, as discussed above.

There is a primary difference in dynamics between the regularly flooded marshes in the southern part of the state and the predominantly irregularly flooded marshes of the northern part. Areas exposed to wave action from large estuaries may also be different in dynamics from areas in narrow embayed creek channels. V. Bellis (personal communication) drew a distinction between the broad fringing marshes of outer estuaries and the narrow marshes in small tributaries and fingers of the estuary. The narrow marshes are sheltered from wave action and will have different circulation and salinity patterns. They may be important breeding sites for fish.

Comments: Since it occurs over extensive areas, this community type is in no danger of disappearing. However, its role in the function of larger ecosystems makes large areas important. A loss of substantial amounts of it could have serious consequences for nutrient cycling and for reproduction of marine and estuarine organisms.

Rare Plant Species: Vascular -- Cyperus dentatus, Eleocharis halophila, Eleocharis rostellata.
Synonyms: None known.

Examples:
Roanoke-Stumpy Point Marshes, Alligator River National Wildlife Refuge, Dare County (Peacock and Lynch 1982a).
Roanoke Island Juncus Marsh, Dare County (Perry 1979).
Cedar Island National Wildlife Refuge, Carteret County (Fussell and Wilson 1983).
Swanquarter National Wildlife Refuge, Hyde County.
Roper Island, Hyde County (Lynch and Peacock 1982a).
Motts Creek, New Hanover County (Weakley 1980a).
Nags Head Woods, Dare County (Atkinson and List 1978).
Shackleford Banks, Carteret County (Au 1974, Godfrey and Godfrey 1976).

References: Atkinson and List (1978), Au (1974), Cowardin, Carter, Golet, and LaRoe (1979), Godfrey and Godfrey (1976), Lynch and Peacock (1982a), Peacock and Lynch (1982a), Perry (1979), Weakley (1980a).

Sample Plant Communities:
lower zones:
Spartina patens.
Juncus roemerianus.
Spartina cynosuroides.

higher zones:
Kosteletzkya virginica-Hibiscus moscheutos.

SALT FLAT

Sites: Supratidal shallow depressions where salt is concentrated by evaporation of sea water.

Soils: Soils are usually mapped as the same series as the surrounding marshes, but have a much higher salt content and perhaps more sandy texture.

Hydrology: Estuarine, irregularly flooded with sea water, hyperhaline (greater than 40 ppt).

Hydrology: Estuarine, irregularly flooded with sea water, hyperhaline.

Vegetation: Generally sparse cover of halophytic herbs such as Salicornia bigelovii, S. maritima (europaea) S. virginica, Distichlis spicata, and rarely also Suaeda linearis, Spergularia marina, and Atriplex patula. Borrichia frutescens may be present. Spartina alterniflora often occurs in the marginal zones. The centers of depressions often are completely barren.

Dynamics: May be changed to other marsh types by shifts in water circulation patterns or salinity, or by erosion.

Range: Throughout the coastal area, where salt marshes occur. Best developed in the southern two thirds of the state.

Associations: Grades to or bordered by Salt Marsh or Brackish Marsh.

Distinguishing Features: Salt Flats are distinguished from all other community types by their dominance by species with high salt tolerances and their occurrence in a hyperhaline environment.

Variation: Vegetation density and species composition vary within and among sites in response to salinity.

Comments: These communities seem quite distinctive where they occur, though they are often small. They seem to occur regularly in areas with Salt Marsh but are often not distinguished in the literature. Their usual small size makes them marginal to distinguish as a separate type.

Rare Plant Species: None known.

Synonyms:
Salt Panne (Godfrey and Godfrey 1976).

Examples:
Salt Flats, Pea Island National Wildlife Refuge, Dare County.
Shackleford and Core Banks, Cape Lookout National Seashore, Carteret County (Godfrey and Godfrey 1976).
Oregon Inlet, Dare County.
Hutaff Island, Pender County (Weakley 1980a).
Lea Island, Pender County (Weakley 1980a).
Ocracoke Island, Cape Hatteras National Seashore, Hyde County.
Masonboro Island, New Hanover County (Weakley 1980a, Hosier and Cleary 1977).

References: Adams (1963), Godfrey and Godfrey (1976), Hosier and Cleary (1977), Weakley (1980a).

Sample Plant Communities:
Salicornia bigelovii/Spergularia marina.
Salicornia bigelovii.
Distichlis spicata-Salicornia virginica.
Salicornia spp.
Distichlis spicata-Atriplex patula-Suaeda linearis.

SALT SHRUB

Sites: Upland margins and small high areas in Salt or Brackish Marshes.

Soils: Soils in these communities are generally mapped as the same series as in the adjacent marsh or uplands, but may represent inclusions.

Hydrology: Intermittently flooded or saturated, supratidal. It is unclear whether this type belongs in the Estuarine or Palustrine system.

Vegetation: Open to closed shrub canopy, typically of Iva frutescens, Baccharis halimifolia, Myrica cerifera, and Juniperus silicicola. Inclusions of marsh vegetation are common.

Dynamics: These communities do not receive the regular tidal flooding with its nutrient input, as do the marshes. Periodic flooding by salt or brackish water may provide nutrients, as does salt spray. Salt water flooding is a periodic disturbance which keeps these communities in an early successional stage, preventing invasion by trees and other shrubs. Additional disturbances may include fire spreading from adjacent communities and, on barrier islands, overwash and sand deposition.

Rising sea level may cause landward migration of the shrub zone or may cause its destruction. Changes in salinity caused by opening or closing of tidal inlets or by storm flooding may likewise cause shifting or destruction of these communities.

Range: Throughout the coastal area, where Salt or Brackish Marshes occur.

Associations: Grades to Salt or Brackish marsh communities in wetter areas. Grades to Maritime Shrub, Maritime Forest, Maritime Wet Grassland, or various mainland communities.

Distinguishing Features: Salt Shrub is distinguished from marsh communities by the dominance of shrubs rather than herbs. It can be distinguished from Maritime Shrub and Maritime Shrub Swamp by the dominance of the species listed above and the absence of species not tolerant of salt. Myrica cerifera may dominate both Salt Shrub and Maritime Shrub. Areas dominated by this species may be difficult to distinguish but associated species and topographic setting usually give indications of the true affinities of an area.

Variation: Frequency of salt water flooding and wetness between flooding are probably the main determinants of variation.

Comments: These communities are not frequently distinguished in description of marshes, hence few examples can be cited. Examples are also sometimes not distinguished from Maritime Shrub. Salt Shrub communities seem to occur regularly on the barrier islands and mainland estuarine margins.

Rare Plant Species: None known.

Synonynms: None known.

Examples:
Ocracoke Island, Cape Hatteras National Seashore, Hyde County.
Core and Shackleford Banks, Cape Lookout National Seashore, Carteret County (Au 1974, Snow and Godfrey 1978).
Bodie Island, Cape Hatteras National Seashore, Dare County.
Nags Head Woods marshes, Dare County (Atkinson and List 1978).
Lea Island, Pender County (Weakley 1980a).
Hutaff Island, Pender County (Weakley 1980a).
Hawkins Island, Onslow County.
Masonboro Island (Weakley 1980a, Hosier and Clearly 1977).
Scattered examples occur on most of the barrier islands along the coast.

References: Atkinson and List (1978), Au (1974), Hosier and Cleary (1977), Snow and Godfrey (1978), Weakley (1980a).

Sample Plant Communities:
Borrichia frutescens.
Baccharis halimifolia-Myrica cerifera.
Borrichia frutescens-Iva frutescens.
Myrica cerifera.

UPPER BEACH

Sites: Oceanward shores of barrier islands.

Soils: The substrate consists of unconsolidated sands, with variable shell content, continually being reworked by wind and water. Such sediments are considered soils by the Soil Conservation Service, but have not been assigned series in the soil classification; rather, they have been called the "Beach- Foredune Association" and the "Beach (occasionally flooded) Association". The sand is variable in texture, and content and fragment size of shell also varies a great deal.

Hydrology: Marine. This community lies above mean high tide, but is inundated by high spring tides and storm tides. The main water sources are rainwater and salt spray, which maintain generally moist conditions.

Vegetation: The vegetation is sparse, characterized by a small number of species, many of them succulents, which are adapted to the environmental characteristics of these sites. Annuals are most prevalent, including Cakile edentula (a winter annual), Chamaesyce (Euphorbia) polygonifolia, Chamaesyce bombensis (Euphorbia ammanioides), Amaranthus pumilus, Polygonum glaucum, Salsola caroliniana (kali), Atriplex arenaria, and Sesuvium maritimum. Characteristic perennials, which begin to stabilize small "pre-dunes", are Iva imbricata, Uniola paniculata, Panicum amarum, Hydrocotyle bonariensis, Triplasis purpurea, Ipomoea imperati (stolonifera), and Sesuvium portulacastrum.

Dynamics: These are, of course, very dynamic communities, dependent on regular natural disturbance. If protected from disturbance they quickly succeed to perennial-dominated Dune Grass communities. Disturbance is of varying degree and frequency, ranging from daily blowing sands to occasional severe overwash and reworking of sand by hurricanes or other storms.

Range: All along the barrier islands. This community occurs linearly along the length of the coast.

Associations: Bordered on the seaward side by the regularly inundated lower beach, which supports a diversity of invertebrate animals, but no vascular plants. Grades landward to the perennial-dominated Dune Grass community. At inlets at eroding ends of islands, the Upper Beach community may also border (generally sharply and discordantly) Brackish Marsh, Salt Marsh, Salt Flat, Salt Shrub, Maritime Dry Grassland, Maritime Wet Grassland, Maritime Forest, and Maritime Shrub, where these communities are being eroded and replaced by Upper Beach. At inlets on accreting ends of islands, Upper Beach may intergrade with Dune Grass through a rather long transition zone of low, semi-stabilized dunes.

Distinguishing Features: Upper Beach communities are distinguished from Dune Grass, Maritime Dry Grassland, and other terrestrial and palustrine communities by having annual vascular plants predominant over perennials. They are distinguished from the lower beach by occurrence above mean high tide and by the occurrence of vascular plants.

Variation: In southern North Carolina, especially south of Cape Fear, species are found which are absent or very rare northward. These species include Ipomoea imperati (I. stolonifera) and Sesuvium portulacastrum. Variations in soil texture, topography, degree and type of past disturbance, seed deposition, and annual weather create considerable spatial and temporal variation in density of vegetation and which species are present.

Comments: Godfrey and Godfrey (1976) describe the natural dune form on most islands as one of relatively low, discontinuous dunes with overwash passes between them. On many islands, artificial dune building by sand fencing and dense palnting of grasses has led to development of a high continuous line of dunes. This has concentrated the effects of storm waves on the beach, increasing erosion there.

Rare Plant Species: Vascular -- Amaranthus pumilus, Chamaesyce bombensis, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum, Sesuvium portulacastrum.

Synonyms: None known.

Examples:
Bear Island, Hammocks Beach State Park, Onslow County.
Shackleford and Core Banks, Cape Lookout National Seashore, Carteret County.
Masonboro Island, New Hanover County.
East Beach, Smith Island Complex, Brunswick County.
Beaches occur continuously along the coast.

References: Au (1974), Bucher and Weakley (1990), Godfrey and Godfrey (1976), Snow and Godfrey (1978).

Sample Plant Communities:
Cakile edentula.
Amaranthus pumilus.
Chamaesyce (Euphorbia) polygonifolia-Amaranthus pumilus.
Salsola caroliniana (kali).
Panicum amarum.

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APPENDIX

This appendix is an alphabetic list of scientific (Latin) and common (English) names of plant species used in the text. We have used scientific names throughout the text, as being the more precise, accurate, concise, and unambiguous way to refer to plant species. We recognize, however, that many potential users of this publication are not fully comfortable with the scientific names of plants; we hope this appendix will aid in the ready understanding of the text by a broader audience.

Where the accepted nomenclature or taxonomy has changed since the publication of Radford, Ahles, and Bell (1968), we indicate the treatment in that reference by the notation "RAB = ".

Abies fraseri	Fraser Fir
Acer floridanum	Southern Sugar Maple
RAB = *Acer saccharum* ssp. *floridanum*	
Acer leucoderme	Chalk Maple
RAB = *Acer saccharum* ssp. *leucoderme*	
Acer negundo	Ash-leaf Maple, Box Elder
Acer pensylvanicum	Striped Maple
Acer rubrum	Red Maple
Acer rubrum var. *drummondii*	Swamp Red Maple
RAB = *Acer rubrum* in part	
Acer rubrum var. *trilobum*	Swamp Red Maple
RAB = *Acer rubrum* in part	
Acer saccharum	Sugar Maple
Acer saccharum var. *saccharum*	Northern Sugar Maple
RAB = *Acer sacharrum* ssp. *saccharum*	
Acer saccharum var. *viride*	Black Maple
RAB = *Acer saccharum* ssp. *nigrum*	
Acer spicatum	Mountain Maple
Acmella oppositifolia	Creeping Spotflower
RAB = *Spilanthes americana* var. *repens*	
Aconitum reclinatum	Trailing Wolfsbane
Acrobolbus ciliatus	A Liverwort
Actaea pachypoda	Doll's-eyes
Adiantum capillus-veneris	Venus Hair Fern
Adiantum pedatum	Maidenhair Fern
Adlumia fungosa	Climbing Fumitory
Aeschynomene indica	Indian Jointvetch
Aeschynomene virginica	Sensitive Jointvetch
Aesculus flava	Yellow Buckeye
RAB = *Aesculus octandra*	
Aesculus pavia	Red Buckeye
Aesculus sylvatica	Painted Buckeye
Agalinis aphylla	Scale-leaf Gerardia
Agalinis decemloba	Piedmont Gerardia
Agalinis fasciculata	Clustered Gerardia
Agalinis linifolia	Flaxleaf Gerardia
Agalinis tenella	A Gerardia
Agalinis virgata	Branched Gerardia
Agastache nepetoides	Yellow Giant-hyssop
Agastache scrophulariifolia	Purple Giant-hyssop
Ageratina altissima var. *roanensis*	Roan Snakeroot

RAB = *Eupatorium rugosum* in part	
Agrostis mertensii	Arctic Bentgrass
RAB = *Agrostis borealis*	
Agrostis perennans	Perennial Bentgrass
Aletris aurea	Golden Colicroot
Aletris farinosa	White Colicroot
Allium burdickii	Narrow-leaved Wild Leek
Allium cuthbertii	Striped Garlic
Allium sp. 1	Savanna Onion
Alnus serrulata	Tag Alder
Alnus viridis ssp. *crispa*	Green Alder
RAB = *Alnus crispa*	
Amaranthus pumilus	Seabeach Amaranth
Amelanchier arborea	Downy Serviceberry
RAB = *Amelanchier arborea* var. *arborea*	
Amelanchier laevis	Allegheny Serviceberry
RAB = *Amelanchier arborea* var. *laevis*	
Amelanchier sanguinea	Roundleaf Shadbush
Ammophila breviligulata	Beach Grass
Amorpha georgiana var. *confusa*	Savanna Indigo-bush
RAB = *Amorpha georgiana* in part	
Amorpha georgiana var. *georgiana*	Georgia Indigo-bush
RAB = *Amorpha georgiana* in part	
Amorpha schwerinii	Piedmont Indigo-bush
Ampelopsis arborea	Peppervine
Ampelopsis cordata	Heartleaf Peppervine
Amphicarpum floridanum	Florida Goober Grass
RAB = *Amphicarpum muhlenbergianum*	
Amphicarpum purshii	Pinebarrens Goober Grass
Amsonia ciliata	Fringed Bluestar
Anastrophyllum saxicola	A Liverwort
Andreaea rupestris	A Moss
Andropogon gerardii	Big Bluestem
Andropogon glomeratus	Bushy Broomsedge
RAB = *Andropogon virginicus* in part	
Andropogon glomeratus var. *glaucopsis*	Chalky Broomsedge
RAB = *Andropogon virginicus* in part	
Andropogon gyrans	Elliott's Bluestem
RAB = *Andropogon elliotii*	
Andropogon mohrii	Bog Bluestem
Andropogon tracyi	Tracy's Bluestem
Andropogon virginicus	Common Broomsedge
RAB = *Andropogon virginicus* in part	
Andropogon virginicus var. *glaucus*	A Broomsedge
RAB = *Andropogon virginicus* in part	
Andropogon spp.	Bluestems
Anemone berlandieri	Southern Thimbleweed
RAB = *Anemone caroliniana* in part	
Anemone quinquefolia	A Thimbleweed
Anemone minima	A Thimbleweed
Anemone virginiana	Tall Thimbleweed

