Distribution and Characterization of Forested Wetlands in the Carolinas and Virginia

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ABSTRACT. *Recent forest inventories of North Carolina, South Carolina, and Virginia, included sampling for hydric vegetation, hydric soils, and wetland hydrology. Forest samples that met all 3 of these criteria were classified us forested wetland. This study characterizes wetland forests by extent, owner, age, forest type, physiography, volume, growth. and removals, and evaluates its contribution to the timber supply. Wetland stands comprise 8.1 million ac, or 17% of the forests in the 3 States. They are over 90% privately owned, they vary widely by type andphysiogr-aphy, and they contribute 21 % of all removals. Classification of wetland area bused simply on broad management class andphysiography will result in inaccurate estimates. South. J. Appl. For. 21(2):64–70.*

The Southern States (Louisiana to Virginia) have more than a third of the wetlands in the lower 48 states (USDA 1994). There is tremendous interest and work toward delineating and mapping these areas (Hefner and Storrs 1991). At a regional scale, most efforts have gone into interpreting aerial photography and satellite imagery for identification (Tiner 1990). The fact that a wetland must possess the 3 criteria of a hydric soil, hydric vegetation, and a wetland hydrology (U.S. Army Corps of Engineers 1987) hinders the accuracy of offsite interpretations because soils must be identified onsite. An intensive sample from the USDA Soil Conservation Service Natural Resources Inventory (NRI) identified broad, as well as specific forest type acreages for subregions of the South. Using this source, Cubbage and Flather (1993) described forested wetland areas by forest type and distribution. However, detailed mensuration data about forested wetlands have not been available to date. Saucier and Cost (1988) quantified forested wetland acreage based on forest type and physiographic region using forest survey data collected in the Southeast. This method did not incorporate federal criteria for hydric vegetation, hydrology, and soils. Subsequently, Tansey and Cost (1990) combined forest survey data with 2 of the 3 criteria to assess forested wetland occurrence.

Since 1990, the Forest Inventory and Analysis (FIA) project (USDA Forest Service, Southern Research Station) has collected data for all 3 wetland defining criteria. These data, in combination with the standard forest measurements collected, now make it possible to describe and quantify many attributes of forested wetlands. Knowing ownership patterns, what forest types are present, the extent of these forests, the age and condition of the stands, how much volume is present, the amount harvested, how many acres are planted, and so on, permits better evaluation of the economic role of wetland forests and the importance of silvicultural exemptions.

NOTE: Manuscript received March 14, 1995, accepted April 15,1996.

Methods

This study did not attempt to delineate forested wetlands in these 3 states; rather, the objective was to describe attributes and extent of forests that contain all 3 criteria common to wetland definitions. Forests that showed evidence of hydric vegetation, hydric soil, and wetland hydrology are referred to as *wetland forests*. The study is based on a statistically valid sample of all forestlands from sample points distributed across the landscape. The forests in this study had two characteristics: first, their current or previous stocking of live trees was 16.7%; second, they were neither being developed for a nonforest use nor being reserved from commercial timber production. Thus most parks, preserves, refuges, and wilderness areas are excluded from the data.

The data came from 23,486 ground plots visited during multiresource inventories of North Carolina (1990), Virginia (1992), and South Carolina (1993). The data were collected in accordance with standard guidelines (USDA 1985) and methods (Johnson 199 1, Johnson 1992, and Conner 1993). Of the 23,486 plots, 14,283 (61%) were classified as forestland, and detailed field measurements were taken. Tree

volume estimates and multiresource forest classifications came from data recorded on these 14,283 ground sample locations that were forested. A combination of variable radius plots and fixed radius plots were systematically spaced within a single forest condition to sample trees with a diameter at breast height (dbh) of 1 in. or larger. Multiresource data included a ground and understory vegetation profile. Collection of wetland defining criteria followed field procedures for identifying wetlands (USDA 1989) and reflected the 3 diagnostic environmental characteristics that the US Army Corps of Engineers (1987) uses to define wetlands (hydric vegetation, hydric soils, and wetland hydrology).

