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An Old-Growth Definition for Evergreen Bay Forests and Related Seral Communities

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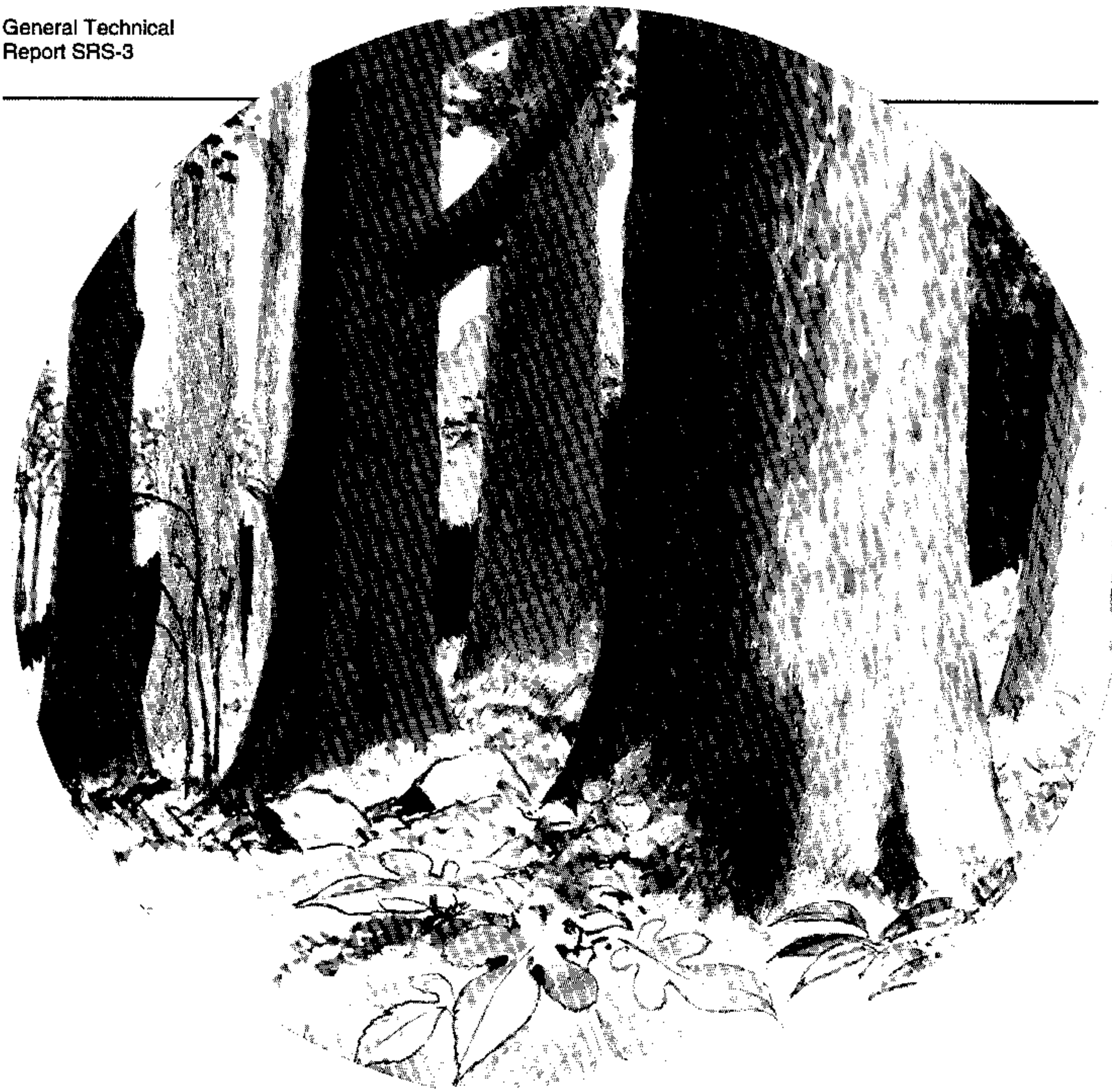

A Section of the Old-Growth Definition Series

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Preface

Old growth is widely acknowledged today as an essential part of managed forests, particularly on public lands. However, this concept is relatively new, evolving since the 1970's when a grassroots movement in the Pacific Northwest began in earnest to define old growth. In response to changes in public attitude, the U.S. Department of Agriculture, Forest Service began reevaluating its policy regarding old-growth forests in the 1980's. Indeed, the ecological significance of old growth and its contribution to biodiversity were apparent. It was also evident that definitions were needed to adequately assess and manage the old-growth resource. However, definitions of old growth varied widely among scientists. To address this discrepancy and other old-growth issues, the National Old-Growth Task Group was formed in 1988. At the recommendation of this committee, old growth was officially recognized as a distinct resource by the Forest Service, greatly enhancing its status in forest management planning. The committee devised "The Generic Definition and Description of Old-Growth Forests" to serve as a basis for further work and to ensure uniformity between Forest Service Stations and Regions. Emphasis was placed on the quantification of old-growth attributes.

At the urging of the Chief of the Forest Service, all Forest Service Stations and Regions began developing old-growth definitions for specific forest types. Because the Southern and Eastern Regions share many forest communities (together they encompass the entire Eastern United States), their efforts were combined, and a cooperative agreement was established with The Nature Conservancy for technical support. The resulting project represents the first large-scale effort to define old growth for all forests in the Eastern United States. This project helped bring the old-growth issue to public attention in the East.

Definitions will first be developed for broad forest types and based mainly on published information and so must be viewed accordingly. Refinements will be made by the Forest Service as new information becomes available. This document represents 1 of 35 forest types for which old-growth definitions will be drafted.

In preparing individual old-growth definitions, authors followed National Old-Growth Task Group guidelines, which differ from the standard General Technical Report format in two ways—the abstract (missing in this report) and the literature citations (listed in Southern Journal of Applied Forestry style). Allowing for these deviations will ensure consistency across organizational and geographic boundaries.

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Introduction

Forests of the North American continent consist of diverse associations of woody and herbaceous plants. Within these forests, many species tend to occur as typical of various physiographic regions and topographic features. Historically, these communities have been viewed as pioneer, seral, or climax, relative to their persistence within the ecosystem. The popularized view of old-growth forests has been one of the plant communities in a climax equilibrium with individual trees hundreds of years old comprising most of the population of the dominant species. In cases where natural disturbances were rare or of limited intensity, community succession could proceed to its climactic condition and dominant individuals of long-lived species could attain ages of 500 to 1,000 years, such as occurs in the Douglas-fir forests of the Pacific Northwest. Sprugel (1991) refers to this concept as the "natural" ecosystem, which has been adhered to by many early ecologists. However, current views of community ecology suggest that nonequilibrium in plant communities is more common than not and that most natural ecosystems are dynamic, even in the absence of human activity (Davis 1984, Brubaker 1988, Sprugel 1991). Frequent and/or catastrophic disturbances, such as fire, can prevent plant communities from attaining a climax equilibrium and the associated characteristics considered common to old growth. Disturbances and changes in climate can influence species disproportionately, altering common community associations according to responses of the individual.