Aneura sharpii	A Liverwort
Angelica atropurpurea	Purple-stem Angelica
Angelica triquinata	Mountain Angelica
Anomodon attenuatus	A Moss
Anomodon rostratus	A Moss
Anthaenantia rufa	Purple Silkyscale
Anthaenantia villosa	Green Silkyscale
Anthoceros ascendens	A Hornwort
Aquilegia canadensis	Columbine
Arabis canadensis	Sicklepod
Arabis glabra	Tower Mustard
Arabis hirsuta var. *adpressipilis*	Slender Rockcress
Arabis lyrata	Lyreleaf Rockcress
Arabis missouriensis	Missouri Rockcress
RAB = *Arabis laevigata* var. *missouriensis*	
Arabis patens	Spreading Rockcress
Aralia nudicaulis	Wild Sarsaparilla
Arenaria lanuginosa	Spreading Sandwort
Arethusa bulbosa	Bog Rose
Arisaema triphyllum	Jack-in-the-Pulpit
Arisaema triphyllum ssp. *stewardsonii*	Bog Jack-in-the-Pulpit
RAB = *Arisaema triphyllum* in part	
Aristida longespica	Red Three-awn
Aristida palustris	Longleaf Three-awn
RAB = *Aristida affinis*	
Aristida stricta	Wiregrass
Aristolochia macrophylla	Dutchman's-Pipe
Aristolochia serpentaria	Turpentineroot
Aronia arbutifolia	Red Chokeberry
RAB = *Sorbus arbutifolia* var. *arbutifolia*	
Aronia melanocarpa	Black Chokeberry
RAB = *Sorbus melanocarpa*	
Arundinaria gigantea	Cane
Arundinaria gigantea ssp. *tecta*	Cane
RAB = *Arundinaria gigantea* in part	
Asarum canadense	Wild Ginger
Asclepias incarnata	Swamp Milkweed
Asclepias longifolia	Longleaf Milkweed
Asclepias pedicellata	Stalked Milkweed
Asclepias purpurascens	Purple Milkweed
Asclepias tomentosa	Sandhills Milkweed
Asclepias tuberosa ssp. *rolfsii*	Sandhills Butterflyweed
Asclepias verticillata	Whorled Milkweed
Asimina parviflora	Small-flower Pawpaw
Asimina triloba	Common Pawpaw
Asplenium bradleyi	Bradley's Spleenwort
Asplenium heteroresiliens	Carolina Spleenwort
Asplenium monanthes	Single-Sorus Spleenwort
Asplenium montanum	Mountain Spleenwort
Asplenium pinnatifidum	Lobed Spleenwort
Asplenium platyneuron	Ebony Spleenwort

Asplenium platyneuron var. *bacculum-rubrum*	Maritime Spleenwort
RAB = *Asplenium platyneuron* in part	
Asplenium resiliens	Blackstem Spleenwort
Asplenium rhizophyllum	Walking Fern
Asplenium ruta-muraria	Wall-Rue
Asplenium trichomanes	Maidenhair Spleenwort
Asplenium X ebenoides	Scott's Spleenwort
Aster acuminatus	Whorled Wood Aster
Aster avitus	Alexander's Rock Aster
Aster carolinianus	Climbing Aster
Aster cordifolius	Common Blue Wood Aster
Aster depauperatus	Serpentine Aster
Aster divaricatus	Heartleaf Aster
Aster dumosus	An Aster
Aster georgianus	Georgia Aster
RAB = *Aster patens* in part	
Aster laevis var. *concinnus*	Smooth Blue Aster
Aster lanceolatus	White Panicle Aster
RAB = *Aster simplex*	
Aster linariifolius	Stiffleaf Aster
Aster macrophyllus	Largeleaf Aster
Aster mirabilis	Piedmont Aster
RAB = *Aster commixtus*	
Aster oblongifolius	Aromatic Aster
Aster patens	Late Purple Aster
Aster paternus	Toothed Whitetop Aster
Aster puniceus var. *firmus*	Purple-stem Aster
Aster shortii	Short's Aster
Aster solidagineus	Narrowleaf Whitetop Aster
Aster spectabilis	Western Showy Aster
Aster tenuifolius	Perennial Saltmarsh Aster
Aster spp.	Asters
Astilbe crenatiloba	Roan False Goat's Beard
Astragalus michauxii	Sandhills Milkvetch
Athyrium filix-femina var. *angustum*	Northern Lady Fern
Athyrium filix-femina var. *asplenioides*	Southern Lady Fern
RAB = *Athyrium asplenioides*	
Atriplex arenaria	Seabeach Orach
Atriplex patula	Halberdleaf Orach
Aulocomnium heterostichum	A Moss
Aulacomnium palustre	A Moss
Aureolaria laevigata	Downy Yellow Oakleach
Azolla caroliniana	Carolina Mosquito Fern
Baccharis angustifolia	Saltwater False-willow
Baccharis glomeruliflora	Silverling
Baccharis halimifolia	Mulletbush, Groundsel-tree
Bacopa caroliniana	Blue Water-hyssop
Bacopa innominata	A Water-hyssop
RAB = *Bacopa cyclophylla*	
Bacopa monnieri	Coastal Water-hyssop
Bacopa rotundifolia	Round-leaf Water-hyssop

Baeomyces fungoides	A Lichen
Balduina atropurpurea	Honeycomb Head
Baptisia alba	White Wild Indigo
RAB = *Baptisia alba & Baptisia pendula*	
Baptisia australis var. *australis*	Blue Wild Indigo
Baptisia cinerea	Ashy Wild Indigo
Baptisia leucophaea var. *bracteata*	Creamy Wild Indigo
RAB = *Baptisia bracteata*	
Baptisia tinctoria	A Wild Indigo
Barbula inaequalifolia	A Moss
Bartonia paniculata	Twining Screwstem
Bartonia verna	White Screwstem
Bartramia pomiformis	Apple Moss
Bartramidula cernua	Dwarf Apple Moss
Bazzania denudata	A Liverwort
Bazzania nudicaulis	A Liverwort
Bazzania trilobata	A Liverwort
Berberis canadensis	American Barberry
Berchemia scandens	Carolina Supplejack
Betula alleghaniensis	Yellow Birch
RAB = *Betula lutea*	
Betula lenta	Sweet Birch, Cherry Birch
Betula nigra	River Birch
Betula papyrifera var. *cordifolia*	Mountain Paper Birch
Bidens coronata	Crowned Beggarticks
Bidens frondosa	Devil's Beggarticks
Bigelowia nudata	Pineland Rayless-goldenrod
RAB = *Chondrophora nudata*	
Bignonia capreolata	Crossvine
RAB = *Anisostichus capreolata*	
Boehmeria cylindrica	False Nettle
Boltonia asteroides	White Doll's-daisy
Boltonia diffusa	Diffuse Doll's-daisy
Boltonia spp.	Doll's-daisies
Borrichia frutescens	Seaside Oxeye
Botrychium jenmanii	Alabama Grape Fern
RAB = *Botrychium alabamense*	
Botrychium lanceolatum var. *angustisegmentum*	Lance-leaf Moonwort
Botrychium matricariifolium	Daisy-leaf Moonwort
Botrychium multifidum	Leathery Grape Fern
Botrychium oneidense	Blunt-lobed Grape Fern
Botrychium simplex	Least Moonwort
Botrychium virginianum	Rattlesnake Fern
Boykinia aconitifolia	Brookfoam
Brachydontium trichodes	Peak Moss
Brachymenium andersonii	Anderson's Brachymenium
Brachymenium systlylium	Mexican Brachymenium
Brachythecium populeum	Matted Feather Moss
Brachythecium rotaeanum	Rota's Feather Moss
Brasenia schreberi	Watershield
Bromus ciliatus	Fringed Brome

Bromus latiglumis	Riverbank Brome
RAB = *Bromus purgans* in part	
Bromus nottowayanus	Nottoway Valley Brome
RAB = *Bromus purgans* in part	
Bromus pubescens	Wood Brome
RAB = *Bromus purgans* in part	
Bryocrumia vivicolor	Gorge Moss
Bryoxiphium norvegicum	Sword Moss
Bryum riparium	A Moss
Buchnera americana	American Bluehearts
RAB = *Buchnera americana & Buchnera floridana*	
Buckleya distichophylla	Piratebush
Bulbostylis capillaris	Tufted Hairsedge
Bulbostylis capillaris ssp. *capillaris*	Tufted Hairsedge
Bulbostylis warei	Ware's Hairsedge
Burmannia biflora	Northern Bluethreads
Buxbaumia aphylla	Bug-on-a-stick
Buxbaumia minakatae	Hump-backed Elves
Cacalia muhlenbergii	Great Indian-plantain
Cacalia ovata	Savanna Indian-plantain
RAB = *Cacalia lanceolata*	
Cacalia rugelia	Rugel's Ragwort
RAB = *Senecio rugelia*	
Cacalia suaveolens	Sweet Indian-plantain
Cakile edentula	Sea Rocket
Calamagrostis cainii	Cain's Reedgrass
Calamagrostis canadensis	Canada Reedgrass
Calamagrostis porteri	Porter's Reedgrass
Calamintha georgiana	Georgia Calamint
RAB = *Satureja georgiana*	
Calamovilfa brevipilis	Pinebarrens Sandreed
Callicarpa americana	Beautyberry
Calliergon cordifolium	A Moss
Calliergonella cuspidata	A Moss
Callitriche terrestris	Terrestrial Water-starwort
RAB = *Callitriche deflexa*	
Calopogon barbatus	Bearded Grass-pink
Calopogon pallidus	Pale Grass-pink
Calopogon tuberosus	Common Grass-pink
RAB = *Calopogon pulchellus*	
Caltha palustris	Marsh Marigold
Calycanthus floridus	Eastern Sweetshrub
Calycanthus floridus var. *floridus*	Eastern Sweetshrub
Calystegia catesbiana ssp. *sericata*	Blue Ridge Bindweed
RAB = *Calystegia sericata*	
Camassia scilloides	Wild Hyacinth
Campanula aparinoides	Marsh Bellflower
Campsis radicans	Trumpetvine
Campylium stellatum	Yellow Starry Fen Moss
Campylopus atrovirens	Cliff Campylopus
Campylopus carolinae	Savanna Campylopus

Campylopus oerstedianus	Oersted's Campylopus
Campylopus paradoxus	Paradoxical Campylopus
Cardamine bulbosa	Bulbous Bittercress
Cardamine clematitis	Mountain Bittercress
RAB = *Cardamine clematitis* in part	
Cardamine concatenata	Cutleaf Toothwort
Cardamine dissecta	Dissected Toothwort
RAB = *Cardamine angustata* var. *multifida*	
Cardamine douglassii	Douglass's Bittercress
Cardamine flagellifera	A Bittercress
RAB = *Cardamine clematitis* in part	
Cardamine longii	Long's Bittercress
Cardamine micranthera	Small-Anthered Bittercress
Cardamine rotundifolia	Mountain Watercress
Carex aenea	Fernald's Hay Sedge
Carex aestivalis	Summer Sedge
Carex alata	Broad-wing Sedge
Carex albursina	White Bear Sedge
Carex amphibola var. *amphibola*	Eastern Narrowleaf Sedge
Carex argyrantha	Hay Sedge
Carex artitecta	Drywoods Sedge
Carex atlantica	Prickly Bog Sedge
Carex barrattii	Barratt's Sedge
Carex biltmoreana	Biltmore Sedge
Carex bromoides	Brome Sedge
Carex brunnescens	Brown Sedge
Carex bullata	Button Sedge
Carex bushii	Bush's Sedge
Carex buxbaumii	Buxbaum's Sedge
Carex canescens ssp. *disjuncta*	Silvery Sedge
Carex chapmanii	Chapman's Sedge
Carex cherokeensis	Cherokee Sedge
Carex collinsii	Collins's Sedge
Carex conoidea	Cone-shaped Sedge
Carex crebriflora	Coastal Plain Sedge
Carex crinita	Fringed Sedge
Carex cristatella	Small Crested Sedge
Carex crus-corvi	Crowfoot Sedge
Carex debilis	White-edge Sedge
Carex decomposita	Cypress Knee Sedge
Carex eburnea	Bristle-leaf Sedge
Carex echinata ssp. *echinata*	Star Sedge
RAB = *Carex muricata* var. *angustata*	
Carex elliottii	Elliott's Sedge
Carex emmonsii	Emmons's Sedge
Carex exilis	Meager Sedge
Carex floridana	Florida Sedge
RAB = *Carex nigromarginata* var. *floridana*	
Carex folliculata	Northern Long Sedge
RAB = *Carex folliculata* var. *folliculata*	
Carex gigantea	Giant Sedge

Carex gracilescens	Slender Loose-flower Sedge
Carex granularis	Limestone Meadow Sedge
Carex gynandra	Mountain Fringed Sedge
Carex hyalinolepis	Shoreline Sedge
Carex impressinervia	A Sedge
Carex intumescens	Bladder Sedge
Carex joorii	Cypress-swamp Sedge
Carex laxiflora	Broad Loose-flower Sedge
Carex leavenworthii	Leavenworth's Sedge
Carex leptalea	Little Bog Sedge
Carex leptonervia	A Wood Sedge
Carex lonchocarpa	Southern Long Sedge
RAB = *Carex folliculata* var. *australis*	
Carex manhartii	Manhart's Sedge
RAB = *Carex purpurifera* in part	
Carex meadii	Mead's Sedge
Carex misera	Wretched Sedge
Carex mitchelliana	Mitchell's Sedge
RAB = *Carex crinita* var. *mitchelliana*	
Carex nigromarginata	Black-edge Sedge
Carex oklahomensis	Oklahoma Sedge
Carex oligocarpa	Rich-woods Sedge
Carex oligosperma	Few-seeded Sedge
Carex pedunculata	Longstalk Sedge
Carex pensylvanica	Pennsylvania Sedge
Carex physorhyncha	Bellow's-beak Sedge
Carex projecta	Necklace Sedge
Carex purpurifera	Purple Sedge
Carex reniformis	Kidney Sedge
Carex roanensis	Roan Sedge
Carex ruthii	Ruth's Sedge
RAB = *Carex muricata* var. *ruthii*	
Carex schweinitzii	Schweinitz's Sedge
Carex sparganioides	Bur-reed Sedge
Carex striata	Walter's Sedge
RAB = *Carex walteriana Carex stricta*	Straight Sedge
Carex tenax	Strong Sedge
Carex tenera	Quill Sedge
Carex tetanica	Rigid Sedge
Carex torta	Twisted Sedge
Carex trisperma	Three-seeded Sedge
Carex turgescens	Swollen Sedge
Carex umbellata	Parasol Sedge
Carex verrucosa	Warty Sedge
Carex vestita	Velvet Sedge
Carex willdenowii var. *megarrhyncha*	Willdenow's Sedge
RAB =	Carex willdenowii in part
Carex woodii	Wood's Sedge
Carex spp.	Sedges
Carphephorus bellidifolius	Sandhill Chaffhead
Carphephorus paniculatus	Hairy Chaffhead