The plant indicator status categories used to evaluate vegetation were obligate, facultative wetland, facultative, facultative upland, and upland (Reed 1988). Obligate status denotes a greater than 99% chance of occurring in wetlands. Facultative wetland status denotes a 67 to 99% chance, and facultative status a 34 to 66% chance of occurring in wetlands. Facultative upland status usually occurs in nonwetlands but has a 1 to 33% chance of occurring in wetlands. Upland status denotes a greater than 99% chance of occurring in nonwetlands. Most trees, shrubs, vines, and grasses were assigned to one of the indicator status categories. The evaluation of vegetation in the ground, understory, and overstory levels assigned equal weight to each level. To satisfy the hydric vegetation component, a majority of the sample plot vegetation had to be facultative wetland or obligate.

Soil evaluations combined USDA Soil Conservation Service (Natural Resource Conservation Service) soil survey maps, a push tube soil probe, and the Munsell color chart. To satisfy the hydric soil component, indicators of anaerobic conditions such as grey mottling and/or greys with appropriate chroma and value, muck layer, or oxidized root rhizospheres had to occur within a foot of the soil surface.

Determining the hydrology of the sample area involved finding evidence of inundation, sediment deposition, or drift lines, along with evaluation of topographic position and drainage. To satisfy the wetland hydrology component, the growing season of most years had to be characterized by at least a week of surface water or by at least 2 weeks of soil saturation from a water table within a foot of the surface. These circumstances tend to create anaerobic conditions, form hydric soils, and favor hydric vegetation. To a certain extent, the 3 criteria have a cause and effect relationship. For instance, anaerobic conditions of hydric soils corroborate the presence of a wetland hydrology. In the absence of direct observation during the growing season, determination of wetland hydrology was based on evidence, evaluation, and corroborating factors.

All 3 wetland defining criteria (hydric vegetation, wetland hydrology, and hydric soils) were present on each of 3,181 forested plots in the 3 States: 1,750 (55%) in North Carolina, 1,175 (37%) in South Carolina, and just 256 (8%) in Virginia. Not surprisingly, the majority of plots with all 3 wetland criteria were in the Coastal Plain province of each State.

Statistical analysis of these data indicate sampling errors of + or – 0.32% for the estimate of forest wetland area, 1.64% for total inventory volume on forest wetland, 3.55% for total growth on forest wetland, and 4.96% for total removals on forest wetland. These sampling errors are expressed in terms of 1 standard error, or 2 chances out of 3. As the totals are broken down by forest type, physiography, age class, or other subdivisions, the sampling error increases. If homogeneity of variances is assumed, sampling error may be approximated for a subset of the region's totals. For example, the flatwoods physiographic class area estimate of 3.36 million ac would have a sampling error of 0.50%, or 0.02 million ac. This means that 2 times out of 3, the true area for this subset would be within the range defined by 3.36 + or -0.02, or 3.34 to 3.38 million ac.

Results and Discussion

Wetland Forest Area and Distribution

About 17% (8.1 million ac) of the 46.6 million forested ac in the 3 states are classified as wetland. North Carolina has the largest share of the wetland forests with 4.6 million ac. (57%), South Carolina has 2.9 million ac (35%), and Virginia has 0.6 million ac (8%). Within each state, forests classified as wetland ranged from 25% in North Carolina and 23% in South Carolina, to just 4% in Virginia.

Figure 1 shows concentrations of wetland forests in the counties of all 3 states. North Carolina leads in the number of counties with 2/3 or more of their forests in wetlands. Counties with the most wetland forests are in the Coastal Plain, which supports 95% of the wetland forests in the 3 states and has 38% of its forests in wetlands. Less than 5% of the wetland forests occur in the Piedmont, which has 2% of its forests in wetlands. The Mountain province has a negligible amount of forestland in wetlands.

Stand Ages, Sizes, and Management Classes

The age structure of wetland stands (Figure 2) for all ownerships resembles other forests in the 3 states. The principal difference is that more wetland forests lack a manageable stand. On these stands, less than 60% of the trees can be featured together under a single management scheme. Wetland stands also have a proportionately greater buildup of acres in the 81 yr and older age class than all forestland (10% vs. 8%), and proportionately less buildup of acres in the 21 through 40 yr old age classes (13% vs. 16%).

Distributions of wetland forest acreage by stand size (sawtimber, poletimber, seedling/sapling) are similar to other forests. Almost half (48%) of the wetland forests are classified as sawtimber, slightly more than the 46% for all forestland. One difference is that sapling/seedling-sized stands are next in abundance on wetlands (27%), whereas poletimber is next in abundance on all forestland (27%).