Considering the current focus within the U.S. Department of Agriculture, Forest Service on managing for healthy, sustainable forest ecosystems, more information is needed on the temporal dynamics of the many forest cover types found in the United States. In other words, what characteristics, other than age of specific individuals, make a forest ecosystem old? Pioneer and seral communities can persist over long periods provided that perturbations necessary to their initiation are frequent. Root stocks, rhizomes, and, in some cases, seed banks can be relatively old, although the aboveground shoots arising from these components may not themselves be old. Can these communities be considered ancient or old growth even if the longevity of the individuals is limited? What constitutes "old growth" in community types that may not ever achieve a climax equilibrium and are subject to frequent, natural disturbances? Should these systems be excluded from the consideration given to more traditional old-growth forests? Definitions including such systems should be developed so that the natural dynamics of the ecosystem as a whole can be sustained, not simply the existing collection of individuals.

Narrative Description

The bay forest type (41) falls under Disturbance Class 3 of the composite list prepared by the National Old-Growth Task Group; forests with infrequent, high intensity, widespread disturbances and the subcategory, palustrine forests. This forest type is similar to the Society of American Foresters forest type 84, slash pine; 85, slash pine-hardwood; and 104, sweetbay-swamp tupelo-redbay. A previously prepared narrative description of the forest type is as follows: "Bay forests occur exclusively in the Coastal Plain physiographic province, and range from Maryland to southeast Texas. These forests are restricted to coastal depressions or floodplains where saturated conditions prevail. Soils usually are organic, although mineral soils do occur in floodplains. Most are highly acidic and low in nutrient availability. Surface flooding is common, but usually is not persistent.

"In addition to loblolly bay (*Gordonia lasianthus*), sweet bay (*Magnolia virginiana*), and red bay (*Persea borbonia*), common species include swamp tupelo (*Nyssa sylvatica* var. *biflora*), sweetgum (*Liqidambar styraciflua*), red maple (*Acer rubrum*), slash pine (*Pinus elliottii*), pond pine (*P. serotina*), live oak (*Quercus virginiana*), bald cypress (*Taxodium distichum*), pond cypress (*T. ascendens*), and Atlantic white cedar (*Chamaecyparis thyoides*). Hydric conditions retard the invasion by flood-sensitive species and consequent succession to other forest types. Disturbance from fire and storm events plays an important role in the ecological development of these systems. This forest type frequently reverts to Atlantic white cedar or pond pine forests (forest types 40 and 29, respectively) after catastrophic fires."

The term "bay," used in this document, has a dual meaning. It refers to both a kind of site, e.g., Carolina bay, and a general grouping of tree species that may inhabit that site, e.g., bay trees.

Occurrence

Bay forests occur in several physiographic provinces with different geologic origins and topographic features. However, bay forests are considered rare and are found in scattered patches, often in a mosaic with other forest types in various stages of succession (Schafale and Harcombe 1983, Abrahamson and others 1984, Bennett and Nelson 1991). Pocosins, Carolina bays and sandhill seeps, stream heads, and stream margins will often support this forest type (Wells 1928, Monk 1966, Waggoner 1975, Christensen et al. 1981, Nelson 1986).

Pocosins

Pocosins occur on low, coastal-plain terraces of Virginia and the Carolinas. These physiographic features are nonalluvial, occurring on divides between rivers, in broad, shallow stream basins, drainage-basin heads, and on broad, flat uplands (Wells 1928, Kologiski 1977). Common synonyms for pocosin and pocosin-like areas include bay, bayland, bayhead, baygall, xeric shrub bog, and evergreen shrub bog (Kologiski 1977, Sharitz and Gibbons 1982, Schafale and Harcombe 1983). Pocosins have shallow to deep organic soils of sandy humus, muck, or peat and intermediate to long hydroperiods with temporary surface water (Kologiski 1977). Soils reported for North Carolina pocosins include Dare, Dorovan, Pamlico, and Ponzer (Kologiski 1977).

Pocosins are often further described as being either tall or short, depending on the average height of the canopy dominants, which can be up to 32.8 feet [10 meters (m)] (Christensen et al. 1981). Bay forests are more closely associated with tall pocosins; evergreen shrub bogs are associated with short pocosins. Kologiski (1977) described the bay forest canopy as only 9.84- to 32.8-feet (3- to 10-m) high with the shrub stratum blending into the canopy layer. Greater fertility and productivity are also generally characteristic of tall pocosins and bay forests (Christensen et al. 1981, Richardson and Gibbons 1993). Evergreen shrub bogs are believed by some to represent an earlier successional stage to the evergreen bay forest and are the result of fire disturbance within the past 10 to 20 years (Buell 1946, Duever et al. 1982). The shrub species found in shrub bogs often occur as understory in bay forests and stunted individuals of sweetbay (*Magnolia virginana* L.), loblolly-bay [*Gordonia lasianthus* (L.) Ellis], and redbay [*Persea borbonia* (L.) Spreng.] often occur in shrub bogs (Richardson and Gibbons 1993). However, Otte (1981) and Christensen et al. (1981) have different views on the successional relationships between shrub bogs and bay forests.

Carolina Bays

Carolina bays are floristically similar to many pocosin sites and may also support evergreen bay forests (Buell 1946, Porcher 1966, Sharitz and Gibbons 1982, Bennett and Nelson 1991), although, when present in Carolina bays, sweetbay and redbay most often occur as shrubs (Schalles et al. 1989). The general term "bay" refers to the dense growth of bay trees found on many upland sites having histic soils with poor drainage; Carolina bays are the most abundant of these types of sites in the Southeast (Schalles 1979).

Carolina bays are unusual topographic features common to the Atlantic Coastal Plain. They are natural, elliptical depressions oriented northwest to southeast often having a pronounced sand rim along the southeastern edge. These depressions are isolated wetlands with no natural drainage outlets and are usually ombrotrophic. Typically, the central zone of a Carolina bay remains more or less inundated, depending upon weather patterns and local hydrology (Bennett and Nelson 1991). This perched, surface water is maintained by an impervious clay lens or a sand-iron-humate complex (Schalles 1979). Soil types within Carolina bays may vary but are usually composed of an organic surface layer of peat varying in depth and underlain by a layer of sand, which usually forms part of the impervious humate complex. However, clay-based bays generally have a mineral soil overlying the clay layer with little or no peat accumulation in the basin (Bennett and Nelson 1991). Bay forests are generally peat-based as opposed to clay-based.

Sandhill Seeps and Drainages

Sandhill seeps are found in the upper Atlantic Coastal Plain. They are usually located at the bases of hills and ridges in depressions where there is groundwater seepage from the adjacent slopes. The soils are histic due to constant saturation, although the seeps are seldom flooded. Stream margins and heads of stream branches along the Gulf Coastal Plain may also develop peaty soils and support bay forests (Monk 1966). These bayheads are visually distinguishable from cypress ponds by the absence of cypress trees and standing water, and the presence of an irregular surface with exposed, highly convoluted roots (Wharton 1978). The Pickney series is representative of the soils found in seeps and stream margins supporting evergreen bay forests. Soils of bayheads are less fertile than those of alluvial swamps with lower concentrations of cations and a lower pH; however, they are more fertile than soils associated with cypress ponds (Monk 1966, 1968).