RAB = *Trilisa paniculata*	
Carphephorus tomentosus	Woolly Chaffhead
Carpinus caroliniana	Ironwood, Musclewood
Carya alba	Mockernut Hickory
RAB = *Carya tomentosa*	
Carya aquatica	Water Hickory
Carya carolinae-septentrionalis	Carolina Shagbark Hickory
Carya cordiformis	Bitternut Hickory
Carya glabra	Pignut Hickory
Carya laciniosa	Big Shellbark Hickory, King Nut
Carya myristiciformis	Nutmeg Hickory
Carya ovalis	Red Hickory
Carya ovata	Shagbark Hickory
Carya pallida	Sand Hickory
Carya spp.	Hickories
Castilleja coccinea	Indian Paintbrush
Castanea dentata	American Chestnut
Castanea pumila	Chinquapin
Caulophyllum giganteum	Northern Blue Cohosh
Caulophyllum thalictroides	Common Blue Cohosh
RAB = *Caulophyllum thalictroides* in part	
Ceanothus americanus	New Jersey Tea
Celastrus scandens	American Bittersweet
Celtis laevigata	Sugarberry
Celtis occidentalis	Mountain Hackberry
RAB = *Celtis occidentalis* var. *occidentalis*	
Celtis tenuifolia	Georgia Hackberry
RAB = *Celtis occidentalis* var. *georgiana*	
Cenchrus tribuloides	Dune Sandbur
Centella asiatica	Spadeleaf
Cephalanthus occidentalis	Buttonbush
Cephaloziella hampeana	A Liverwort
Cephaloziella massalongi	A Liverwort
Cephaloziella obtusilobula	A Liverwort
Cephaloziella spinicaulis	A Liverwort
Ceratophyllum muricatum	Prickly Hornwort
RAB = *Ceratophyllum echinatum*	
Ceratophyllum spp.	Hornworts
Cercis canadensis	Redbud
Cetraria arenaria	A Lichen
Chamaecyparis thyoides	Atlantic White Cedar
Chamaedaphne calyculata	Leatherleaf, Cassandra
RAB = *Cassandra calyculata*	
Chamaelirium luteum	Fairywand
Chamaesyce cordifolia	Heartleaf Sandmat
RAB = *Euphorbia cordifolia*	
Chamaesyce polygonifolia	Seabeach Sandmat
RAB = *Euphorbia polygonifolia*	
Chamaesyce bombensis	Southern Seabeach Sandmat
RAB = *Euphorbia ammannioides*	
Chaptalia tomentosus	Sunbonnets

Chasmanthium latifolium	River Oats, Fish-on-a-String
RAB = *Uniola latifolia*	
Chasmanthium laxum	Slender Spikegrass
RAB = *Uniola laxa*	
Chasmanthium nitidum	A Spanglegrass
RAB = *Uniola nitida*	
Chasmanthium sessiliflorum	Longleaf Spikegrass
RAB = *Uniola sessiliflora*	
Cheilanthes alabamensis	Alabama Lip-fern
Cheilanthes lanosa	Hairy Lipfern
Cheilanthes tomentosa	Woolly Lipfern
Cheilolejeunea evansii	A Liverwort
Cheilolejeunea myriantha	A Liverwort
Cheilolejeunea rigidula	A Liverwort
Chelone cuthbertii	Cuthbert's Turtlehead
Chelone glabra	White Turtlehead
Chelone lyonii	Pink Turtlehead
Chelone obliqua	Red Turtlehead
Chenopodium ambrosioides	Mexican Tea, Epazote
Chenopodium simplex	Giant-seed Goosefoot
Chionanthus virginicus	Fringetree
Chimaphila maculata	Pipsissewa
Chrysoma pauciflosculosa	Woody Goldenrod
RAB = *Solidago pauciflosculosa*	
Chrysopogon pauciflorus	Goldenbeard
Chrysopsis scabrella	Rough Golden-aster
Chrysosplenium americanum	American Golden-saxifrage
Cicuta maculata	Spotted Water-hemlock
Cimicifuga americana	Mountain Bugbane
Cimicifuga racemosa	Black Bugbane, Black Cohosh
Cinna latifolia	Slender Wood-reed
Circaea alpina	Alpine Enchanter's-nightshade
Circaea lutetiana ssp. *canadensis*	Southern Enchanter's-nightshade
Cirriphyllum piliferum	A Moss
Cirsium carolinianum	Carolina Thistle
RAB = *Carduus carolinianus*	
Cirsium lecontei	Leconte's Thistle
RAB = *Carduus lecontei*	
Cirsium muticum	Swamp Thistle
RAB = *Carduus muticus*	
Cirsium repandum	Sandhill Thistle
RAB = *Carduus repandus*	
Cirsium virginianum	Virginia Thistle
RAB = *Carduus virginianus*	
Cladina evansii	A Reindeer Lichen
Cladina spp.	Reindeer Lichens
Cladium mariscoides	Twig-Rush
Cladium mariscus ssp. *jamaicense*	Sawgrass
RAB = *Cladium jamaicense*	
Cladonia caroliniana	Carolina Reindeer Lichen
Cladonia psoromica	Bluff Mtn. Reindeer Lichen

Cladonia uncialis	A Reindeer Lichen
Cladonia spp.	Reindeer Lichens
Cladrastis lutea	Yellowwood
Claytonia caroliniana	Carolina Spring-beauty
Claytonia virginiana	Virginia Spring-beauty
Cleistes divaricata	Rosebud Orchid
Clematis glaucophylla	White-leaved Leatherflower
Clematis occidentalis	Rock Clematis
RAB = *Clematis verticillaris*	
Clematis ochroleuca	Curlyheads
Clematis virginiana	Virgin's-bower
Clethra acuminata	Mountain Sweet-pepperbush
Clethra alnifolia	Coastal Sweet-pepperbush
Climacium americanum	A Moss
Clintonia borealis	Bluebead Lily
Clintonia umbellulata	Blackbead Lily
Cnidoscolus stimulosus	Tread-softly
Cocculus carolinus	Carolina Coralbeads
Coeloglossum viride var. *virescens*	Long-bracted Frog Orchid
RAB = *Habenaria viridis* var. *bracteata*	
Coelorachis cylindrica	Carolina Jointgrass
RAB = *Manisuris cylindrica*	
Coelorachis rugosa	Wrinkled Jointgrass
RAB = *Manisuris rugosa*	
Collinsonia canadensis	Canada Richweed
Collinsonia serotina	A Richweed
Collinsonia tuberosa	Piedmont Horsebalm
Collinsonia verticillata	Whorled Horsebalm
Cololejeunea ornata	A Liverwort
Commelina erecta var. *angustifolia*	Dune Dayflower
RAB = *Commelina erecta* in part	
Comptonia peregrina	Sweetfern
Conioselinum chinense	Hemlock-parsley
Conium maculatum	Poison-hemlock
Conocephalum conicum	Snakeskin Liverwort
Conopholis americana	Squaw-root
Convallaria montana	Appalachian Lily-of-the-Valley
RAB = *Convallaria majalis* var. *montana*	
Conyza canadensis var. *pusilla*	Smooth Horseweed
RAB = *Erigeron canadensis* var. *pusillus*	
Coreopsis latifolia	Broadleaf Coreopsis
Coreopsis major	Greater Coreopsis
RAB = *Coreopsis major* var. *major* & var. *stellata*	
Coreopsis pubescens	Star Coreopsis
Coreopsis verticillata	Whorled Coreopsis
Cornus alternifolia	Pagoda Cornel, Alternate Dogwood
Cornus amomum	Silky Dogwood
Cornus asperifolia	Roughleaf Dogwood
Cornus florida	Flowering Dogwood
Cornus stricta	Stiff Dogwood

Corydalis flavula	Yellow Fumewort
Corydalis sempervirens	Rock Harlequin, Pink Fumewort
Corylus cornuta	Beaked Hazelnut
Crataegus marshallii	Parsley-leaf Hawthorn
Crataegus spathulata	Little-hip Hawthorn
Crataegus spp.	Hawthorns
Crinum americanum	Swamp-lily
Croton monanthogynus	Prairie-tea Croton
Croton punctatus	Seaside Croton
Crotonopsis elliptica	Eggleaf Rushfoil
Cryptotaenia canadensis	Honewort
Ctenium aromaticum	Toothache Grass
Cunila origanoides	Dittany, Rock Oregano
Cuscuta cephalanthi	Buttonbush Dodder
Cuscuta coryli	Hazel Dodder
Cylindrocolea andersonii	A Liverwort
Cylindrocolea rhizantha	A Liverwort
Cymophyllus fraseri	Fraser's Sedge
Cynanchum angustifolium	Hammock Swallow-wort
RAB = *Cynanchum palustre*	
Cyperus dentatus	Toothed-leaf Flatsedge
Cyperus distans	A Flatsedge
Cyperus granitophilus	Granite-loving Flatsedge
Cyperus houghtonii	Houghton's Flatsedge
Cyperus lecontei	Leconte's Flatsedge
Cyperus refractus	Reflexed Flatsedge
Cyperus squarrosus	Awned Flatsedge
RAB = *Cyperus aristatus*	
Cyperus tetragonus	Four-angled Flatsedge
Cypripedium acaule	Pink Ladyslipper
Cypripedium pubescens	Yellow Ladyslipper
RAB = *Cypripedium calceolus* var. *pubescens*	
Cypripedium reginae	Showy Ladyslipper
Cyrilla racemiflora	Ti-ti
Cystopteris bulbifera	Bulblet Bladder-fern
Cystopteris protrusa	Cove Bladder-fern
RAB = *Cystopteris protrusa* in part	
Cystopteris tennesseensis	Tennessee Bladder-fern
Cystopteris tenuis	Upland Bladder-fern
RAB = *Cystopteris protrusa* in part	
Dalea pinnata	Summer Farewell
RAB = *Petalostemum pinnatum*	
Dalibarda repens	Robin Runaway
Danthonia compressa	Mountain Oat Grass
Danthonia spicata	Northern Oat Grass
Decodon verticillatus	Swamp-loosestrife
Decumaria barbara	Climbing Hydrangea
Delphinium exaltatum	Tall Larkspur
Delphinium tricorne	Dwarf Larkspur
Dennstaedtia punctilobula	Hay-scented Fern
Deschampsia cespitosa ssp. *glauca*	Tufted Hairgrass

RAB = *Deschampsia caespitosa* var. *glauca*	
Deschampsia flexuosa	Wavy Hairgrass
Desmodium fernaldii	Fernald's Tick-trefoil
Desmodium nudiflorum	Woodland Tick-trefoil
Desmodium ochroleucum	Creamy Tick-trefoil
Desmodium pauciflorum	Few-flower Tick-trefoil
Desmodium sessilifolium	Sessile Tick-trefoil
Desmodium spp.	Tick-trefoils
Diamorpha smallii	Elf Orpine
RAB = *Sedum smallii*	
Dicentra canadensis	Squirrel Corn
Dicentra cucullaria	Dutchman's-britches
Dicentra eximia	Bleeding Heart
Dichanthelium boreale	Northern Witch Grass
RAB = *Panicum bicknellii*	
Dichanthelium commutatum	Variable Witchgrass
RAB = *Panicum commutatum*	
Dichanthelium dichotomum	Common Witchgrass
RAB = *Panicum dichotomum*	
Dichanthelium erectifolium	Erectleaf Witchgrass
RAB = *Panicum erectifolium*	
Dichanthelium lanuginosum	A Witchgrass
RAB = *Panicum lanuginosum*	
Dichanthelium latifolium	Broadleaf Witchgrass
RAB = *Panicum latifolium*	
Dichanthelium ovale var. *ovale*	Eggleaf Witchgrass
RAB = *Panicum ovale*	
Dichanthelium sphaerocarpon	Roundseed Witchgrass
RAB = *Panicum sphaerocarpon*	
Dichanthelium spretum	Eaton's Witchgrass
RAB = *Panicum spretum*	
Dichanthelium wrightianum	Wright's Witchgrass
RAB = *Panicum wrightianum*	
Dichanthelium spp.	Witchgrasses
RAB = *Panicum* spp.	
Dichodontium pellucidum	A Moss
Dicranum condensatum	Sandhill Broom-moss
Dicranum undulatum	Bog Broom-moss
Dicranum spp.	Broom-mosses
Didiplis diandra	Water Purslane
RAB = *Peplis diandra*	
Diervilla sessilifolia	Southern Bush-honeysuckle
Diodia teres	Rough Buttonweed
Diodia virginica	Virginia Buttonweed
Dionaea muscipula	Venus Flytrap, Meadow Clams
Dioscorea hirticaulis	Hairy Yam
RAB = *Dioscorea villosa* var. *hirticaulis*	
Dioscorea villosa	Yellow Yam
Diospyros virginiana	Persimmon
Diphylleia cymosa	Umbrella-leaf, Pyxie Parasol
Diplazium pycnocarpon	Glade Fern

RAB = *Athyrium pycnocarpon*	
Diplophyllum andrewsii	A Liverwort
Diplophyllum obtusatum	A Liverwort
Dirca palustris	Leatherwood
Disporum maculatum	Nodding Mandarin
Distichlis spicata	Salt Grass
Ditrichum ambiguum	Ambiguous Ditrichum
Dodecatheon meadia	Shooting Star
Draba ramosissima	Branching Draba
Draba reptans	Creeping Draba
Drepanocladus fluitans	Floating Sickle-moss
Drepanolejeunea appalachiana	A Liverwort
Drosera brevifolia	Dwarf Sundew
RAB = *Drosera leucantha*	
Drosera capillaris	Pink Sundew
Drosera filiformis	Threadleaf Sundew
Drosera intermedia	Spoonleaf Sundew
Drosera rotundifolia	Roundleaf Sundew
Dryopteris campyloptera	Mountain Woodfern
Dryopteris carthusiana	Spinulose Woodfern
RAB = *Dryopteris spinulosa*	
Dryopteris cristata	Crested Woodfern
Dryopteris goldiana	Goldie's Woodfern
Dryopteris intermedia	Fancy Fern
Dryopteris ludoviciana	Southern Woodfern
Dryopteris marginalis	Marginal Woodfern
Dryopteris spp.	Woodferns
Dulichium arundinaceum	Three-way Sedge
Echinacea laevigata	Smooth Coneflower
Echinacea pallida	Pale Coneflower
Echinacea purpurea	Purple Coneflower
Echinodorus parvulus	Dwarf Burhead
Egeria densa	Waterweed
Eleocharis atropurpurea	Purple Spikerush
Eleocharis baldwinii	Baldwin's Spikerush
Eleocharis cellulosa	Gulfcoast Spikerush
Eleocharis elongata	Florida Spikerush
Eleocharis engelmannii	Engelmann's Spikerush
Eleocharis equisetoides	Horsetail Spikerush
Eleocharis erythropoda	Bald Spikerush
Eleocharis fallax	Creeping Spikerush
Eleocharis flavescens	Yellow Spikerush
Eleocharis halophila	Salt Spikerush
Eleocharis melanocarpa	Blackfruit Spikerush
Eleocharis parvula	Little-spike Spikerush
Eleocharis obtusa	Blunt Spikerush
Eleocharis robbinsii	Robbins's Spikerush
Eleocharis rostellata	Beaked Spikerush
Eleocharis smallii	Small's Spikerush
Eleocharis tenuis	Slender Spikerush
Eleocharis tricostata	Three-angle Spikerush

Eleocharis vivipara	Viviparous Spikerush
Eleocharis spp.	Spikerushes
Elephantopus nudatus	Smooth Elephant-foot
Elodea canadensis	Canada Elodea
Elodea nuttallii	Nuttall's Elodea
Elodea spp.	Elodeas
Elymus canadensis	Nodding Wild Rye
Elymus hystrix	Bottlebrush Grass
RAB = *Hystrix patula*	
Elymus riparius	Riverbank Wild Rye
Elymus trachycaulus ssp. *trachycaulus*	Slender Wheatgrass
RAB = *Agropyron trachycaulum*	
Elymus virginicus	Virginia Wild Rye
Encalypta procera	Extinguisher Moss
Enemion biternatum	Atlantic Isopyrum
RAB = *Isopyrum biternatum*	
Entodon compressus	Flattened Entodon
Entodon concinnus	Lime Entodon
Entodon sullivantii	Sullivant's Entodon
Epidendrum conopseum	Green Fly Orchid
Epifagus virginiana	Beechdrops
Epigaea repens	Trailing Arbutus
Epilobium angustifolium	Purple Willowherb
Epilobium ciliatum	Purpleleaf Willowherb
Epilobium leptophyllum	Narrowleaf Willowherb
Equisetum X *ferrissii*	Ferriss's Scouring Rush
Eragrostis frankii	Frank's Lovegrass
Eragrostis lugens	Mourning Lovegrass
Eragrostis pilosa	Indian Lovegrass
Erianthus alopecuroides	Woolly Plumegrass
Erigenia bulbosa	Harbinger-of-Spring
Erigeron vernus	Spring Fleabane
Eriocaulon aquaticum	Seven-angled Pipewort
RAB = *Eriocaulon pellucidum*	
Eriocaulon compressum	Soft-headed Pipewort
Eriocaulon decangulare	Ten-angled Pipewort
Eriocaulon lineare	Linear Pipewort
Eriocaulon parkeri	Parker's Pipewort
Eriocaulon spp.	Pipeworts
Eriophorum virginicum	Tawny Cottongrass
Eryngium aquaticum	Rattlesnake-master, Marsh Eryngo
Eryngium integrifolium	Blue-flower Eryngo
Erythrina herbacea	Coralbean
Erythronium americanum ssp. *americanum*	American Trout Lily
RAB = *Erythronium americanum* in part	
Erythronium umbilicatum ssp. *monostolum*	Appalachian Trout Lily
RAB = *Erythronium americanum* in part	
Erythronium umbilicatum ssp. *umbilicatum*	Southern Trout Lily
RAB = *Erythronium americanum* in part	
Eucladium verticillatum	Lime-seep Eucladium
Eupatorium altissimum	Tall Thoroughwort

Eupatorium incarnatum	Pink Thoroughwort
Eupatorium leptophyllum	Limesink Dog-fennel
RAB = *Eupatorium capillifolium* var. *leptophyllum*	
Eupatorium pilosum	Pilose Thoroughwort
Eupatorium resinosum	Resinous Boneset
Eupatorium spp.	Thoroughworts
Euphorbia commutata	Cliff Spurge
Euphorbia corollata	Flowering Spurge
Euphorbia exserta	Sandhill Spurge
RAB = *Euphorbia gracilior*	
Euphorbia ipecacuanhae	Carolina Ipecac
Euphorbia purpurea	Glade Spurge
Eurhynchium pringlei	Pringle's Eurhynchium
Eustachys glauca	Saltmarsh Fingergrass
RAB = *Chloris glauca*	
Eustachys petraea	Dune Fingergrass
RAB = *Chloris petraea*	
Euthamia graminifolia	Flattop Goldenrod
RAB = *Solidago graminifolia*	
Evonymus americana	American Strawberry-bush
RAB = *Euonymus americanus*	
Evonymus atropurpurea	Eastern Burningbush
RAB = *Euonymus atropurpureus*	
Fagus grandifolia	Beech
Filipendula rubra	Queen-of-the-Prairie
Fimbristylis castanea	Marsh Fimbry
Fimbristylis miliacea	Grass-like Fimbry
Fimbristylis perpusilla	Harper's Fimbry
Fimbristylis spadicea	A Fimbry
Fimbristylis spp.	Fimbries
Fissidens exilis	Small Pocket Moss
Fissidens hallii	Hall's Pocket Moss
Fissidens osmundioides	A Pocket Moss
Fontinalis spp.	An Aquatic Moss
Fothergilla major	Large Fothergilla
Fragaria vesca	Woodland Strawberry
Fragaria virginiana	Wild Strawberry
Frasera caroliniensis	Columbo
RAB = *Swertia caroliniensis*	
Fraxinus americana	White Ash
Fraxinus caroliniana	Carolina Ash
Fraxinus pennsylvanica	Green Ash
Fraxinus profunda	Pumpkin Ash
RAB = *Fraxinus tomentosa*	
Froelichia gracilis	Slender Snake-cotton
Frullania oakesiana	A Liverwort
Frullania plana	A Liverwort
Fuirena squarrosa	Hairy Umbrella-sedge
Gaillardia aestivalis	Sandhills Gaillardia
Gaillardia pulchella	Firewheel, Dune Gaillardia

Galactia mollis	Soft Milk-Pea
Galax urceolata	Galax
RAB = *Galax aphylla*	
Galium asprellum	Rough Bedstraw
Galium circaezans	Licorice Bedstraw
Galium hispidulum	Coastal Bedstraw
Galium lanceolatum	Lanceleaf Wild Licorice
Galium obtusum	Bluntleaf Bedstraw
Galium pilosum	Hairy Bedstraw
Galium triflorum	Fragrant Bedstraw
Galium spp.	Bedstraws
Gaultheria procumbens	Wintergreen, Teaberry
Gaura angustifolia	Southern Beeblossom
Gaylussacia baccata	Black Huckleberry
Gaylussacia dumosa	Dwarf Huckleberry
Gaylussacia frondosa	Blue Huckleberry
Gaylussacia ursina	Bear Huckleberry
Gaylussacia spp.	Huckleberries
Gelsemium rankinii	Swamp Jessamine
Gelsemium sempervirens	Carolina Jessamine
Gentiana autumnalis	Pinebarren Gentian
Gentiana flavida	Yellow Gentian
RAB = *Gentiana alba*	
Gentianopsis crinita	Fringed Gentian
RAB = *Gentiana crinita*	
Geranium maculatum	Wild Geranium
Geum aleppicum	Yellow Avens
Geum canadense	Canada Avens
Geum geniculatum	Bent Avens
Geum laciniatum	Rough Avens
Geum radiatum	Mountain Avens
Geum spp.	Avens
Glandularia canadensis	Rose Mock-vervain
RAB = *Verbena canadensis*	
Glyceria laxa	Lax Mannagrass
RAB = *Glyceria canadensis* var. *laxa*	
Glyceria melicaria	Melic Mannagrass
Glyceria nubigena	Smoky Mountain Mannagrass
Glyceria obtusa	Atlantic Mannagrass
Glyceria septentrionalis	Eastern Mannagrass
Goodyera pubescens	Downy Rattlesnake Orchid
Goodyera repens	Dwarf Rattlesnake Orchid
Gordonia lasianthus	Loblolly Bay
Grammitis nimbata	Dwarf Polypody
Gratiola aurea	Golden Hedge-hyssop
Gratiola ramosa	Branched Hedge-hyssop
Grimmia cribrosa	Copper Grimmia
Grimmia laevigata	A Grimmia
Grimmia spp.	Grimmias
Gymnocarpium sp. 1	Appalachian Oak Fern

Gymnoderma lineare	Rock Gnome Lichen
Gymnopogon brevifolius	Skeleton Grass
Habenaria repens	Water-spider Orchid
Halesia tetraptera	Silverbell
RAB = *carolina*	
Halodule beaudettei	Beaudette's Shoalweed
Hamamelis virginiana	Witch-hazel
Harpanthus drummondii	A Liverwort
Hedwigia ciliata	Hedwig's Rockmoss
Helenium autumnale	Autumn Sneezeweed
Helenium brevifolium	Littleleaf Sneezeweed
Helenium pinnatifidum	Dissected Sneezeweed
Helenium vernale	Spring Sneezeweed
Helianthemum bicknellii	Plains Sunrose
Helianthemum carolinianum	Carolina Sunrose
Helianthemum corymbosum	Pinebarren Sunrose
Helianthemum georgianum	Georgia Sunrose
Helianthemum propinquum	Creeping Sunrose
Helianthemum rosmarinifolium	Rosemary Sunrose
Helianthus angustifolius	Narrowleaf Sunflower
Helianthus floridanus	Florida Sunflower
Helianthus glaucophyllus	Whiteleaf Sunflower
Helianthus heterophyllus	Savanna Sunflower
Helianthus laevigatus	Smooth Sunflower
Helianthus occidentalis	Few-leaf Sunflower
Helianthus schweinitzii	Schweinitz's Sunflower
Helianthus spp.	Sunflowers
Heliotropium curassavicum	Seaside Heliotrope
Helonias bullata	Swamp Pink
Hepatica acutiloba	Sharp-lobed Hepatica
Hepatica americana	Round-lobed Hepatica
Heteranthera multiflora	Multiflowered Mud-Plantain
Heteranthera reniformis	Kidneyleaf Mud-plantain
Heteropogon melanocarpus	Tanglehead
Heuchera americana	Common Alumroot
Heuchera americana var. *hispida*	Hispid Alumroot
RAB = *Heuchera americana* in part	
Heuchera caroliniana	Carolina Alumroot
Heuchera longiflora	Long-Flower Alumroot
RAB = *Heuchera longiflora* var. *aceroides*	
Heuchera parviflora	Cave Alumroot
Heuchera villosa	Crag-jangle
Heuchera spp.	Aluroots
Hexalectris spicata	Crested Coralroot
Hexastylis arifolia	Arrowleaf Heartleaf
Hexastylis contracta	Mountain Heartleaf
Hexastylis lewisii	Lewis's Heartleaf
Hexastylis minus	Little Heartleaf
RAB = *Hexastylis minor*	
Hexastylis naniflora	Dwarf-flowered Heartleaf
Hexastylis rhombiformis	French Broad Heartleaf

Hexastylis spp.	Heartleafs
Hibiscus aculeatus	Savanna Hibiscus
Hibiscus coccineus	Scarlet Hibiscus
Hibiscus moscheutos	Crimson-eyed Hibiscus
Hieracium gronovii	Queendevil
Hieracium paniculatum	Appalacian Hawkweed
Hieracium scabrum	Rough Hawkweed
Hieracium venosum	Rattlesnake Hawkweed
Hierochloe odorata	Holy Grass, Sweet Grass
Homalia trichomanoides	Lime Homalia
Homaliadelphus sharpii	Sharp's Homaliadelphus
Hookeria acutifolia	Hooker's Moss
Hottonia inflata	Water Violet
Houstonia caerulea	Common Bluet
Houstonia longifolia var. *longifolia*	Longleaf Bluet
RAB = *Houstonia longifolia* in part	
Houstonia montana	Mountain Bluet
RAB = *Houstonia purpurea* in part	
Houstonia purpurea	Summer Bluet
RAB = *Houstonia purpurea* in part	
Houstonia purpurea var. *calycosa*	A Summer Bluet
RAB = *Houstonia purpurea* in part	
Houstonia serpyllifolia	Michaux's Bluet
Houstonia tenuifolia	Narrowleaf Bluet
Hudsonia montana	Mountain Golden-heather
Hudsonia tomentosa	Woolly Beach Heather
Humulus lupulus var. *lupuloides*	American Hops
RAB = *Humulus lupulus* in part	
Humulus lupulus var. *pubescens*	American Hops
RAB = *Humulus lupulus* in part	
Huperzia lucidula	Shining Clubmoss
RAB = *Lycopodium lucidulum*	
Huperzia porophila	Rock Clubmoss
RAB = *Lycopodium porophilum*	
Huperzia selago	Fir Clubmoss
RAB = *Lycopodium selago*	
Hybanthus concolor	Green Violet
Hydrangea arborescens	Wild Hydrangea
RAB = *Hydrangea arborescens* ssp. *arborescens*	
Hydrangea cinerea	Ashy Hydrangea
RAB = *Hydrangea arborescens* ssp. *discolor*	
Hydrastis canadensis	Golden Seal
Hydrocotyle americana	Mountain Pennywort
Hydrocotyle bonariensis	Dune Pennywort
Hydrocotyle ranunculoides	Floating Pennywort
Hydrocotyle umbellata	Marsh Pennywort
Hydrocotyle verticillata var. *triradiata*	Whorled Pennywort
Hydrophyllum canadense	Bluntleaf Waterleaf
Hydrophyllum macrophyllum	Largeleaf Waterleaf
Hydrophyllum virginianum	Brookflower
Hydrothyria venosa	An Aquatic Lichen

Hygrohypnum closteri	Closter's Brook-hypnum
Hylocomium splendens	Stairstep Moss
Hymenocallis caroliniana	Carolina Spider-lily
RAB = *Hymenocallis occidentalis*	
Hymenocallis crassifolia	Georgia Spider-lily
Hymenophyllum (Sphaerocionium) sp.	Filmy-fern Gametophyte
Hyophila involuta	A Moss
Hypericum adpressum	Bog St. John's-wort
Hypericum buckleyi	Blue Ridge St. John's-wort
Hypericum densiflorum	Bushy St. John's-wort
Hypericum denticulatum	Coppery St. John's-wort
Hypericum denticulatum var. *acutifolium*	Outcrop St. John's-wort
Hypericum fasciculatum	Peelbark St. John's-wort
Hypericum frondosum	Cedar-glade St. John's-wort
Hypericum gentianoides	Pineweed
Hypericum graveolens	Mountain St. John's-wort
Hypericum hypericoides	St. Andrew's-cross
Hypericum mitchellianum	Blue Ridge St. John's-wort
Hypericum nitidum	A St. John's-wort
Hypericum suffruticosum	Pineland St. John's-wort
Hypnum pratense	A Moss
Hypoxis juncea	Fringed Yellow Stargrass
Hypoxis sessilis	Sessile Yellow Stargrass
Hypoxis spp.	Yellow Stargrasses
Ilex ambigua	Carolina Holly
RAB = *Ilex ambigua* var. *ambigua*	
Ilex amelanchier	Sarvis Holly
Ilex cassine	Dahoon
RAB = *Ilex cassine* var. *cassine*	
Ilex collina	Long-Stalked Holly
Ilex coriacea	Gallberry
Ilex decidua	Possum-haw
Ilex glabra	Inkberry
Ilex laevigata	Smooth Winterberry
Ilex longipes	Georgia Holly
RAB = *Ilex decidua* var. *longipes*	
Ilex montana	Mountain Holly
RAB = *Ilex ambigua* var. *montana*	
Ilex myrtifolia	Myrtle Dahoon
RAB = *Ilex myrtifolia* var. *myrtifolia*	
Ilex opaca	American Holly
Ilex verticillata	Common Winterberry
Ilex vomitoria	Yaupon
Impatiens capensis	Orange Jewelweed
Impatiens pallida	Yellow Jewelweed
Impatiens spp.	Jewelweeds
Ipomoea imperati	Beach Morning Glory
RAB = *Ipomoea stolonifera*	
Ipomoea macrorhiza	Manroot
Ipomopsis rubra	Standing Cypress
Iresine rhizomatosa	Rootstock Bloodleaf