Fire Ecology

Frequent disturbance across the landscape often results in a mosaic of vegetative cover types (Hamilton 1984). The patchwork nature of evergreen bay forests is related to their extreme susceptibility to fire, after which they may revert back to any one of several freshwater, hydric vegetative cover types depending on the intensity of the burn and depth to the water table during and following the burn (Monk 1968, Wells and Whitford 1976, Kologiski 1977, Duever et al. 1982, Hamilton 1984, Bennett and Nelson 1991). Fire intensity determines the amount or depth of peat burned away. Up to 6 feet (1.8 m) of peat were consumed by a severe fire in the Okefenokee Swamp, removing the base of support for the cypress (*Taxodium*) and tupelo (*Nyssa*) trees present on the site and causing them to collapse (Wharton 1978). Catastrophic fires also destroy seed banks and kill root systems and stumps that might survive less severe burns. Water-table depth during a fire influences fire intensity and depth of the burn; after a fire, water-table depth determines which of the available species will be able to recolonize the site. With shallow burns, as may occur when water tables are high, bay swamps may revert to pine swamps; with deeper burns, they may revert to cypress-gum ponds (Penfound 1952, Monk 1968). With a devastating surface fire, bay swamps may be replaced by Atlantic white-cedar [*Chamaecyparis thyoides* (L.) B.S.P.]; and with recurrent fire, the bay swamp, pond pine-slash pine wetlands, and Atlantic white-cedar bogs may revert to shrub bogs (Monk 1968). After a fire, pocosins may return to a pre-fire pocosin condition or develop into an Atlantic white-cedar bog, a sedge bog, an evergreen bay forest, or a deciduous bay forest (Monk 1968, Wells and Whitford 1976, Kologiski 1977, Duever et al. 1982, Bennett and Nelson 1991).

Most ecologists studying these systems agree that a successional relationship exists between sedge bogs, shrub bogs, pocosins, Atlantic white-cedar bogs, pine swamps, cypress-gum ponds, and bay forests (Penfound 1952, Hamilton 1984). However, there is disagreement on the direction and driving forces of succession. Wells (1928) suggested that the pocosin or shrub bog was a seral stage within a successional sequence, of which the evergreen bay forest is considered to be climax (Monk 1968). The succession process requires a few hundred years without disturbance. In the more fertile shrub bog communities, fire appears to be a major influence in succession (Christensen 1981). Kologiski (1977) used the term “fire disclimax” to describe the successional stage commonly known as pocosin and also suggested that the evergreen bay forest would eventually dominate.

On the other hand, Christensen et al. (1981) also noted that in the absence of fire, many ombrotrophic shrub bogs show little signs of succeeding to swamp forests and that some shrub bogs have been relatively stable for several thousand years. Otte (1981) proposed a succession sequence driven by nutrient levels, with the bay forest as a seral stage and the short pocosin as the equilibrium stage. Richardson and Gibbons (1993) observed gradients in phosphorus (P) availability and the nitrogen:phosphorus (N:P) ratio associated with differences in cover type, i.e., short pocosin versus bay forest. The nutrient-driven theory of succession is also supported by pollen analysis. This form of succession occurs in conjunction with paludification (Richardson and Gibbons 1993).

Depth of peat or, more precisely, depth to the mineral soil below the peat layer appears to be the major fertility factor influencing succession and community types (Christensen et al. 1988 as cited by Richardson and Gibbons 1993). Many shrub bogs and shrub pocosins have a deeper layer of peat than do bay forests and only a minor canopy component of stunted tree species (Buell 1946, Bennett and Nelson 1991, Richardson and Gibbons 1993). Fire reduces peat accumulation and releases nutrients tied up in organic matter, suggesting that fire and fertility are intimately related and both may play a role in succession and stability.

Plant composition of these systems is also determined by frequency of fire as well as fire intensity (Monk 1968, Christensen 1981, Taggart 1981). Fire cycles of 50 to 150 years are required for the development of mature evergreen bay forests (Wharton 1978). Buell (1946) and Monk (1966) believed that the climax vegetation community of a Carolina bay shrub bog was the broadleaf bay forest and also considered this forest type successor to Atlantic white-cedar stands and pine pocosins when fire was absent from the ecosystem for long intervals. Buell (1946) went so far as to suggest that the dominant climax tree species would be swampbay (also known as redbay) [*P. pubescens (borbonia)*] due to its extreme shade tolerance. In an 80-year-old, declining Atlantic white-cedar stand in Brunswick County, North Carolina, Buell and Cain (1943) noted that swampbay was the most abundant tree species in the understory, with 3,967 individuals per acre (98 individuals 100 m^{-2}). Sweetbay had 810 individuals per acre (20 individuals 100 m^{-2}). No Atlantic white-cedar seedlings were found and 90 percent of all seedlings present were swampbay. Kologiski (1977) also stated that the most common seedling in many of the evergreen bay forest stands of the Green Swamp in North Carolina was swampbay.

In addition to fire frequency and intensity, plant composition is also influenced by site hydrology. Short pocosins have been associated with high summer water tables and anaerobic conditions throughout the year, whereas tall pocosins and bay swamps have a highly seasonal water table (Bridgham and Richardson 1993). In areas with a defined moisture gradient, shrub bogs gradually give way to swamp forests as moisture increases. The spatial progression is characterized by decreasing shrub diversity and increasing tree diversity, in association with decreasing peat depth and increasing nutrient availability and productivity (Christensen et al. 1981).

Site hydrology, i.e., duration and depth of flooding, and climatic factors, i.e., precipitation and lightning strikes, also influence fire frequency and intensity in shrub bog/bay forest systems. Slightly elevated areas dry out more frequently, and periodic droughts increase the possibility of intense fires. However, bay swamps associated with seeps and streamheads seldom dry out due to the constant seepage of groundwater into the peat substratum, which is capable of absorbing and retaining large quantities of water (Wharton 1978).

Alteration of the water table by agricultural and silvicultural drainage practices over the past years has increased the frequency of dry periods and subsequently the possibility of fires in the Coastal Plain. Such management practices may have inadvertently interrupted the succession of shrub bogs to bay forests and severely reduced in size or damaged mature bay forests (Buell 1946, Monk 1966, Christensen 1981). However, a high frequency of fire in the Southeast before 1800 has been documented by early explorers and attributed to the activity of Native Americans (Christensen 1981). Even with the disturbance of the natural hydrology, fires may be less frequent today than they were 200 years ago.

Fire is necessary to the cycling of nutrients in the shrub bog/bay forest system. Shrub bogs may stagnate if nutrients remain tied up in the slowly decomposing litter, especially on inherently poor sites with deep peat accumulations (Christensen 1981). However, Monk (1968) indicated that soil fertility was more important in controlling the direction of succession than in limiting the advancement of succession. Many pocosin plants seem to require fire to complete their life cycle, and the absence of fire may be more of a disturbance than a very intense wildfire (Christensen 1981, Christensen et al. 1981). Prescribed fire has not been an acceptable substitute for wildfire and does not provide conditions necessary for regeneration. Gresham and Lipscomb (1985) reported that *Gordonia* required a high degree of soil disturbance, such as would occur from a very intense wildfire, for successful seedling recruitment.

In summary, plant composition in shrub bog/bay forest systems is determined by fire frequency and intensity, climate, hydrology, and site fertility. Fire frequency and intensity are influenced by climate and hydrology, and site fertility is influenced by hydrology and fire frequency and intensity. Regenerative capacity, i.e., potential seed banks and living rootstocks, is also determined in part by fire intensity and frequency. The complex web of interactions controlling succession within these depressional wetlands ensures myriad possible alternatives in vegetative cover types, one of which is the evergreen bay forest. Due to the long fire cycle required to achieve this cover type and the longevity of the regenerative components of a bay forest, the mere existence of an evergreen bay forest suggests it is indeed both climax and “ancient” relative to surrounding cover types occurring within depressional wetlands.

Life History and Community Associates

The floristic richness and species diversity of bay forests are relatively low compared with other southeastern forest types (Buell 1946, Monk 1968, Abrahamson et al. 1984). As stated in the narrative description, bay forests are usually dominated by the three bay species: loblolly-bay, sweetbay, and redbay.