Iris prismatica	Slender Blue Iris
Iris virginica	Virginia Blueflag
Isoetes piedmontana	Piedmont Quillwort
Isoetes riparia	Riverbank Quillwort
Isoetes virginica	Virginia Quillwort
RAB = *Isoetes melanopoda* in part	
Isopterygium distichaceum	A Moss
Isotria medeoloides	Small Whorled Pogonia
Itea virginica	Virginia Sweetspire
Iva frutescens	Bigleaf Marsh Elder
Iva imbricata	Seacoast Marsh Elder
Iva microcephala	Small-Headed Marsh Elder
Jeffersonia diphylla	Twin Leaf
Juglans cinerea	Butternut
Juglans nigra	Black Walnut
Juncus abortivus	Pinebarren Rush
Juncus articulatus	Jointleaf Rush
Juncus brachycarpus	Whiteroot Rush
Juncus brevicaudatus	Mountain Rush
Juncus effusus	Lamp Rush
Juncus elliottii	Bog Rush
Juncus gymnocarpus	Naked-Fruit Rush
Juncus longii	Long's Rush
Juncus polycephalus	Many-head Rush
Juncus roemerianus	Black Needlerush
Juncus secundus	Nodding Rush
Juncus subcaudatus	Woods Rush
Juncus torreyi	Torrey's Rush
Juncus trifidus var. *carolinianus*	Carolina One-Flowered Rush
RAB = *Juncus trifidus* var. *monanthos*	
Juncus trigonocarpus	Red-pod Rush
Juncus validus	Round-pod Rush
Juncus spp.	Rushes
Juniperus communis var. *depressa*	Dwarf Juniper
Juniperus virginiana	Virginia Red-cedar
Juniperus virginiana var. *silicicola*	Coastal Red-cedar
RAB = *Juniperus silicicola*	
Justicia americana	Common Water-willow
Kalmia carolina	Carolina Sheeplaurel
RAB = *Kalmia angustifolia* var. *caroliniana*	
Kalmia cuneata	White Wicky
Kalmia latifolia	Mountain Laurel, Ivy
Kosteletzkya virginica	Seashore Mallow
Krigia biflora	Two-flower Cynthia
Krigia montana	Mountain Cynthia
Kyllinga odorata	Fragrant Flatsedge
RAB = *Cyperus sesquiflorus*	
Lachnanthes caroliniana	Redroot
Lachnocaulon beyrichianum	Southern Bogbutton
Lachnocaulon minus	Brown Bogbutton
Lactuca canadensis	Canada Wild Lettuce

Laportea canadensis	Wood-nettle
Lasallia papulosa	A Rock-tripe
Lathyrus japonicus var. *glaber*	Beach Pea
Lathyrus palustris	Marsh Peavine
Lathyrus pusillus	Tiny Peavine
Lathyrus venosus	Smooth Peavine
Lechea torreyi	Torrey's Pinweed
Leersia hexandra	Southern Cutgrass
Leersia lenticularis	Catchfly Cutgrass
Leersia oryzoides	Rice Cutgrass
Leiophyllum buxifolium	Sand-myrtle
Lejeunea bermudiana	A Liverwort
Lejeunea blomquistii	A Liverwort
Lejeunea cavifolia	A Liverwort
Lejeunea dimorphophylla	A Liverwort
Lejeunea glaucescens var. *acrogyna*	A Liverwort
Lemna gibba	Inflated Duckweed
Lemna perpusilla	Small Duckweed
Lemna spp.	Duckweeds
Leptodontium excelsum	Grandfather Mtn. Leptodontium
Leptodontium flexifolium	Pale-margined Leptodontium
Leptohymenium sharpii	Mount Leconte Moss
Leptoscyphus cuneifolius	A Liverwort
Lespedeza capitata	Roundhead Bushclover
Lespedeza spp.	Bushclovers
Leucobryum albidum	Small-leaf Pincushion Moss
Leucobryum glaucum	Large-leaf Pincushion Moss
Leucothoe axillaris	Coastal Doghobble
RAB = *Leucothoe axillaris* var. *axillaris*	
Leucothoe fontanesiana	Highland Doghobble
RAB = *Leucothoe axillaris* var. *editorum*	
Leucothoe racemosa	Swamp Doghobble
Leucothoe recurva	Mountain Doghobble
Liatris aspera	Rough Blazing-star
Liatris graminifolia	Grassleaf Blazing-star
Liatris helleri	Heller's Blazing-star
Liatris microcephala	Small-head Blazing-star
Liatris scariosa	New England Blazing-star
Liatris secunda	A Blazing-star
Liatris spicata	Bog Blazing-star
Liatris squarrulosa	Earle's Blazing-star
RAB = *Liatris earlei*	
Liatris turgida	Shale-barren Blazing-star
Ligustrum sinense	Chinese Privet
Lilaeopsis carolinensis	Carolina Lilaeopsis
Lilium canadense ssp. *canadense*	Yellow Canada Lily
Lilium canadense ssp. *editorum*	Red Canada Lily
Lilium catesbaei	Pine Lily
Lilium grayi	Gray's Lily
Lilium philadelphicum	Wood Lily
Lilium sp. 1	Blackwater Turk's-cap Lily

Lilium sp. 2	Sandhills Wood Lily
Limnobium spongia	Frog's-bit
Limosella australis	Awl-leaf Mudwort
RAB = *Limosella subulata*	
Lindbergia brachyptera	Lindberg's Maple-moss
Lindera benzoin	Common Spicebush, Benzoin
Lindera melissifolia	Southern Spicebush
Lindera subcoriacea	Bog Spicebush
Lindernia dubia var. *anagallidea*	Yellowseed Pimpernel
RAB = *Lindernia anagallidea*	
Lindernia monticola	Flatrock Pimpernel
Lindernia saxicola	Riverbank Pimpernel
Linum floridanum	Florida Yellow Flax
RAB = *Linum medium* var. *floridanum* in part	
Linum floridanum var. *chrysocarpum*	Yellow-fruited Flax
RAB = *Linum medium* var. *floridanum* in part	
Linum sulcatum var. *sulcatum*	Glade Flax
Liparis loeselii	Fen Orchid
Lipocarpha micrantha	Small-flowered Hemicarpha
RAB = *Hemicarpha micrantha*	
Liquidambar styraciflua	Sweet Gum
Liriodendron tulipifera	Tuliptree
Listera australis	Southern Twayblade
Listera cordata	Heart-leaved Twayblade
Listera smallii	Appalachian Twayblade
Lithospermum canescens	Hoary Puccoon
Litsea aestivalis	Pondspice
Lobelia boykinii	Boykin's Lobelia
Lobelia canbyi	Canby's Lobelia
Lonicera canadensis	American Fly-honeysuckle
Lonicera dioica	Limber Honeysuckle
Lonicera flava	Yellow Honeysuckle
Lonicera japonica	Japanese Honeysuckle
Lonicera sempervirens	Coral Honeysuckle
Lophiola aurea	Golden Crest
RAB = *Lophiola americana*	
Lophocolea appalachiana	A Liverwort
Lophocolea muricata	A Liverwort
Lopholejeunea muelleriana	A Liverwort
Lophozia attenuata	A Liverwort
Lophozia barbata	A Liverwort
Lophozia capitata	A Liverwort
Lophozia excisa	A Liverwort
Lophozia hatcheri	A Liverwort
Lophozia heterocolpa	A Liverwort
Lotus purshianus var. *helleri*	Prairie Birdfoot-trefoil
RAB = *Lotus helleri*	
Ludwigia alata	Winged Seedbox
Ludwigia brevipes	Long Beach Seedbox
Ludwigia lanceolata	Lanceleaf Seedbox
Ludwigia linifolia	Flaxleaf Seedbox

Ludwigia microcarpa	Tiny-fruited Seedbox
Ludwigia palustris	Marsh Seedbox
Ludwigia sphaerocarpa	Globe-fruit Seedbox
Ludwigia suffruticosa	Shrubby Seedbox
Ludwigia spp.	Seedboxes
Lupinus villosus	Lady Lupine
Luziola fluitans	Southern Water Grass
RAB = *Hydrochloa caroliniensis*	
Luzula multiflora	Heath Woodrush
Luzula spp.	Woodrushes
Lycopodiella alopecuroides	Foxtail Clubmoss
RAB = *Lycopodium alopecuroides*	
Lycopodiella inundata	Bog Clubmoss
Lycopodium annotinum	Stiff Clubmoss
Lycopodium dendroideum	A Clubmoss
RAB = *Lycopodium obscurum* in part	
Lycopodium hickeyi	Hickey's Clubmoss
RAB = *Lycopodium obscurum* in part	
Lycopus amplectens	Clasping Water-horehound
Lycopus angustifolius	Southern Bog Water-horehound
RAB = *Lycopus rubellus* var. *angustifolius*	
Lycopus cokeri	Coker's Water-horehound
Lycopus rubellus	Red Water-horehound
RAB = *Lycopus rubellus* var. *rubellus*	
Lycopus uniflorus	Northern Water-horehound
Lygodium palmatum	Climbing Fern
Lyonia ligustrina	Maleberry
Lyonia lucida	Fetterbush, Shinyleaf
Lyonia mariana	Staggerbush
Lysimachia asperulifolia	Rough-leaf Loosestrife
Lysimachia fraseri	Fraser's Loosestrife
Lysimachia hybrida	Lowland Loosestrife
RAB = *Lysimachia lanceolata* var. *hybrida*	
Lysimachia loomisii	Carolina Loosestrife
Lysimachia quadrifolia	Whorled Loosestrife
Lysimachia terrestris	Swamp-candles
Lysimachia tonsa	Southern Loosestrife
Lythrum alatum	Wing-angle Loosestrife
RAB = *Lythrum lanceolatum*	
Lythrum lineare	Saltmarsh Loosestrife
Macbridea caroliniana	Carolina Bogmint
Macrocoma sullivantii	Sullivant's Maned-moss
Magnolia acuminata	Cucumber-tree
Magnolia fraseri	Fraser's Magnolia
Magnolia grandiflora	Southern Magnolia
Magnolia macrophylla	Bigleaf Magnolia
Magnolia tripetala	Umbrella Magnolia
Magnolia virginiana	Sweetbay
Maianthemum canadense	Canada Mayflower
Maianthemum racemosum	Solomon's-plume
RAB = *Smilacina racemosa*	

Malaxis spicata	Florida Adder's Mouth
Manfreda virginica	Eastern Agave
RAB = *Agave virginica*	
Marshallia graminifolia	Grassleaf Barbara's Buttons
Marshallia grandiflora	Largeflower Barbara's Buttons
Marshallia trinervia	Broadleaf Barbara's Buttons
Marsupella paroica	A Liverwort
Matelea decipiens	Glade Milkvine
Matelea flavidula	Yellow Carolina Milkvine
Matelea obliqua	Climbing Milkvine
Mayaca aubletii	Bogmoss
Medeola virginiana	Indian Cucumber-root
Meehania cordata	Meehania
Megaceros sp. 1	A Liverwort
Melampyrum lineare	Cow-wheat
Melanthium parviflorum	Appalachian Bunchflower
RAB = *Veratrum parviflorum*	
Melanthium woodii	Ozark Bunchflower
Melica mutica	Two-flowered Melic
Melica nitens	Three-flowered Melic
Menispermum canadense	Moonseed
Menyanthes trifoliata	Buckbean
Menziesia pilosa	Minniebush
Metzgeria pubescens	A Liverwort
Metzgeria temperata	A Liverwort
Metzgeria uncigera	A Liverwort
Microstegium vimineum	Japanese Grass
Mikania scandens	Climbing Hempvine
Milium effusum	Millet-grass
Minuartia alabamensis	Alabama Sandwort
Minuartia caroliniana	Carolina Sandwort
RAB = *Arenaria caroliniana*	
Minuartia glabra	Smooth Sandwort, Flatrock Sandwort
RAB = *Arenaria glabra* var. *glabra*	
Minuartia godfreyi	Godfrey's Sandwort
RAB = *Arenaria godfreyi*	
Minuartia groenlandica	Greenland Sandwort
RAB = *Arenaria glabra* var. *groenlandica*	
Minuartia uniflora	Single-flowered Sandwort
RAB = *Arenaria uniflora*	
Mitchella repens	Partridgeberry
Mitella diphylla	Miterwort
Mnium affine	A Mnium
Mnium appalachianum	Appalachian Mnium
Mnium carolinianum	Carolina Mnium
Mnium marginatum	A Mnium
Monarda didyma	Red Bee-balm
Monarda media	Purple Bee-balm
Monotropsis odorata	Sweet Pinesap
RAB = *Monotropsis odorata* var. *odorata* & var. *lehmaniae*	
Morus rubra	Red Mulberry

Muhlenbergia expansa	Savanna Muhly
Muhlenbergia filipes	Duneslack Muhly
Muhlenbergia glomerata	Bristly Muhly
Muhlenbergia mexicana	Mexican Muhly
Muhlenbergia sobolifera	A Muhly
Muhlenbergia sylvatica	Woodland Muhly
Muhlenbergia torreyana	Torrey's Muhly
Mylia taylorii	A Liverwort
Myrica cerifera	Wax-myrtle, Southern Bayberry
RAB = *Myrica cerifera* var. *cerifera* & var. *pumila*	
Myrica gale	Sweet Gale
RAB = *Gale palustris*	
Myrica heterophylla	Evergreen Bayberry
Myrica pensylvanica	Northern Bayberry
Myriophyllum laxum	Loose Watermilfoil
Myriophyllum pinnatum	Cutleaf Water-milfoil
Myriophyllum tenellum	Leafless Watermilfoil
Myriophyllum spp.	Watermilfoils
Najas gracillima	Slender Waternymph
Nardia lescurii	A Liverwort
Nardia scalaris	A Liverwort
Narthecium americanum	Bog Asphodel
Nelumbo lutea	American Lotus
Nemophila aphylla	Baby-blue-eyes
RAB = *Nemophila microcalyx*	
Nestronia umbellula	Nestronia
Nuphar lutea	Cowlily
Nuphar lutea ssp. *sagittifolia*	Narrowleaf Cowlily
Nymphaea odorata	Water Lily
Nymphoides aquatica	Big Floatingheart
Nymphoides cordata	Little Floatingheart
Nymphoides spp.	Floatinghearts
Nyssa aquatica	Water Tupelo
Nyssa biflora	Swamp Tupelo
RAB = *Nyssa sylvatica* var. *biflora*	
Nyssa sylvatica	Black Gum
RAB = *Nyssa sylvatica* var. *sylvatica*	
Oenothera fruticosa	Narrowleaf Evening Primrose
Oenothera humifusa	Seaside Evening Primrose
Oenothera perennis	Perennial Sundrops
Oldenlandia boscii	Bosc's Bluet
Oncophorus raui	A Moss
Onoclea sensibilis	Sensitive Fern
Onosmodium virginianum	Virginia Marbleseed
Oplismenus setarius	Shortleaf Basket Grass
Opuntia compressa	Common Prickly-pear
Opuntia pusilla	Dune Prickly-pear
RAB = *Opuntia drummondii*	
Orbexilum lupinellum	Lupine Scurfpea
RAB = *Psoralea lupinellus*	
Orbexilum macrophyllum	Bigleaf Scurfpea