According to *Silvics of North America*, loblolly-bay is a small-to-medium-sized tree or shrub (Gresham and Lipscomb 1990). At 10 years of age, specimens averaged 21.3 feet (6.5 m) in height and 2.2 inches [5.6 centimeters (cm)] in diameter at breast height (d.b.h.). Measurements of older specimens were not reported, although individuals at least 25 years old were noted. Elias (1980) reports the species to be short-lived with a maximum height of 65.6 feet (20 m) and diameter of 19.7 inches (50 cm). The National Champion, located on the Ocala National Forest, has a circumference of 13.4 feet (4.09 m) a diameter of 4.3 feet (1.31 m), a height of 95.2 feet (29 m), and a crown spread of 52.5 feet (16 m).[1] Loblolly-bay rarely occurs in pure stands (Gresham and Lipscomb 1985). The species is considered shade tolerant and is a strong competitor, but it is extremely sensitive to fire. Seedlings seem to require relatively open conditions and exposed soil for establishment. Few seedlings have been observed in the field. Stump and root-collar sprouts appear to be the most common form of regeneration for this species.

Sweetbay is also listed as a slow-growing, small-to-medium-sized tree (Priester 1990). It is considered a shrub in the northern reaches of its range (New Jersey), where it attains a height of 23.6 to 59.1 inches (60 to 150 cm). In the southern portion of its range (Florida), it varies in height from 49.2 to 98.4 feet (15 to 30 m) and in d.b.h. from 3.9 to 35.4 inches (10 to 90 cm). A record specimen measuring 50.4 inches (128 cm) d.b.h. and 91.9 feet (28 m) tall has been recorded in Florida; however, the age of this individual was not given. Individuals up to 70 years old were reported in the understory of a declining 80-year-old, Atlantic white-cedar stand in North Carolina (Buell and Cain 1943). Early growth of the sweetbays was slow, but their growth rate increased as the growth rate of the cedars declined. Regeneration is best in natural openings or clearcuts, although seedlings are fairly tolerant of shade and competing vegetation (Priester 1990). However, Buell and Cain (1943) found no seedlings of sweetbay in the cedar stand mentioned above. Like loblolly-bay, sweetbay also produces stump sprouts. Sweetbay is considered resistant to fire but will succumb after repeated burning.

Redbay is also listed as a tree or a shrub with size and growth habit varying over its range. Heights up to 68.9 feet (21 m) have been reported along with diameters of 35.8 inches (91 cm) (Brendemuehl 1990). Redbay occurring in pocosins has been described as a shrub. Ages associated with these dimensions were not reported. Redbay is tolerant of shade but also grows well in the open. As previously mentioned, redbay seedlings were abundant under a mature Atlantic white-cedar canopy (Buell and Cain 1943). However, reproduction may be erratic, and poor growth forms often occur under overstory competition (Brendemuehl 1990). Fire damage to redbay is severe and may interfere with reproduction.

[1] Personal communication. 1994. Laura Lowery, Ocala National Forest, Lake George Ranger District, 17147 East Highway 40, Silver Springs, FL 34488-5849.

Bay forest communities usually have a dense understory. Shrub, vine, and herbaceous species include the following: fetter-bush (*Leucothoe racemosa* D. Don), tetter-bush *[Lyonia lucida* (Lam.) K. Kosh], swamp cyrilla (*Cyrilla racemiflora* L.), buckwheat-tree or titi [*Cliftonia monophylla* (Lam.) Britton ex Sarg.], maleberry [*L. ligustrina* (L.) DC], sweet pepperbush (*Clethra alnifolia* L.), inkberry [*Ilex glabra* (L.) Gray], gallberry (*I. lucida*), sweet gallberry [*I. coriacea* (Pursh) Chapm.], American holly (*I. opaca* Ait.), dahoon holly (*I. cassine* L.), possumhaw (*I. decidua* Walt), wax-myrtle (*Myrica cerifera* L.), Virginia willow (*Itea virginica* L. Virginian), greenbrier (*Smilax* spp.), zenobia [*Zenobia pulverulenta* (Bartr.)], leather leaf [*Cassandra calyculata* (L.) Moench], sheepkill (*Kalmia augustifolia* L.), and cane [*Arundinaria gigantea* (Walt.) Chapm.] (Buell 1946, Porcher 1966, Monk 1968, Waggoner 1975, Abrahamson et al. 1984). *Cassandra calyculata* is listed on the rare/threatened/endangered plant list (Bennett and Nelson 1991). Several ferns and mosses have also been listed in the literature as commonly occurring in bay forests. These include *Osmunda cinnamomea*, *O. regalis*, *Woodwardia virginica, W. areolata*, and *Sphagnum spp.* (Porcher 1966, Kologiski 1977, Wharton 1978, Barry 1980). The herbaceous component is usually sparse (Nelson 1986) but may include partridge berry (*Mitchella repens* L.) and wild ginger (*Hexastylis arifolia*) (Barry 1980).

Age Structure

There is little information in the literature on age structure for the dominant tree species in evergreen bay forests. They are all described as moderately slow growing, and yet specimens have achieved heights of 98.4 feet (30 m) and diameters of 36.2 inches (92 cm). Loblolly-bay averaged 9.1 and 14.2 inches (23 and 36 cm) per year in height growth and 0.2 inches (0.58 cm) per year in diameter growth for two separate sites on the Coastal Plain of South Carolina (Gresham and Lipscomb 1985). At these growth rates, it would require about 100 years to achieve dimensions of 75.5 feet (23 m) tall and 22.8 inches (58 cm) d.b.h. One bay tree located on the Hofmann Forest in North Carolina was reportedly 85 years old.[2] However, specimens 50 to 150 years old do not meet the popular concept of “old growth” or “ancient forest.”

The absence of relatively “old” individuals of the dominant tree species in a bay forest stand does not necessarily

[2] Personal communication. 1994. Richard Braham, Professor, North Carolina State University, Raleigh, NC 27695.

indicate the natural longevity of those species but may indicate frequent fires that prevent aboveground components from reaching old age. However, stumps and rootstocks partially protected from severe fire damage may be old. Both loblolly-bay and sweetbay commonly regenerate by means of stump and root-collar sprouts (Gresham and Lipscomb 1985). Wharton (1978) considered the bay swamp one of Florida's oldest and most stable environments because of the bay's ability to stump sprout following fire. Therefore, it may be appropriate to assign old-growth status to those plant communities with individuals whose propagating parts are long-lived, whether the aboveground shoot is old by currently accepted standards. With temporally dynamic systems, such as the bay forest/Atlantic white-cedar bog/evergreen shrub bog, it may be more important to recognize the longevity of the nonequilibrium ecosystem rather than that of the current stand of individual aboveground stems.

Stand Structure

There are few quantitative data in the literature on stand structure for evergreen bay forests of any age, much less those considered mature. Gresham and Lipscomb (1985) detailed 50 sites on the South Carolina Coastal Plain supporting loblolly-bay (table 1). For their purposes, these sites had only to include one loblolly-bay specimen larger than 1.2 inches (3 cm) d.b.h. and, therefore, the sites studied cannot all be considered bay forest stands. Redbay was also a dominant tree species on these sites with sweetbay occurring as well. The three other major tree species were blackgum [*Nyssa sylvatica* var *biflora* (Walt.) Sarg.], loblolly pine (*Pinus taeda* L.), and pond pine (*P. serotina* Michx.), together with the two dominant bay species, they comprised over 60 percent of the average site composition and 84 percent of the basal area. The three bay species alone averaged 299 stems per acre [740 stems per hectare (ha^{-1})] (39 percent of the total) and a basal area of 30.7 square feet per acre (7.05 m^2 ha^{-1}) (28 percent of the total). Shrub densities averaged 18,728 stems per acre (46,278 stems ha^{-1}), with *L. lucida* and *C. alnifolia* comprising 73 percent of the shrub composition.