RAB = *Psoralea macrophylla*	
Orbexilum onobrychis	Lanceleaf Scurfpea
RAB = *Psoralea onobrychis*	
Orbexilum pedunculatum var. *pedunculatum*	Sampson's-snakeroot
RAB = *Psoralea psoralioides* var. *eglandulosa*	
Orontium aquaticum	Golden Club
Orthodontium pellucens	Translucent Orthodontium
Orthotrichum keeverae	Keever's Bristle-moss
Orthotrichum obtusifolium	Blunt Bristle-moss
Osmanthus americana	Wild Olive, Devilwood
Osmorhiza claytonii	Mountain Sweet-cicely
Osmunda cinnamomea	Cinnamon Fern
Osmunda regalis var. *spectabilis*	Royal Fern
Ostrya virginiana	Hop-hornbeam
Oxalis montana	Moutain Wood-sorrel
RAB = *Oxalis acetosella*	
Oxydendrum arboreum	Sourwood
Oxypolis canbyi	Canby's Cowbane
Oxypolis filiformis	Tall Cowbane
Oxypolis rigidior	Stiff Cowbane
Oxypolis ternata	Savanna Cowbane
Pachysandra procumbens	Allegheny Spurge
Palamocladium leskeoides	Palamocladium
Panax quinquefolius	Ginseng
Panax trifolius	Dwarf Ginseng
Panicum amarum	Bitter Panic Grass
Panicum flexile	Wiry Panic Grass
Panicum hemitomon	Maidencane
Panicum rigidulum var. *combsii*	Red-top Panic Grass
RAB = *Panicum longifolium* var. *combsii*	
Panicum tenerum	Southeastern Panic Grass
Panicum verrucosum	Warty Panic Grass
Panicum virgatum	Switchcane
Panicum spp.	Panic Grasses
Parietaria floridana	Florida Pellitory
Parietaria pensylvanica	Pennsylvania Pellitory
Parietaria praetermissa	Largeseed Pellitory
Parnassia asarifolia	Kidneyleaf Grass-of-Parnassus
Parnassia caroliniana	Carolina Grass-of-Parnassus
Parnassia grandifolia	Largeleaf Grass-of-Parnassus
Paronychia argyrocoma	Silverling
Paronychia fastigiata	Forked Nailwort
Paronychia montana	Mountain Nailwort
RAB = *Paronychia fastigiata* in part	
Parthenium integrifolium var. *auriculatum*	Glade Wild Quinine
Parthenium integrifolium var. *mabryanum*	Mabry's Wild Quinine
Parthenium radfordii	Wavyleaf Wild Quinine
Parthenocissus quinquefolia	Virginia Creeper
Paspalum bifidum	Pitchfork Crown Grass
Paspalum dissectum	Mudbank Crown Grass
Paspalum fluitans	Horsetail Crown Grass

Paspalum praecox	Early Crown Grass
Paspalum pubiflorum	Hairy-seed Crown Grass
Paspalum setaceum var. *rigidifolium*	Slender Crown Grass
Paspalum vaginatum	Seashore Crown Grass
Paspalum spp.	Crown Grasses
Passiflora lutea	Passionflower
Pedicularis canadensis	Wood-betony
Pedicularis lanceolata	Swamp Lousewort
Pediomelum canescens	Buckroot
RAB = *Psoralea canescens*	
Pellaea atropurpurea	Purple Cliff-brake
Pellaea wrightiana	Wright's Cliff-brake
Pellia epiphylla	A Thallose Liverwort
Pellia neesiana	A Thallose Liverwort
Peltandra sagittifolia	Spoonflower, White Arrow-arum
Peltandra virginica	Green Arrow-arum
Penstemon smallii	Small's Beardtongue
Persea borbonia	Red Bay
RAB = *Persea borbonia* in part	
Persea palustris	Swamp Red Bay
RAB = *Persea borbonia* in part	
Phacelia bipinnatifida	Fernleaf Phacelia
Phacelia dubia	Smallflower Phacelia
Phacelia maculata	Spotted Phacelia
Phacelia ranunculacea	Buttercup Phacelia
Phanopyrum gymnocarpum	Savanna Panic Grass
RAB = *Panicum gymnocarpon*	
Phaseolus sinuatus	Sandhills Bean
Phegopteris connectilis	Northern Beech Fern
RAB = *Thelypteris phegopteris*	
Philadelphus hirsutus	Streambank Mock Orange
Philadelphus inodorus	Scentless Mock Orange
Philonotis fontana	Seepage Moss
Phleum pratense	Timothy
Phlox amplifolia	Largeleaf Phlox
Phlox divaricata ssp. *divaricata*	Wild Blue Phlox
RAB = *Phlox divaricata* in part	
Phlox divaricata ssp. *laphamii*	Wild Blue Phlox
RAB = *Phlox divaricata* in part	
Phlox nivalis ssp. *hentzii*	Trailing Phlox
Phlox subulata	Moss Pink
Phoradendron serotinum	Mistletoe
Phragmites australis	Reed
RAB = *Phragmites communis*	
Phryma leptostachya	Lopseed
Phyla nodiflora	Wedgeleaf, Frogfruit
RAB = *Lippia nodiflora*	
Physocarpus opulifolius	Ninebark

Physalis walteri	Seaside Ground-cherry
RAB = *Physalis viscosa* var. *maritima Picea rubens*	Red Spruce
Pieris floribunda	Mountain Fetterbush
Pinguicula caerulea	Blue Butterwort
Pinguicula lutea	Yellow Butterwort
Pinguicula pumila	Small Butterwort
Pinus echinata	Shortleaf Pine
Pinus palustris	Longleaf Pine
Pinus pungens	Table Mountain
Pine Pinus serotina	Pond Pine, Pocosin Pine
Pinus strobus	White Pine
Pinus taeda	Loblolly Pine, Old Field Pine
Pinus virginiana	Virginia Pine
Pinus spp.	Pines
Piptochaetium avenaceum	Needlegrass
RAB =Stipa avenacea	
Pityopsis adenolepis	Carolina Silkgrass
RAB = *Heterotheca adenolepis*	
Plagiochasma wrightii	A Liverwort
Plagiochila austinii	A Liverwort
Plagiochila caduciloba	A Liverwort
Plagiochila columbiana	A Liverwort
Plagiochila corniculata	A Liverwort
Plagiochila echinata	A Liverwort
Plagiochila ludoviciana	A Liverwort
Plagiochila miradorensis	A Liverwort
Plagiochila sharpii	A Liverwort
Plagiochila sullivantii var. *spinigera*	A Liverwort
Plagiochila sullivantii var. *sullivantii*	A Liverwort
Plagiochila undata	A Liverwort
Plagiochila virginica var. *caroliniana*	A Liverwort
Plagiochila virginica var. *euryphylla*	A Liverwort
Planera aquatica	Planertree, Water-elm
Plantago cordata	Heart-leaf Plantain
Plantago sparsiflora	Pineland Plantain
Platanthera blephariglottis	White Fringed Orchid
RAB = *Habenaria blephariglottis* in part	
Platanthera cristata	Small Yellow-fringed Orchid
RAB = *Habenaria cristata*	
Platanthera flava var. *herbiola*	Northern Green Orchid
RAB = *Habenaria flava* var. *herbiola*	
Platanthera grandiflora	Large Purple-fringed Orchid
RAB = *Habenaria psycodes* var. *grandiflora*	
Platanthera integra	Yellow Fringeless Orchid
RAB = *Habenaria integra*	
Platanthera integrilabia	White Fringeless Orchid
RAB = *Habenaria blephariglottis* in part	
Platanthera nivea	Snowy Orchid
RAB = *Habenaria nivea*	
Platanthera peramoena	Purple Fringeless Orchid
RAB = *Habenaria peramoena*	

Platanus occidentalis	Sycamore
Platydictya confervoides	Alga-like Matted-moss
Pleea tenuifolia	Rush-featherling
Pluchea foetida	Stinking Camphorweed
Pluchea rosea	Rosy Camphorweed
Poa alsodes	Grove Bluegrass
Poa paludigena	Bog Bluegrass
Poa palustris	Swamp Bluegrass
Poa saltuensis	Drooping Bluegrass
RAB = *Poa languida*	
Podophyllum peltatum	May-apple, American Mandrake
Polygala brevifolia	Little-leaf Milkwort
Polygala cruciata	Drumheads
Polygala cruciata var. *aquilonia*	Mountain Drumheads
RAB = *Polygala cruciata* in part	
Polygala curtissii	Curtiss's Milkwort
Polygala grandiflora	Showy Milkwort
Polygala hookeri	Hooker's Milkwort
Polygala lutea	Orange Milkwort
Polygala senega	Seneca Snakeroot
Polygonatum biflorum	Common Solomon's-seal
Polygonella americana	American Jointweed
Polygonella articulata	Coast Jointweed
Polygonella polygama	October-flower
Polygonum amphibium	Water Smartweed
RAB = *Polygonum coccineum*	
Polygonum cespitosum	Water-pepper
Polygonum erectum	Erect Knotweed
Polygonum glaucum	Seabeach Buckwheat
Polygonum hirsutum	Hairy Smartweed
Polygonum hydropiperoides	Swamp Smartweed
Polygonum punctatum	Dotted Smartweed
Polygonum sagittatum	Arrowleaf Tearthumb
Polygonum scandens var. *cristatum*	Climbing Buckwheat
Polygonum tenue	Glade Knotweed
Polygonum virginianum	Jumpseed
RAB = *Tovara virginiana*	
Polygonum spp.	Smartweeds
Polymnia canadensis	Whiteflower Leafcup
Polypodium polypodioides	Resurrection Fern
Polypodium virginianum	Rockcap Fern
Polypodium spp.	Polypodies
Polystichum acrostichoides	Christmas Fern
Polytrichum appalachianum	Appalachian Haircap Moss
Polytrichum commune	Bog Haircap Fern
Polytrichum juniperinum	Juniper Moss
Polytrichum ohioense	Ohio Haircap Moss
Polytrichum spp.	Haircap Mosses
Pontederia cordata	Pickerelweed
Ponthieva racemosa	Shadow-witch

Populus grandidentata	Bigtooth Aspen
Populus heterophylla	Swamp Cottonwood
Porella japonica ssp. *appalachiana*	A Liverwort
Porella wataugensis	A Liverwort
Porpidia cineroatra	A Crustose Lichen
Porpidia diversa	A Crustose Lichen
Porpidia herteliana	A Crustose Lichen
Porpidia macrocarpa	A Crustose Lichen
Porpidia tuberculosa	A Crustose Lichen
Porteranthus stipulatus	Indian Physic
RAB = *Gillenia stipulata*	
Portulaca smallii	Small's Portulaca
Potamogeton confervoides	Conferva Pondweed
Potamogeton natans	Floating-leaf Pondweed
Potamogeton spp.	Pondweeds
Potentilla canadensis	Canada Cinquefoil
Prenanthes alba	White Rattlesnakeroot
RAB = *Prenanthes alba* ssp. *alba*	
Prenanthes altissima	Tall Rattlesnakeroot
Prenanthes roanensis	Roan Rattlesnakeroot
Prenanthes serpentaria	Lion's-foot
Prenanthes trifoliolata	Gall-of-the-Earth
Prenanthes sp. 1	Pale Rattlesnakeroot
RAB = *Prenanthes alba* ssp. *pallida*	
Proserpinaca pectinata	Combleaf Mermaidweed
Prunus alabamensis	Alabama Black Cherry
RAB = *Prunus serotina* var. *alabamensis*	
Prunus allegheniensis	Allegheny Sloe
Prunus caroliniana	Carolina Laurel-cherry
Prunus nigra	Canada Plum
RAB = *Prunus americana* var. *lanata*	
Prunus pensylvanica	Fire Cherry
Prunus pumila var. *susquehanae*	Sand Cherry
Prunus serotina	Black Cherry
Prunus umbellata	Hog Plum
Prunus virginiana	Choke-cherry
Psilocarya nitens	Shortbeak Baldsedge
Psilocarya scirpoides	Long-beak Bald-sedge
Ptelea trifoliata	Wafer-ash
Pteridium aquilinum	Bracken
Pteroglossaspis ecristata	Eulophia
RAB = *Eulophia ecristata*	
Ptilidium ciliare	A Liverwort
Ptilidium pulcherrimum	A Liverwort
Ptilimnium costatum	Ribbed Bishop's-weed
Ptilimnium nodosum	Harperella
RAB = *Ptilimnium fluviatile & Ptilimnium nodosum*	
Ptilium crista-castrensis	Knight's-plume Moss
Pycnanthemum setosum	Awned Mountain-mint
Pycnanthemum virginianum	Virginia Mountain-mint
Pycnanthemum spp.	Mountain-mints

Pyrola americana	American Shinleaf
RAB = *Pyrola rotundifolia* var. *americana*	
Pyrola elliptica	A Shinleaf
Pyrularia pubera	Buffalo-nut
Pyxidanthera barbulata var. *brevifolia*	Sandhills Pyxie-moss
Quercus alba	White Oak
Quercus austrina	Bluff Oak
Quercus bicolor	Swamp White Oak
Quercus coccinea	Scarlet Oak
Quercus falcata	Spanish Oak
RAB = *Quercus falcata* var. *falcata*	
Quercus geminata	Sand Live Oak
RAB = *Quercus virginiana* in part	
Quercus hemisphaerica	Darlington Oak, Sand Laurel Oak
RAB = *Quercus laurifolia* in part	
Quercus ilicifolia	Bear Oak
Quercus imbricaria	Shingle Oak
Quercus incana	Bluejack Oak
Quercus laevis	Turkey Oak
Quercus laurifolia	Diamondleaf Oak, Swamp Laurel Oak
Quercus lyrata	Overcup Oak
Quercus margarettae	Sand Post Oak
Quercus marilandica	Blackjack Oak
Quercus michauxii	Basket Oak, Swamp Chestnut Oak
Quercus montana	Chestnut Oak
RAB = *Quercus prinus*	
Quercus muehlenbergii	Chinquapin Oak
Quercus nigra	Water Oak
Quercus pagoda	Cherrybark Oak
RAB = *Quercus falcata* var. *pagodaefolia*	
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus rubra	Red Oak
Quercus rubra var. *ambigua*	Northern Red Oak
RAB = *Quercus rubra* var. *borealis*	
Quercus shumardii	Shumard Oak
Quercus stellata	Post Oak
Quercus velutina	Black Oak
Quercus virginiana	Live Oak
RAB =	Quercus virginiana in part
Racomitrium heterostichum	A Moss
Radula tenax	A Liverwort
Radula voluta	A Liverwort
Radula spp.	Liverworts
Ranunculus allegheniensis	Allegheny Mountain Buttercup
Ranunculus ambigens	Water-plantain Spearwort
Ranunculus fascicularis	A Buttercup
Ranunculus flabellaris	Yellow Water-crowfoot
Ranunculus hederaceus	Ivy Buttercup
Ranunculus laxicaulis	Swamp Buttercup
RAB = *Ranunculus laxicaulis & Ranunculus subcordatus*	