Braham (see footnote 2) collected data in a bay forest at the Horticulture Crops Research Station, Clinton, NC. Loblolly-bay made up 58 percent of the total basal area and had the largest number of stems per ha (table 1). Red maple (*Acer rubrum* L.) was second with 16 percent of the total basal area and 130 stems per acre (321 stems ha^{-1}). Swamp tupelo, sweetgum (*Liquidambar styraciflua* L.), redbay, and sweetbay were the other major tree species in the community.

In a study describing the influence of fire on a typical "blackgum bay" in the Okefenokee Swamp in Georgia, the three bay species made up 24 percent and 54 percent of the total number of tree stems counted along two 50-chain transects (Cypert 1961) (table 1). Sweetbay was second only to blackgum in total number of stems for both transects. Basal areas for the three bay species combined were 28.5 and 77.2 square feet per acre (6.54 and 17.7 m^2 ha^{-1}), and total basal area averaged 202.6 square feet per acre (46.47 m^2 ha^{-1}) for the two transects. Basal area of sweetbay was second only to blackgum for both transects. Fire-induced mortality along the two transects averaged 5 and 50 percent for the bay species. Fire damage in this section of the swamp was considered typical.

In three other areas of the swamp that were severely burned, bay species made up 80 percent of 117 stems per acre (290 stems ha^{-1}), 71 percent of 21 stems per acre (52 stems ha^{-1}), and 8 percent of 203 stems per acre (501 stems ha^{-1}) before the fire. All stems of the bay species were killed by the fire; however, 17, 6, and 15 bay sprouts per acre (43, 15, and 37 bay sprouts ha^{-1}) were present several years after the fire. Pre-fire basal areas for the bay species were as follows for the three study areas: 80.7, 2.9, and 1.4 square feet per acre (18.5, 0.67, and 0.32 m^2 ha^{-1}), and for all tree species combined were 121.6, 11.8, and 95.1 square feet per acre (27.9, 2.7, and 21.8 m^2 ha^{-1}), respectively. These values represent a wide range of stand conditions on sites supporting typical bay forest vegetation.

In a typical South Carolina pocosin, tree densities and basal areas were lower than in other wetland forest types (Jones 1981) (table 1). Pond pine was most numerous, with loblolly-bay second in number. However, pondcypress [*Taxodium distichum* var. *nutans* (Ait.) Sweet] had greater basal area than loblolly-bay. Redbay and sweetbay densities combined had 10 stems per acre (25 stems ha^{-1}) with a combined basal area of 0.4 square feet per acre (0.08 m^2 ha^{-1}). Other tree and large shrub species on the site included swamp tupelo, red maple, wax-myrtle, and dahoon holly.

Jones (1981) also provides some additional information on diversity and community structure of six bay forest sites located in South Carolina. These sites averaged 11 tree species and 14 shrub species, a tree basal area of 145.2 square feet per acre (33.3 m^2 ha^{-1}) and a shrub cover of 10.7 inches per foot (88.9 cm m^{-1}).

Richardson and Gibbons (1993) summarized stand characteristics of short pocosins, tall pocosins, and bay/gum forests showing results similar to those reported above (table 1). Only tall pocosins had tree-size (loblolly) bay trees, but numbers and basal areas were low. Pond pine, red maple, and Atlantic white-cedar were the only other tree species present in the tall pocosin. The three bay species made up

Table 1—Stand structure characteristics in old-growth evergreen bay forests and related seral communities

Species	Gordonia sites[a]		Transect A[b]		Transect B[b]		SC pocosin[c]		Short pocosin[d]		Tall pocosin[d]		Bay/gum forest[d]		Hoffmann forest[e]		Bay forest community[e f]	
	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density	Basal area	Density
	m^2/ha	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*	*m^2/ha*	*stems/ha*
Gordonia lasianthus	4.64	322	0.54	11	1.87	24	0.88	125	- -	- -	0.04	13	.98	233	14.51	93	17.26	482
Persea borbonia	2.15	343	.11	4	3.57	42	.06	18	- -	- -	- -	- -	4.74	308	- -	- -	1.04	68
Magnolia virginiana	.26	75	5.90	53	12.25	114	.02	7	- -	- -	- -	- -	.37	75	- -	- -	.28	99
Nyssa sylvatica	3.91	211	33.95	156	23.73	123	.42	77	- -	- -	- -	- -	7.13	33	- -	- -	- -	- -
N. biflora	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	2.88	68
Pinus taeda	5.32	134	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	.28	6
P. serotina	4.93	134	- -	- -	- -	- -	8.70	538	3.89	395	2.93	156	5.10	166	11.92	30	- -	- -
P. elliotti	- -	- -	- -	- -	.04	2	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Taxodium ascendens	- -	- -	- -	- -	- -	- -	1.34	103	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
T. distichum	- -	- -	2.43	12	1.28	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Quercus nigra	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	.29	31
Acer rubrum	- -	- -	1.60	53	1.69	23	.07	7	- -	- -	.04	13	15.07	133	- -	- -	4.80	321
Chamaecyparis thyoides	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	2.08	75	- -	- -	- -	- -	- -	- -
Liquidambar styraciflua	.77	102	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	18.88	175	- -	- -	.81	6
Ilex cassine	- -	- -	1.59	98	.24	6	.01	4	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
I. opaca	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	.59	86
Myrica cerifera	.46	156	- -	- -	- -	- -	.04	11	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Symplocos tinctoria	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	1.23	3
Miscellaneous	2.37	435	.21	7	1.95	74	- -	- -	- -	- -	- -	- -	.43	108	- -	- -	.40	216
Total	24.81	1912	46.33	394	46.62	408	11.54	890	3.89	395	5.09	257	52.7	1231	26.43	123	29.86	1386

[a] Gresham and Lipscomb 1985.
[b] Cypert 1961.
[c] Jones 1981.
[d] Richardson and Gibbons 1993.
[e] Personal communication. 1994. Richard Braham, Professor, North Carolina State University, Raleigh, NC 27695.
[f] Located in Sampson County, North Carolina.

49 percent of the stems per acre and 12 percent of the basal area in the bay/gum forest. Other dominant tree species in that stand included red maple, sweetgum, blackgum, and pond pine. Sweetgum and red maple accounted for 36 percent and 27 percent of the basal area, respectively, and only 14 percent and 11 percent of the stems per acre.

Soils

Soils of bay forests are typically histosols, organic soils whose fertility depends on the hydrologic conditions. However, bay forest species can also be found on spodosols, inceptisols, ultisols, and to a lesser degree entisols and mollisols (Gresham and Lipscomb 1990). Variations in size and growth habit reported for the dominant tree species are probably related to differences in soil-site characteristics of the different soil orders. Elevated areas that depend on precipitation for nutrients and water (ombrotrophic) have the poorest productivity (Bridgham and Richardson 1993). However, poor sites may have greater species diversity due to the inability of any one species to dominate (Christensen 1981). Richardson and Gibbons (1993) suggest that the ecosystem gradient from short to tall pocosin to bay forest represents a natural gradient of increasing P availability and decreasing N:P ratio.

Accumulation of peat in the substrate is a common attribute of bay forests. Buell (1946) described in detail the soil profile in a typical Carolina bay—Jerome Bog in North Carolina. This particular bay had a small bay forest stand along its western edge. Peat accumulations ranged in depth from 4 to 11 feet (1.2 to 3.4 m) and consisted of a surface black peat and an underlying brown peat. In the deepest section of the bay, an underlying clay lens was also present over a sand layer. The surface of the bay was described as a "continuous thick, coarse, tough mat of tree roots and the roots and rhizomes of shrubs," indicating a shallow, surface-rooting habit in the peat substrate. The surface black peat was described as fine, soft, and sticky when wet, drying to a hard, brittle mass when dry, containing charred plant fragments and fine charcoal throughout, with pollen in the lower portion. The layer of black peat was thinnest under the bay forest. The underlying brown peat contained partially decomposed plant fragments, charcoal, numerous logs, and an abundance of pollen. Both the logs and the pollen were in a well-preserved state. The abundance of charcoal in the peat substrate, particularly its presence in the deepest sections of the underlying layer of brown peat, confirms the historical importance of fire in the shrub bog/bay forest ecosystem.

In North Carolina, Bridgham and Richardson (1993) studied the soil chemistry along a hydrology gradient in a freshwater peatland comprised of short pocosin, tall pocosin, and gum swamp. Bay species were not listed as major vegetation components of these communities; however, it is likely that soil chemistry is similar between these communities and evergreen bay forest sites, given the relationships between bay forests and pocosins. Both short and tall pocosins were nutrient-deficient with low levels of total and available P, N, and basic cations and a low pH. They differed primarily in seasonal hydrology and peat depth. Gum swamps had high levels of N and P but low levels of exchangeable calcium (Ca) and magnesium (Mg) and a low percent base saturation.

Richardson and Gibbons (1993) summarized Walbridge's (1986) soil chemistry work on pocosins and bay forests in North Carolina and found results similar to those of Bridgham and Richardson (1993) described above. Although pH values were similar among the three site types (3.7 to 3.9), exchangeable and total P as well as total N levels were higher in the bay forest than in the short and tall pocosins. Exchangeable P values ranged from 5.5 to 30.9 pounds per acre [6.2 to 34.6 kilograms (kg) ha^{-1}] and total P values ranged from 17.5 to 105.3 pounds per acre (19.6 to 118 kg ha^{-1}) for short and tall pocosin and bay forests. Total N values were 1,002.8, 847.6, and 1,993.2 pounds per acre (1124, 950, and 2234 kg ha^{-1}) for short pocosin, tall pocosin, and bay forests, respectively.

Christensen et al. (1988) also studied plant communities on peat and hydric mineral soils in the Croatan National Forest in North Carolina and found that pocosin soils had greater peat depth, exchangeable Mg and potassium (K), and cation exchange capacity and lower bulk density, extractable P, Ca:Mg ratios, and pH than the other plant communities studied.

Gresham and Lipscomb (1985) described soils associated with loblolly-bay and redbay on the South Carolina Coastal Plain. These included Leon sand, Lynn Haven fine sand, Rutledge loamy sand, Pickney loamy fine sand, and Chipley fine sand. The surface peat layer of these soils ranged from 1.2 to 5.6 inches (3 to 14 cm) thick. All soils were low in pH, ranging from 3.2 to 4.8. Also in South Carolina, Jones (1981 as cited by Sharitz and Gibbons 1982) described soils supporting bay forest stands as having more than 15.8 inches (40 cm) of organic substrate, 54 percent organic matter, 59 percent sand, 31 percent silt, and 10 percent clay.

In a typical Florida bayhead dominated by loblolly, sweet, and redbay, Monk (1966, 1968) described soil as being lower in Ca, Mg, K, Ca:Mg ratio, Ca:K ratio, milliequivalents of cations, P, and pH compared with mixed deciduous hardwood swamps found in Florida. These edaphic features were strongly related to the dominant tree species present in each of the swamp types studied. The greater longevity of evergreen foliage and high nutrient-use efficiency may give bay species an advantage over deciduous species on infertile sites (Christensen et al. 1981).

Also in Florida, Abrahamson et al. (1984) listed the soil series Sanibel and Pompano depressional, very poorly drained and poorly drained, respectively, as common to bayheads located on the Archbold Biological Station, a 3,904.2-acre (1580-ha) biological preserve located on the Lake Wales Ridge in Highlands County. The three bayheads found on the station occupied only 13.6 acres (5.52 ha) or 0.35 percent of the total land area of the station. Both soil types had a surface layer of muck; however, the layer was thinner on the Pompano depressional soil series. Nutrient analysis of the soil found it similar to other soil series supporting bay forests. Major nutrients averaged 2.1, 51.2, 42.2, and 57.2 pounds per acre (2.3, 57.4, 47.3, and 64.1 kg ha^{-1}) of P, K, Ca, and Mg, respectively, and pH averaged 4.7. Phosphorus and Ca values were lower than on other sites on the station and K and Mg values were high to intermediate compared to other forested sites.

Snags and Downed Woody Debris

No quantitative information was available in the literature on numbers of snags per acre or the amount of downed woody debris found in bay forest stands.

Threats to Existence

Many sites inhabited by bay species are so unproductive as to have limited usefulness in silviculture or agriculture. However, the use of phosphorus fertilization and bedding with minor drainage by timber companies has resulted in the establishment of pine plantations on many acres of pocosins. For example, in the 17-year period after 1962, pocosin acreage in North Carolina was decreased by 69 percent (Ash et al. 1983). Nevertheless, some timber companies are beginning to recognize the value of the rare bay forest type and are designating these small patches as natural preserves.[3] Peat mining is another threat to pocosins and bay

[3] Personal communication. 1994. Mac Baughman, Westvaco Corporation, P.O. Box 1950, Summerville, SC 29484.

forests. Interest in bioenergy fuels resulted in an increase in the number of permits to mine peat from North Carolina pocosins during the early 1980's (Ash et al. 1983).

Carolina bays are also subject to disturbance; half of all bays in South Carolina identified by Bennett and Nelson (1991) had one-fifth or more of their ellipse disturbed. Types of disturbance included ditches, row cropping, pine plantations, logging, development, roads, rights-of-way, and farm ponds. Eighty percent of all disturbed bays had multiple disturbances. However, as with some of the pocosins, State heritage trust programs are attempting to identify and protect as many relatively undisturbed Carolina bays as possible.

Aside from conversion, the greatest threat to "old-growth" bay forests is wildfire. Silvicultural practices, such as minor drainage, and agricultural use of adjacent upland areas could indirectly influence both the frequency and intensity of wildfire in shrub bogs and mature bay forests. A lowering of the water table could result in more frequent and deeper burns. On the other hand, prescribed fire and fire suppression, as practiced in forest management, could decrease the occurrence of wildfire, thus allowing the succession of shrub bogs to mature bay forests. For that reason, current forest management practices may promote the development of mature bay forests. At the same time, intense wildfires may be required for seedling recruitment, and lack thereof may prevent regeneration of many bay forest species. Drainage of these systems is also a form of disturbance, stimulating productivity and reducing species diversity (Christensen 1981).