Ranunculus micranthus	Rock Buttercup
Ranunculus recurvatus	Hooked Buttercup
Ranunculus scleratus	Blister Buttercup
Rhabdoweisia crenulata	Himalayan Ribbed-weissia
Rhamnus caroliniana	Carolina Buckthorn
Rhexia alifanus	Savanna Meadow-beauty
Rhexia aristosa	Awned Meadow-beauty
Rhexia cubensis	West Indies Meadow-beauty
Rhexia lutea	Yellow Meadow-beauty
Rhexia mariana	Maryland Meadow-beauty
Rhododendron arborescens	Smooth Azalea
Rhododendron calendulaceum	Flame Azalea
Rhododendron carolinianum	Mountain Carolina Rhododendron
RAB = *Rhododendron minus* in part	
Rhododendron catawbiense	Catawba Rhododendron, Mtn. Rosebay
Rhododendron cumberlandense	Cumberland Azalea
Rhododendron maximum	Pale Rhododendron, Great Laurel
Rhododendron minus	Foothills Carolina Rhododendron
RAB = *Rhododendron minus* in part	
Rhododendron periclymenoides	Common Wild Azalea
RAB = *Rhododendron nudiflorum*	
Rhododendron prinophyllum	Election Pink
RAB = *Rhododendron roseum*	
Rhododendron vaseyi	Pink-shell Azalea
Rhododendron viscosum	Northern Swamp Azalea
Rhus aromatica	Fragrant Sumac
Rhus copallina	Winged Sumac
Rhus michauxii	Michaux's Sumac
Rhynchospora alba	White Beakrush
Rhynchospora breviseta	Shortbristle Beakrush
Rhynchospora capitellata	Brownish Beakrush
Rhynchospora cephalantha	Bunched Beakrush
Rhynchospora colorata	Small Whitetop Sedge
RAB = *Dichromena colorata*	
Rhynchospora corniculata	Shortbristle Horned Beakrush
Rhynchospora decurrens	Swamp Forest Beakrush
Rhynchospora elliottii	Elliott's Beakrush
RAB = *Rhynchospora schoenoides*	
Rhynchospora fascicularis	Fasciculate Beakrush
Rhynchospora filifolia	Threadleaf Beakrush
Rhynchospora harveyi	Harvey's Beakrush
Rhynchospora intermixta	Humble Beakrush
Rhynchospora inundata	Narrowfruit Beakrush
Rhynchospora latifolia	Large Whitetop Sedge
RAB = *Dichromena latifolia*	
Rhynchospora megalocarpa	Sandy-field Beakrush
Rhynchospora microcarpa	Southern Beakrush
Rhynchospora miliacea	Millet Beakrush
Rhynchospora odorata	Fragrant Beakrush
Rhynchospora oligantha	Feather-bristle Beakrush
Rhynchospora pallida	Pale Beakrush

Rhynchospora pleiantha	Coastal Beakrush
Rhynchospora stenophylla	Littleleaf Beakrush
Rhynchospora tracyi	Tracy's Beakrush
Rhynchospora wrightiana	Wright's Beakrush
Rhynchospora spp.	Beakrushes
Rhytidium rugosum	Golden Glade-moss
Ribes cynosbati	Eastern Prickly Gooseberry
Ribes glandulosum	Skunk-currant
Ribes rotundifolium	Appalachian Gooseberry
Ribes spp.	Gooseberries
Riccardia multifida	An Aquatic Liverwort
Riccia fluitans	A Liverwort
Ricciocarpus natans	A Liverwort
Robinia hispida	Hispid Locust
Robinia hispida var. *fertilis*	Fruitful Locust
RAB = *Robinia hispida* in part	
Robinia hispida var. *kelseyi*	Kelsey's Locust
RAB = *Robinia kelseyi*	
Robinia hispida var. *rosea*	Boynton's Locust
RAB = *Robinia boyntonii*	
Robinia pseudoacacia	Black Locust
Robinia viscosa var. *hartwegii*	Hartweg's Locust
RAB = *Robinia hartwigii*	
Robinia viscosa var. *viscosa*	Clammy Locust
RAB = *Robinia viscosa*	
Rosa palustris	Swamp Rose
Rubus allegheniensis	Allegheny Blackberry
Rubus canadensis	Smooth Blackberry
Rubus hispidus	Northern Dewberry
Rubus idaeus ssp. *sachalinensis*	Red Raspberry
RAB = *Rubus idaeus* var. *canadensis*	
Rudbeckia heliopsidis	Sun-facing Coneflower
Rudbeckia laciniata	Green-head Coneflower
Rudbeckia laciniata var. *humilis*	A Green-head Coneflower
RAB = *Rudbeckia laciniata* in part	
Rudbeckia triloba var. *pinnatiloba*	Pinnate-lobed Black-eyed Susan
RAB = *Rudbeckia triloba* in part	
Rudbeckia triloba var. *rupestris*	A Black-eyed Susan
RAB = *Rudbeckia triloba* in part	
Ruellia humilis	Low Wild-petunia
Ruellia purshiana	Pursh's Wild-petunia
Ruellia strepens	A Wild-petunia
Rumex acetosella	Sour-sorrel
Rumex altissimus	Pale Dock
Sabal minor	Dwarf Palmetto
Sabal palmetto	Cabbage Palmetto
Sabatia campestris	Prairie Sabatia
Sabatia kennedyana	Plymouth Gentian
RAB = *Sabatia dodecandra* var. *kennedyana*	
Sabatia quadrangula	Four-angle Sabatia
Sabatia stellaris	Marsh Sabatia

Sacciolepis striata	American Cupscale
Sageretia minutiflora	Small-flowered Buckthorn
Sagittaria engelmanniana	Engelmann's Arrowhead
Sagittaria fasciculata	Bunched Arrowhead
Sagittaria isoetiformis	Quillwort Arrowhead
RAB = *Sagittaria teres*	
Sagittaria kurziana	Spring-tape
Sagittaria lancifolia	Lanceleaf Arrowhead
RAB = *Sagittaria lancifolia & S. falcata*	
Sagittaria latifolia	Broadleaf Arrowhead
Sagittaria latifolia var. *pubescens*	Hairy Broadleaf Arrowhead
Sagittaria platyphylla	Delta Arrowhead
RAB = *Sagittaria graminea* var. *platyphylla*	
Sagittaria stagnorum	Water Arrowhead
RAB = *Sagittaria subulata* var. *gracillima*	
Sagittaria spp.	Arrowheads
Salicornia bigelovii	Bigelow's Saltwort
Salicornia maritima	Jointed Saltwort
RAB = *Salicornia europaea*	
Salicornia virginica	Virginia Saltwort
Salicornia spp.	Saltworts
Salix humilis	Mountain Willow
Salix nigra	Black Willow
Salix sericea	Silky Willow
Salsola caroliniana	Carolina Beach-thistle
RAB = *Salsola kali*	
Salvia azurea	Azure Sage
Sambucus canadensis	Canada Elder
Sambucus racemosa var. *pubens*	Mountain Elder
RAB = *Sambucus pubens*	
Sanguinaria canadensis	Bloodroot
Sanguisorba canadensis	Canada Burnet
Sanicula canadensis	Canada Sanicle
Sanicula marilandica	Maryland Sanicle
Sanicula spp.	Sanicles
Sarracenia flava	Yellow Pitcher Plant, Trumpets
Sarracenia minor	Hooded Pitcher Plant
Sarracenia jonesii	Mountain Sweet Pitcher Plant
RAB = *Sarracenia rubra* in part	
Sarracenia oreophila	Green Pitcher Plant
Sarracenia purpurea	Purple Pitcher Plant
Sarracenia rubra ssp. *rubra*	Sweet Pitcher Plant
RAB = *Sarracenia rubra* in part	
Sassafras albidum	Sassafras
Saururus cernuus	Lizard's-tail
Saxifraga careyana	Carey's Saxifrage
Saxifraga caroliniana	Carolina Saxifrage
Saxifraga micranthidifolia	Branch Lettuce
Saxifraga pensylvanica	Swamp Saxifrage
Saxifraga michauxii	Michaux's Saxifrage
Saxifraga virginiensis	Early Saxifrage

Scapania mucronata	A Liverwort
Schisandra glabra	Magnolia Vine
Schizachyrium scoparium	Little Bluestem
RAB = *Andropogon scoparius* in part	
Schizachyrium scoparium var. *littorale*	Seaside Bluestem
RAB = *Andropogon scoparius* in part	
Schlotheimia lancifolia	Highlands Moss
Schwalbea americana	Chaffseed
Scirpus acutus	Hardstem Bulrush
Scirpus americanus	Three-square
Scirpus cespitosus	Deerhair Bulrush
RAB = *Scirpus cespitosus* var. *callosus*	
Scirpus cyperinus	Cottongrass Bulrush
Scirpus divaricatus	Spreading Bulrush
Scirpus etuberculatus	Canby's Bulrush
Scirpus expansus	Woodland Bulrush
Scirpus flaccidifolius	Reclining Bulrush
Scirpus georgianus	Georgia Bulrush
Scirpus koilolepis	Keeled Bulrush
Scirpus lineatus	Lined Bulrush
RAB = *Scirpus lineatus* & *Scirpus fontinalis*	
Scirpus polyphyllus	Leafy Bulrush
Scirpus subterminalis	Swaying Bulrush
Scirpus spp.	Bulrushes
Scleria georgiana	Georgia Nutrush
Scleria minor	Slender Nutrush
Scleria oligantha	Littlehead Nutrush
Scleria reticularis var. *pubescens*	Muehlenberg's Nutrush
RAB = *Scleria reticularis* in part	
Scleria reticularis var. *reticularis*	Netted Nutrush
RAB = *Scleria reticularis* in part	
Scleria triglomerata	Whip Nutrush
Scleria verticillata	Savanna Nutrush
Scleria spp.	Nutrushes
Sclerolepis uniflora	One-flower Hardscale
Scopelophila cataractae	Agoyan Cataract Moss
Scopelophila ligulata	Copper Moss
Scutellaria australis	Southern Skullcap
RAB = *Scutellaria parvula* in part	
Scutellaria galericulata	A Skullcap
Scutellaria leonardii	Shale-barren Skullcap
RAB = *Scutellaria parvula* in part	
Scutellaria nervosa	Veined Skullcap
Scutellaria ovata ssp. *bracteata*	A Heartleaf Skullcap
RAB = *Scutellaria ovata* in part	
Scutellaria ovata ssp. *ovata*	A Heartleaf Skullcap
RAB = *Scutellaria ovata* in part	
Scutellaria ovata ssp. *rugosa*	A Heartleaf Skullcap
RAB = *Scutellaria ovata* in part	
Scutellaria saxatilis	Rock Skullcap
Scutellaria serrata	Showy Skullcap

Sedum glaucophyllum	Cliff Stonecrop
RAB = *Sedum nevii*	
Sedum pusillum	Puck's Orpine
Sedum rosea	Roseroot, King's Crown
Sedum telephioides	Appalachian Stonecrop, Live-for-ever
Sedum ternatum	Woodland Stonecrop
Selaginella apoda	Meadow Spikemoss
Selaginella arenicola	Sand Spikemos
Selaginella rupestris	Rock Spikemoss
Selaginella tortipila	Twisted-hair Spikemoss
Senecio aureus	Golden Ragwort
Senecio glabellus	Butterweed
Senecio millefolium	Divided-leaf Ragwort
Senecio obovatus	Roundleaf Ragwort
Senecio pauperculus	Balsam Ragwort
Senecio plattensis	A Ragwort
Senecio schweinitzianus	Schweinitz's Ragwort
RAB = *Senecio robbinsii*	
Senecio anonymus	Small's Ragwort
RAB = *Senecio smallii*	
Senecio tomentosus	Woolly Ragwort
Senna hebecarpa	Wild Senna
RAB = *Cassia hebecarpa*	
Senna marilandica	Maryland Wild Senna
RAB = *Cassia marilandica*	
Sesuvium maritimum	Slender Sea-purslane
Sesuvium portulacastrum	Shoreline Sea-purslane
Setaria geniculata	Common Foxtail Grass
Setaria magna	Giant Foxtail Grass
Seymeria pectinata	Sticky Afzelia
Shortia galacifolia	Oconee Bells
Sibbaldiopsis tridentata	Three-tooth Cinquefoil
RAB = *Potentilla tridentata*	
Sida elliottii	Elliott's Fan-petal
Sida inflexa	Fernald's Fan-petal
Sideroxylon lycioides	Buckthorn Bumelia
RAB = *Bumelia lycioides*	
Sideroxylon tenax	Tough Bumelia
RAB = *Bumelia tenax*	
Silene caroliniana	Carolina Pink
Silene ovata	Mountain Catchfly
Silphium asteriscus	Starry Rosinweed
Silphium asteriscus var. *laevicaule*	Starry Rosinweed
RAB = *Silphium dentatum*	
Silphium compositum	Ragged Rosinweed
Silphium compositum ssp. *reniforme*	Kidneyleaf Rosinweed
RAB = *Silphium compositum* var. *reniforme*	
Silphium perfoliatum ssp. *connatum*	Virginia Cup-plant
Silphium perfoliatum ssp. *perfoliatum*	Northern Cup-plant

Silphium terebinthinaceum	Prairie Dock
Sisyrinchium dichotomum	White-eyed Grass
Sisyrinchium mucronatum	Sweet-soil Blue-eyed Grass
Sium suave	Water-parsnip
Smilax auriculata	Seaside Greenbrier
Smilax biltmoreana	Biltmore Carrionflower
RAB = *S. ecirrhata* var. *biltmoreana*	
Smilax bona-nox	Saw Greenbrier
Smilax glauca	Glaucous Greenbrier
Smilax hugeri	Huger's Carrionflower
Smilax lasioneura	A Carrionflower
Smilax laurifolia	Blaspheme-vine
Smilax rotundifolia	Horsebrier, Common Greenbrier
Smilax walteri	Coral Greenbrier
Smilax spp.	Greenbriers
Solanum gracilius	Graceful Nightshade
RAB = *Solanum gracile*	
Solidago arguta var. *arguta*	A Goldenrod
RAB = *Solidago arguta* in part	
Solidago caesia	Bluestem Goldenrod
Solidago caesia var. *curtisii*	Curtis's Goldenrod
RAB = *Solidago curtisii* var. *curtisii*	
Solidago caesia var. *hispida*	Curtis's Goldenrod
RAB = *Solidago curtisii* var. *pubens*	
Solidago glomerata	Cluster Goldenrod
Solidago gracillima	Graceful Goldenrod
Solidago latissimifolia	Broadleaf Goldenrod
RAB = *Solidago caesia* in part	
Solidago leavenworthii	Leavenworth's Goldenrod
Solidago nemoralis	Gray Goldenrod
Solidago odora	Sweet Goldenrod
Solidago patula	Seepage Goldenrod
Solidago patula var. *strictula*	Pocosin Goldenrod
Solidago plumosa	Yadkin River Goldenrod
Solidago porteri	Porter's Goldenrod
Solidago ptarmicoides	Prairie Goldenrod
Solidago puberula var. *puberula*	Downy Goldenrod
Solidago pulchra	Carolina Goldenrod
Solidago rigida	Bold Goldenrod
Solidago sempervirens	Seaside Goldenrod
Solidago spithamaea	Blue Ridge Goldenrod
Solidago tortifolia	Twisted-leaf Goldenrod
Solidago uliginosa	Bog Goldenrod
Solidago ulmifolia	Elm-leaf Goldenrod
Solidago verna	Spring-flowering Goldenrod
Solidago spp.	Goldenrods
Sorbus americana	Mountain-ash, American Rowan
Sorghastrum nutans	Yellow Indian-grass
Sparganium americanum	American Bur-reed
Sparganium angustifolium	Greenfruit Bur-reed
RAB = *Sparganium chlorocarpum*	