The very existence of mature bay forests today is the result of a series of stochastic events that provided an exposed mineral-soil seedbed (probably the result of catastrophic wildfire) and yet an extended period free from wildfire. This had the combined effect of seedling establishment and uninterrupted succession to the climax condition—mature, evergreen bay forest. Management that will produce such a fortuitous chain of events might be difficult, if not impossible, in light of unpredictable weather patterns, land-use planning for adjacent areas, and public health concerns. It is probably more feasible to maintain current sites with adequate fire suppression and conservation easements than to attempt to create new mature bay forests. Fire suppression during the seral stages of bay ecosystem succession may lead to the eventual development of a mature bay forest, but may not be economically feasible or desirable in some circumstances.

Representative Stands

Several representative stands of evergreen bay forests still exist throughout the Southeastern United States and can be found associated with each of the physiographic features described above. However, because little information is available on the ages of these stands, it is inappropriate to assume that they are "old-growth" bay forests. The individuals suggesting their inclusion in this list believed that these stands came closest to what might be considered "old growth" for this forest type. Further research in these areas would provide additional information regarding (1) age distributions of perennating parts, as well as aboveground stems; (2) successional relationships between pocosins, bay forests, and Atlantic white-cedar bogs; and (3) the influence of hydrology on peat accumulation, fire frequency and intensity, and nutrient cycling in these dynamic, interrelated systems.

North Carolina

The Hofmann Forest owned by the North Carolina Forestry Foundation has approximately 622.7 acres (252 ha) of bay forest in two forest-management units (FMU 218 and 404). These areas have reportedly not burned for over 40 years. In 1992, the average age of the stands was 56 years with one loblolly-bay 85 years old. Loblolly-bay was the dominant species followed by pond pine (table 1). This area is slowly succeeding from a pond pine stand to a bay forest in the absence of fire, and stands dominated by both species are interspersed in a patchwork mosaic (see footnote 2).

Dr. Braham (see footnote 2) also described a bay community in Sampson County, North Carolina, that he visited in 1988 (table 1). The stand contained some large specimens of loblolly-bay, one of which until recently had been on record as the North Carolina State Champion. Several trees in the stand exceeded 20.9-inches (53-cm) d.b.h.

Several other areas in North Carolina, classified as pocosins, are reported to have some bay forest intact. These include Angola Bay, Holly Shelter, and Green Swamp, all located in the southeastern corner of North Carolina. Angola Bay and Holly Shelter were classified by Wells (1946) as estuary bays, the elevated flat bottoms of ancient estuaries when sea levels were higher than those at present. Angola Bay has about 20,015.1 acres (8100 ha) of pocosin, Holly Shelter about 29,899.1 acres (12,100 ha), and Green Swamp about 13,837.6 acres (5600 ha) (Taggart 1981). The acreage of mature bay forest is unknown and is intermixed with more typical pocosin vegetation. Angola Bay and

Holly Shelter are owned by the State of North Carolina and a portion of Green Swamp is owned by The Nature Conservancy. Kologiski (1977) described community structure in the Green Swamp and noted that in 1977, bay forest existed in areas that did not burn in 1955 and 1969, years of large fires in the swamp. The most recent fire previous to those fires was in 1932, suggesting that the bay forest areas were at least 45 years old in 1977. Little recent information was available for these sites.

South Carolina

River's Bridge State Park, located off Highway 641 in Bamberg County, has been reported to have a stand of old evergreen bay forest.[4] It fits the description of bay forests associated with stream margins.

Pigeon Pond (also known as Pigeon Bay) has also been reported to have a stand of loblolly-bay trees.[5] Pigeon Pond, a 808-acre (327-ha) Carolina bay located off State Road 135 between Highways 311 and 176 in Berkeley County, is owned by the Westvaco Corporation. It has been placed in the company's "unique stand category" and current plans are to preserve the bay as a natural area (see footnote 3). Bay trees in this Carolina bay are reported to be 11.9 to 14.2 inches (30 to 36 cm) in diameter.

Snuggedy Swamp, accessible only by boat, has also been reported to have an old-growth evergreen bay forest. Snuggedy Swamp is located on the Ashepoo River of the ACE Basin in Colleton County. Additional information concerning Snuggedy Swamp may be obtained from Mike Prevost with The Nature Conservancy or Dr. Bert Pittman of the South Carolina Heritage Trust Program.

Barry (1980) also mentions the existence of "a well-developed bay forest" as well as an Atlantic white-cedar bog in Lexington County, South Carolina. Attempts to verify their continued existence and to gain additional information as to their locations were not successful.

Georgia

Seventeen Mile Creek in Coffee County has an excellent example of a mature bay swamp, according to Wharton (1978). There are about 98.8 acres (40 ha) of bay swamp located along a 1.5-mile [2.4-kilometer (km)] stretch on the

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[4] Personal communication. 1994. Richard Porcher, Professor, The Citadel, 171 Moultrie Street, Charleston, SC 29409.

[5] Personal communication. 1994. Steve Bennet, The South Carolina Heritage Trust Program, Columbia, SC 29631.

eastern side of the stream. This bay swamp occurs at the base of sandhills that are present only on the eastern side of the stream. Other cover types (according to Wharton 1978) associated with the bay swamp include evergreen shrub bog, creek swamp, and upland, broadleaf, evergreen forest. Wharton states there is little evidence to suggest that the mature evergreen shrub bog is in succession toward bay forest; the shrub bog appears to be a stable community. Together, these plant communities occupy 200.2 acres (81 ha) of lowland along this creek bottom. The bay swamp is made up of mature loblolly-bay with lesser amounts of sweetbay and redbay. Dominant trees were up to 15 inches (38 cm) in d.b.h. In a personal communication during the summer of 1994, Wharton indicated that most of the stand was still intact, to the best of his knowledge.

Wharton also recommends two other locations in Georgia as examples of bay swamps—Ohoopee Sandhills in Emanuel County and Whitewater Creek, where it crosses Highway 137 in Taylor County. The Whitewater Creek community also contains Atlantic white-cedar in addition to the typical bay species and shrubs.

The Okefenokee Swamp ecosystem also has areas mapped as bay forests by McCaffrey and Hamilton (1984) with 80 percent of the canopy cover made up of "broad-leaved evergreen trees of medium height." Wharton (1978) classified the Okefenokee as a bog swamp but acknowledged the presence of many related communities made up of bay species along with others typical of bay swamps, e.g., cypress, blackgum, and red maple. Crew members of the USDA Forest Service, Forest Inventory and Analysis unit, reported pure stands of sweetbay in bays of the Okefenokee with an average d.b.h. of 16.1 inches (41 cm) and some individuals as large as 24 inches (61 cm) d.b.h. in 1980 to 1981.[6] The largest individuals appeared to be in decline and may have been representative of "old-growth" at that time.

Florida

The Bradwell Bay Wilderness Area, located in the Wakulla Ranger District of the Apalachicola National Forest, has been reported to have a stand typical of the bay forest type.[7]

The National Champion Loblolly-Bay tree is also located in Florida on the Ocala National Forest; however, it does not occur in a typical bay forest. According to Laura Lowery with the USDA Forest Service (see footnote 1), it is located in a rather unusual topographic setting—a 56.8-acre (23-ha) limestone sink with an underlying clay pan that occurs in a 882.2-acre (357-ha) longleaf pine "island" surrounded by sand pine scrub.

The Ocala National Forest does, however, have a representative bay swamp in the area known as Rocky Point. This site has been described as being an extensive, dry, pineland grading into a floodplain forest toward Lake George[8] and possesses many of the species considered typical of the evergreen bay forest type. The age of this stand was not given.

Alabama

Patches of bay forest are reported in the Conecuh National Forest, located in southern Alabama on the Florida border in Escambia and Covington Counties. These areas extend across the border into the northern Florida panhandle. The patches of bay forest occur as inclusions in other cover types. These areas include (1) Bear Bay, located in Covington County in Bradley Quad T2NR24W Sector 27, 26, 34; (2) Wolf Thicket Bay, also located in Covington County in Wing Quad T1NR14E Sector 11, 12, 1; and (3) Blackwater Bay and Falco Bay located in Wing Quad T1NR15E Sector 6, 5, 7, 8 and T1NR14E Sector 13, 18, respectively. Loblolly-bay has been found in only two locations, although redbay and sweetbay are present throughout. (This information was obtained through Jarel Hilton and Chris Oberholster of the Alabama Natural Heritage Program and through Suzanne Oberholster of the USDA Forest Service.)

Grand Bay Savannah Bioreserve is located on the border between Alabama and Mississippi on the coast below Interstate 10 in Mobile and Jackson Counties. This natural preserve has been reported to have patches of evergreen bay

[6] Personal communication. 1994. Mike Lick, USDA Forest Service, De Soto National Forest, Black Creek Ranger District, Wiggins, MS 39577.

[7] Personal communication. 1994. Donna Streng, Tall Timbers Research Station, Route 1, Box 678, Tallahassee, FL 32312.

[8] Personal communication. 1994. Gerald Guala II, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611.

forest in a mosaic with other wetland cover types, such as titi-dominated shrub bogs and pond cypress strands.[9] [10] [11]

Mississippi

Grand Bay Savannah Bioreserve (described above for Alabama) also extends into Mississippi and may have scattered patches of evergreen shrub bog and bay forest.

Loblolly-bay is considered rare in Mississippi and bay forests in this State are composed primarily of the bay species sweetbay with some redbay. However, five or six sites have been reported to contain loblolly-bay, one of which is located on the DeSoto National Forest. This area is located on the Black Creek Ranger District in Compartment 47 along Turkey Branch. The 148.3-acre (60-ha) site includes a loblolly-bay forest and associated uplands and has been nominated as a Research Natural Area. The classification of this area as such should assure its preservation for future study.[12]

Most of the other drainheads supporting bay forests are mainly made up of sweetbay and were cutover in the 1930's and 1940's. These areas, which support almost pure stands of sweetbay, are small, some being only 5 to 7.4 acres (2 to 3 ha). The existence of mature bay trees on these sites is questionable[13] (see also footnote 6). In the future, some of these areas will be managed by the national forest as "lands unsuitable for timber" and may develop into mature bay forests.

Louisiana

Baygalls with sweetbay and redbay exist in the form of stream heads and drains, but currently loblolly-bay has not been located in the State of Louisiana.[14] The Kisatchie National Forest is the site of many such baygalls, supporting stands of large sweetbay; however, these stands may not be very old nor do they contain some of the largest sweetbay trees. Charter Oak Baygall, located in southeast Louisiana in St. Tammany Parish and owned by The Nature Conservancy, is one of the best representatives of the bay forest type in this State. Overstory dominants include swamp blackgum, sweetbay, and red maple. Redbay exists in the shrub understory along with *Cyrilla* and *Cliftonia*, which is rare for Louisiana. Swamp blackgum individuals as large as 35.4-inches (90-cm) d.b.h. and sweetbay individuals 29.9- to 35.4-inches (76- to 90-cm) d.b.h. have been reported.[15]

Summary

The evergreen bay forest cover type can occur on a variety of habitat types (abiotic features of the landscape based on land form and soil type) throughout the Atlantic and Gulf Coastal Plains. A common characteristic among the diverse landforms is the development of histic soils. Although duration, frequency, and seasonality vary, periods of soil saturation or soil inundation are common to sites supporting bay forests. Hydrologic and nutrient input for such sites can range from ombrotrophic to spring-fed, depending on the local topography and hydrology. These differences in hydrology, along with differences in soil type, lead to differences in fertility. The depth of the peat or histic horizon and the presence or absence of underlying mineral soil also influence site fertility, and these taken together strongly influence the successional relationships among sedge bogs, shrub bogs, and bay forests. Fire also plays a major role in the development of these systems, but its importance depends on the local topography and hydrology. All these site characteristics can vary significantly among pocosins, Carolina bays, and intermittent drainage heads. Although each of these landforms may support bay forest plant communities, the direction of succession and the position of each community type along the successional sere may vary from location to location. Hence, a single description of features indicative of old growth in these bay forest systems is not necessarily appropriate nor

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[9] Personal communication. 1994. Jarel Hilton, Alabama Natural Heritage Program, Department of Conservation and Natural Resources, Division of Lands, Folsom Administrative Building, 64 N. Union Street, Room 752, Montgomery, AL 36130.

[10] Personal communication. 1994. Ron Wieland, Mississippi Natural Heritage Program, Museum of Natural Science, 111 N. Jefferson Street, Jackson, MS 39201-2897.

[11] Personal communication. 1994. Will McDearman, Department of Fish and Wildlife, 6578 Dogwood View Parkway, Suite. A, Jackson, MS 39213.

[12] Personal communication. 1994. Steve Lee, USDA Forest Service, DeSoto National Forest, Black Creek Ranger District, Wiggins, MS 39577.

[13] Personal communication. 1994. Tom Cruise, USDA Forest Service, DeSoto National Forest, Black Creek Ranger District, Wiggins, MS 39577.

[14] Personal communication. 1994. Julia Larke, Louisiana State Heritage Program, Department of Wildlife and Fish, P.O. Box 98000, Baton Rouge, LA 70898-9000.

[15] Personal communication. 1994. Latimore Smith, Louisiana State Heritage Program, Department of Wildlife and Fish, P.O. Box 98000, Baton Rouge, LA 70898-9000.

ecologically sound. Until these successional relationships are better understood, it may be more appropriate to consider preservation of representative systems with examples of the full mosaic of the successional sere on a variety of landforms.

The evergreen bay forest community is a rare and unique system regardless of the age of individuals. As previously discussed, the bay forest system as a whole, made up of the various successional stages associated with this cover type, is considered to be stable. Due to the susceptibility of some of these systems to fire, aboveground components may not be particularly old. However, belowground components, including root stocks and seed banks involved in regeneration, may be very old. Hence, old growth should be evaluated in terms of both aboveground and belowground components and community stability over time within the natural cycles of disturbance. Obviously, more information than is currently available in the literature is necessary to make ecologically sound descriptions of these systems. Recognizing that they are indeed rare, State and Federal agencies, along with conservation groups, are making an effort to set aside these bay forest systems. With further study, more ecologically appropriate descriptions will be possible.

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This document describes old-growth conditions in an evergreen bay forest stand. Bay forests occur throughout the Atlantic and Gulf Coastal Plains. However, they are considered rare and are present across the landscape in a patchwork mosaic with other forest types in various stages of succession. Bay forests can be found associated with pocosins, Carolina bays and sandhill seeps, stream heads, and stream margins. The dominant species include loblolly-bay, sweetbay, and redbay, hence the name evergreen bay forest. However, several other swamp species associates are common, as well as many highly flammable shrub species. This forest type is subject to infrequent, high intensity, widespread disturbances such as fire. Fire is necessary to the nutrient cycling of this forest type and in conjunction with hydrology, controls succession. These stands are frequently inundated by surface water, resulting in the development of histic soils low in fertility. Alteration of the hydrology by man and catastrophic wildfire are considered to be the greatest threats to the existence of bay forests.

Keywords: Carolina bay, disturbance, fire, hydric, loblolly-bay, peat, pocosin, redbay, shrub bog,

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