Spartina alterniflora	Saltmarsh Cordgrass
Spartina cynosuroides	Big Cordgrass
Spartina patens	Saltmeadow Cordgrass
Spartina pectinata	Freshwater Cordgrass
Spergularia marina	Saltmarsh Sandspurrey
Sphagnum angustifolium	Narrowleaf Peatmoss
Sphagnum bartlettianum	Bartlett's Peatmoss
Sphagnum capillifolium	Northern Peatmoss
Sphagnum cuspidatum	A Peatmoss
Sphagnum fallax	Pretty Peatmoss
Sphagnum fitzgeraldii	Fitzgerald's Peatmoss
Sphagnum flexuosum	Flexuous Peatmoss
Sphagnum imbricatum	A Peatmoss
Sphagnum lescurii	Yellow Peatmoss
Sphagnum palustre	A Peatmoss
Sphagnum pylaesii	Simple Peatmoss
Sphagnum quinquefarium	A Peatmoss
Sphagnum recurvum	A Peatmoss
Sphagnum rubellum	Red Peatmoss
Sphagnum russowii	Russow's Peatmoss
Sphagnum squarrosum	Squarrose Peatmoss
Sphagnum subsecundum	Orange Peatmoss
Sphagnum subtile	A Peatmoss
Sphagnum tenellum	Delicate Peatmoss
Sphagnum torreyanum	Giant Peatmoss
Sphagnum warnstorfii	Fen Peatmoss
Sphagnum spp.	Peatmosses
Sphenolobopsis pearsonii	A Liverwort
Sphenopholis filiformis	Longleaf Wedgescale
Sphenopholis obtusata var. *major*	Prairie Wedgescale
RAB = *Sphenopholis intermedia*	
Spiraea alba	White Meadowsweet
Spiraea alba var. *alba*	Narrowleaf Meadowsweet
Spiraea alba var. *latifolia*	Broadleaf Meadowsweet
Spiraea betulifolia ssp. *corymbosa*	Shinyleaf Meadowsweet
RAB = *Spiraea betulifolia*	
Spiraea tomentosa	Hardhack, Steeplebush
Spiraea virginiana	Virginia Spiraea
Spiranthes brevilabris var. *floridana*	Florida Ladies'-tresses
RAB = *Spiranthes gracilis* var. *floridana*	
Spiranthes cernua	White Nodding Ladies'-tresses
Spiranthes laciniata	Lace-lip Ladies'-tresses
Spiranthes longilabris	Giant Spiral Orchid
Spiranthes ochroleuca	Yellow Ladies'-tresses
Spiranthes vernalis	Spring Ladies'-tresses
Spirodela polyrrhiza	Common Water-flaxseed
Splachnum pennsylvanicum	Southern Dung Moss
Sporobolus asper	Rough Dropseed
Sporobolus clandestinus	Secret Dropseed
Sporobolus heterolepis	Prairie Dropseed
Sporobolus junceus	Sandhill Dropseed

Sporobolus teretifolius	Wireleaf Dropseed
Sporobolus virginicus	Saltmarsh Dropseed
Stachys clingmanii	Clingman's Hedge-nettle
Stachys eplingii	Epling's Hedge-nettle
Stachys nuttallii	Heartleaf Hedge-nettle
Stachys tenuifolia var. *tenuifolia*	Smooth Hedge-nettle
RAB = *Stachys tenuifolia*	
Staphylea trifolia	Bladdernut
Stellaria alsine	Longstalk Starwort
Stellaria corei	Core's Starwort
Stellaria pubera	Giant Starwort
Stewartia malacodendron	Silky Camellia
Stewartia ovata	Mountain Camellia
Stipulicida setacea	Wireplant
Streptopus amplexifolius	Clasping Twisted-stalk
Streptopus roseus	Rosy Twisted-stalk
Streptopus roseus var. *roseus*	Southern Rosy Twisted-stalk
RAB = *Streptopus roseus* in part	
Strophostyles helvula	Trailing Wild Bean
Stylisma aquatica	Water Dawnflower
RAB = *Bonamia aquatica*	
Stylisma patens	Sandhill Dawnflower
RAB = *Bonamia patens*	
Stylisma patens ssp. *angustifolia*	Narrowleaf Dawnflower
RAB = *Bonamia patens* var. *angustifolia*	
Stylisma pickeringii var. *pickeringii*	Pickering's Dawnflower
RAB = *Bonamia pickeringii*	
Styrax grandifolia	Storax, Bigleaf Snowbell
Suaeda linearis	Sea-blite
Symphoricarpos orbiculatus	Coralberry
Symplocos tinctoria	Horsesugar, Sweetleaf
Synandra hispidula	Synandra
Syngonanthus flavidulus	Yellow Hatpins
Syrrhopodon incompletus	Cuban Schliessmund
Talinum teretifolium	Fameflower
Taxiphyllum alternans	Japanese Yew-moss
Taxodium ascendens	Pondcypress
Taxodium distichum	Baldcypress
Taxus canadensis	Canada Yew
Teloschistes flavicans	A Lichen
Tephrosia virginiana	Goat's Rue
Thalictrum clavatum	Mountain Meadowrue
Thalictrum cooleyi	Cooley's Meadowrue
Thalictrum dioicum	Early Meadowrue
Thalictrum macrostylum	A Meadowrue
Thalictrum pubescens var. *hepaticum*	King-of-the-meadow
RAB = *Thalictrum polygamum* in part	
Thalictrum spp.	Meadowrues
Thamnobryum alleghaniense	A Moss
Thaspium pinnatifidum	Mountain Thaspium
Thelypteris noveboracensis	New York Fern

Thelypteris palustris var. *pubescens*	Marsh Fern
Thelypteris simulata	Bog Fern
Thermopsis mollis var. *fraxinifolia*	Ash-leaved Golden-banner
RAB = *Thermopsis fraxinifolia*	
Thermopsis mollis var. *mollis*	Appalachian Golden-banner
RAB = *Thermopsis mollis*	
Thermopsis villosa	Aaron's-rod
Thuidium delicatulum	Feather Moss
Thuja occidentalis	Amer. Arborvitae, Flat-cedar
Tiarella cordifolia var. *collina*	Common Foamflower
Tiarella cordifolia var. *cordifolia*	Mountain Foamflower
Tilia americana var. *americana*	American Basswood
RAB = *Tilia americana*	
Tilia americana var. *caroliniana*	Carolina Basswood
RAB = *Tilia caroliniana*	
Tilia americana var. *heterophylla*	Appalachian Basswood
RAB = *Tilia heterophylla*	
Tillandsia usneoides	Spanish-moss
Tipularia discolor	Cranefly Orchid
Tofieldia glabra	Carolina Asphodel
Tofieldia glutinosa	Sticky Bog Asphodel
RAB = *T. racemosa* var. *glutinosa*	
Tofieldia racemosa	Savanna Bog Asphodel
RAB = *Tofieldia racemosa* var. *racemosa*	
Torreyochloa pallida	Pale Mannagrass
RAB = *Glyceria pallida*	
Tortella flavovirens	Beach Moss
Tortula ammonsiana	Ammons's Tortula
Tortula fragilis	Fragile Tortula
Tortula papillosa	Papillose Tortula
Tortula propagulosa	Budding Tortula
Toxicodendron pubescens	Poison Oak
RAB = *Rhus toxicodendron*	
Toxicodendron radicans	Poison Ivy
RAB = *Rhus radicans*	
Toxicodendron vernix	Poison Sumac
RAB = *Rhus vernix*	
Trachelospermum difforme	Climbing Dogbane
Tradescantia subaspera	Zigzag Spiderwort
Tradescantia virginiana	Virginia Spiderwort
Tragia urticifolia	Spurge-nettle
Trautvetteria carolinensis	Tassel-rue
Triadenum walteri	Marsh St. John's-wort
RAB = *Hypericum walteri*	
Trichomanes boschianum	Appalachian Filmy-fern
Trichomanes petersii	Dwarf Filmy-fern
Trichomanes sp. 1	A Filmy Fern Gametophyte
Trichostema brachiatum	Glade Bluecurls
Trichostema dichotomum	Common Bluecurls
Trichostema setaceum	Narrowleaf Bluecurls
Trichostema sp. 1	Bald Head Bluecurls

Tridens carolinianus	Carolina Triodia
Tridens strictus	Spike Triodia
Trientalis borealis	Starflower
Trifolium carolinianum	Carolina Clover
Trifolium reflexum	Buffalo Clover
Trillium cuneatum	Purple Toadshade
RAB = *Trillium cuneatum* var. *cuneatum*	
Trillium discolor	Pale Yellow Trillium
Trillium erectum	Red Trillium, Stinking Benjamin
RAB = *Trillium erectum* in part	
Trillium flexipes	Bent White Trillium
Trillium grandiflorum	Large White Trillium
Trillium pusillum var. 1	Alabama Least Trillium
RAB = *Trillium pusillum* in part	
Trillium pusillum var. *pusillum*	Carolina Least Trillium
RAB = *Trillium pusillum* in part	
Trillium pusillum var. *virginianum*	Virginia Least Trillium
RAB = *Trillium pusillum* in part	
Trillium recurvatum	Prairie Trillium
Trillium rugelii	Southern Nodding Trillium
RAB = *Trillium cernuum*	
Trillium sessile	Sessile Toadshade
Trillium simile	Sweet White Trillium
Trillium undulatum	Painted Trillium
Trillium spp.	Trilliums
Triosteum angustifolium	Narrowleaf Tinker's-weed
Triosteum aurantiacum	Coffee Tinker's-weed
Triphora trianthophora	Three Birds Orchid
Triplasis purpurea	Purple Sandgrass
Trisetum spicatum	Soft Trisetum
Tritomaria exsectiformis	A Liverwort
Tsuga canadensis	Canada Hemlock
Tsuga caroliniana	Carolina Hemlock
Typha angustifolia	Narrowleaf Cattail
Typha domingensis	Southern Cattail
Typha latifolia	Common Cattail
Ulmus alata	Winged Elm
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm
Umbilicaria spp.	Rock Tripe
Uniola paniculata	Sea Oats
Urtica chamidryoides	Stinging Nettle
Utricularia cornuta	Horned Bladderwort
Utricularia geminiscapa	Two-flowered Bladderwort
Utricularia gibba	Humped Bladderwort
RAB = *Utricularia gibba* & *U. biflora*	
Utricularia inflata	Swollen Bladderwort
Utricularia juncea	Southern Bladderwort
Utricularia macrorhiza	Greater Bladderwort
RAB = *Utricularia vulgaris*	

Utricularia minor	Small Bladderwort
Utricularia olivacea	Dwarf Bladderwort
Utricularia resupinata	Northeastern Bladderwort
Utricularia spp.	Bladderworts
Uvularia perfoliata	Perfoliate Bellwort
Uvularia puberula	Pale Yellow Bellwort
RAB = *Uvularia pudica*	
Uvularia sessilifolia	Sessile-leaf Bellwort
Vaccinium arboreum	Sparkleberry, Farkleberry
Vaccinium constablaei	Mountain Highbush Blueberry
Vaccinium crassifolium	Creeping Blueberry
Vaccinium elliottii	Mayberry
Vaccinium erythrocarpum	Highbush Cranberry
Vaccinium fuscatum	Black Highbush Blueberry
RAB = *Vaccinium atrococcum*	
Vaccinium hirsutum	Hairy Blueberry
Vaccinium macrocarpon	Cranberry
Vaccinium stamineum	Deerberry
Vaccinium spp.	Blueberries
Valerianella umbilicata	Woodland Cornsalad
Veratrum viride	False Hellebore
Verbena riparia	Riverbank Vervain
Verbena scabra	Sandpaper Vervain
Verbena stricta	Hoary Vervain
Verbesina alternifolia	Wingstem
Verbesina helianthoides	Sunflower Crownbeard
Verbesina walteri	Walter's Crownbeard
Veronica americana	American Speedwell
Veronica anagallis-aquatica	Blue Water Speedwell
Veronicastrum virginicum	Culver's-root
Viburnum acerifolium	Mapleleaf Arrowwood
Viburnum dentatum	An Arrowwood
RAB = *Viburnum dentatum* var. *dentatum*	
Viburnum lantanoides	Hobblebush
RAB = *Viburnum alnifolium*	
Viburnum nudum var. *cassinoides*	Northern Wild Raisin
RAB = *Viburnum cassinoides*	
Viburnum nudum var. *nudum*	Southern Wild Raisin
RAB = *Viburnum nudum*	
Viburnum prunifolium	Black Haw
Viburnum rafinesquianum	Downy Arrowwood
Viburnum recognitum	Northern Arrowwood
RAB = *Viburnum dentatum* var. *lucidum*	
Viburnum spp.	Arrowwoods
Vigna luteola	Wild Cowpea
Viola brittoniana var. *brittoniana*	Northern Coastal Violet
Viola brittoniana var. *pectinata*	Northern Coastal Violet
Viola canadensis	Tall White Violet
Viola conspersa	American Dog Violet
Viola obliqua	Marsh Blue Violet
RAB = *Viola cucullata*	

Viola macloskeyi ssp. *pallens*	Smooth White Violet
RAB = *Viola macloskeyi* var. *pallens*	
Viola pedata	Bird's-foot Violet
Viola rotundifolia	Roundleaf Violet
Viola villosa	Carolina Violet
Viola walteri	Prostrate Blue Violet
Viola spp.	Violets
Vitis rotundifolia	Muscadine, Scuppernong
Vitis spp.	Grapes
Vittaria sp. 1	Appalachian Gametophyte
Vulpia octoflora	Eight-flower Six-weeks Grass
RAB = *Festuca octoflora*	
Warea cuneifolia	Carolina Warea
Wisteria frutescens	American Wisteria
Wolffia brasiliensis	Watermeal, Mudmary's
RAB = *Wolffia papulifera*	
Wolffiella gladiata	Sword Bogmat
RAB = *Wolfiella floridana*	
Woodsia ilvensis	Rusty Woodsia
Woodsia scopulina	Allegheny Cliff Fern
Woodwardia areolata	Netted Chainfern
Woodwardia virginica	Virginia Chainfern
Xanthorhiza simplicissima	Yellowroot
Xerophyllum asphodeloides	Beargrass, Eastern Turkeybeard
Xyris baldwiniana	Baldwin's Yellow-eyed-grass
Xyris brevifolia	Short-leaved Yellow-eyed-grass
Xyris caroliniana	Carolina Yellow-eyed-grass
Xyris difformis var. *curtissii*	Curtiss's Yellow-eyed-grass
RAB = *Xyris curtissii*	
Xyris difformis var. *floridana*	Florida Yellow-eyed-grass
RAB = *Xyris difformis* in part	
Xyris elliottii	Elliott's Yellow-eyed-grass
Xyris flabelliformis	Savanna Yellow-eyed-grass
Xyris jupicai	A Yellow-eyed-grass
Xyris laxifolia var. *iridifolia*	Iris-leaf Yellow-eyed-grass
RAB = *Xyris iridifolia*	
Xyris smalliana	Small's Yellow-eyed-grass
Yucca aloifolia	Aloe Yucca
Yucca filamentosa	Adam's-needle
RAB = *Yucca filamentosa* var. *filamentosa*	
Yucca flaccida	Weakleaf Yucca
RAB = *Yucca filamentosa* var. *smalliana*	
Yucca gloriosa	Moundlily Yucca
Zannichellia palustris	Horned-pondweed
Zanthoxylum clava-herculis	Toothache Tree
Zenobia pulverulenta	Zenobia, Honeycups
Zephyranthes atamasco	Atamasco Lily
Zigadenus densus	Savanna Death-camas
Zigadenus elegans ssp. *glaucus*	White Death-camas
RAB = *Zigadenus glaucus*	
Zigadenus glaberrimus	Sandbog Death-camas

Zigadenus leimanthoides	Pinebarren Death-camas
Zizania aquatica	Wild Rice
Zizaniopsis miliacea	Southern Wild Rice