Wetland forests occur across the range of FIA's broad management classes. As expected, but perhaps to a lesser extent than anticipated, wetland forests are most prevalent in the lowland hardwood class, which contains 55% (4.5 million ac) of all wetland forests (Figure 3). Pines account for the next largest portion, with 29% (2.4 million ac) of the total (4 1% in pine plantations and the rest in natural pine stands). Pine plantations, which account for 12% (almost 1.0 million ac) of all wetland forests, routinely occupy sites once covered

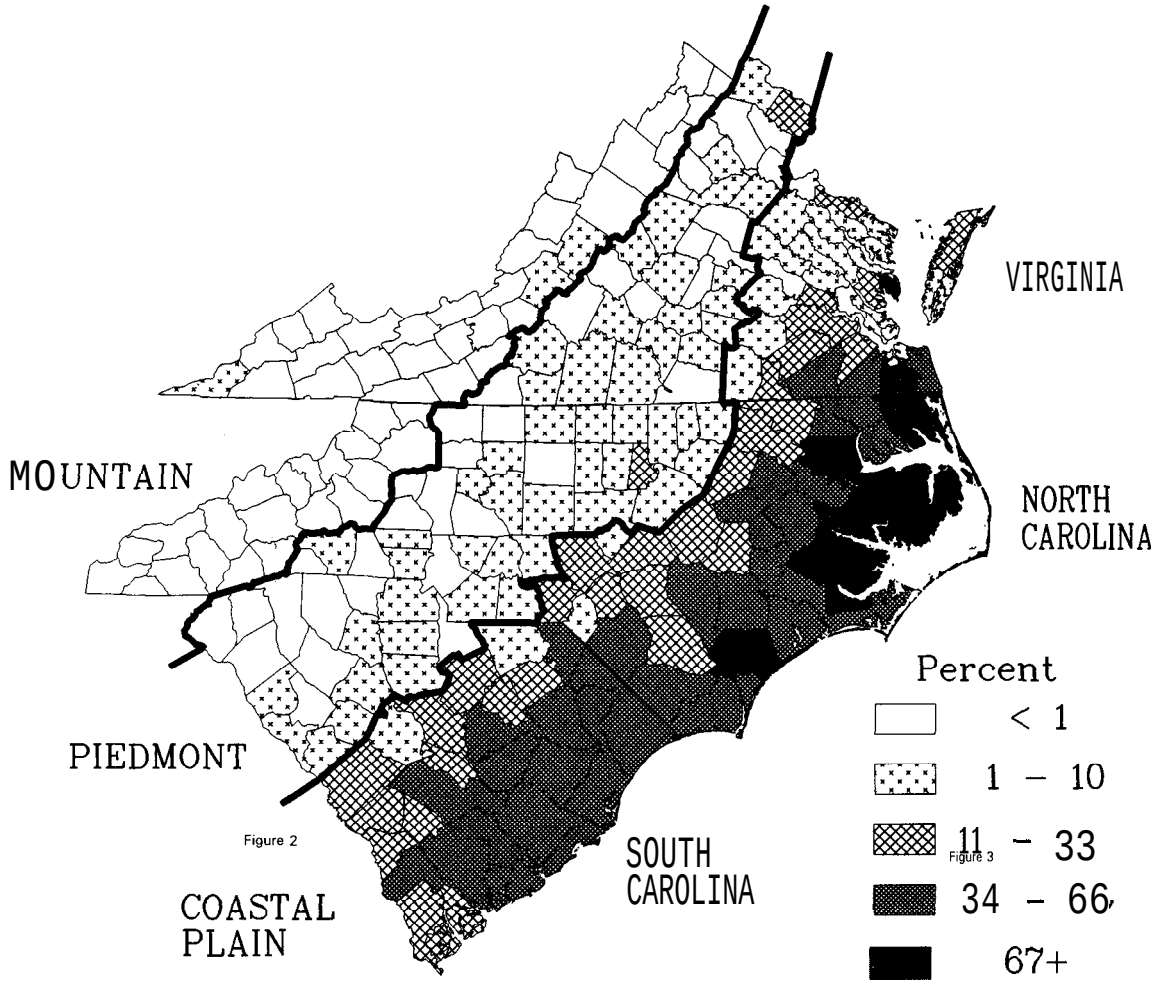

Figure 1. Percent of forestland designated as wetland by state, province, and county.

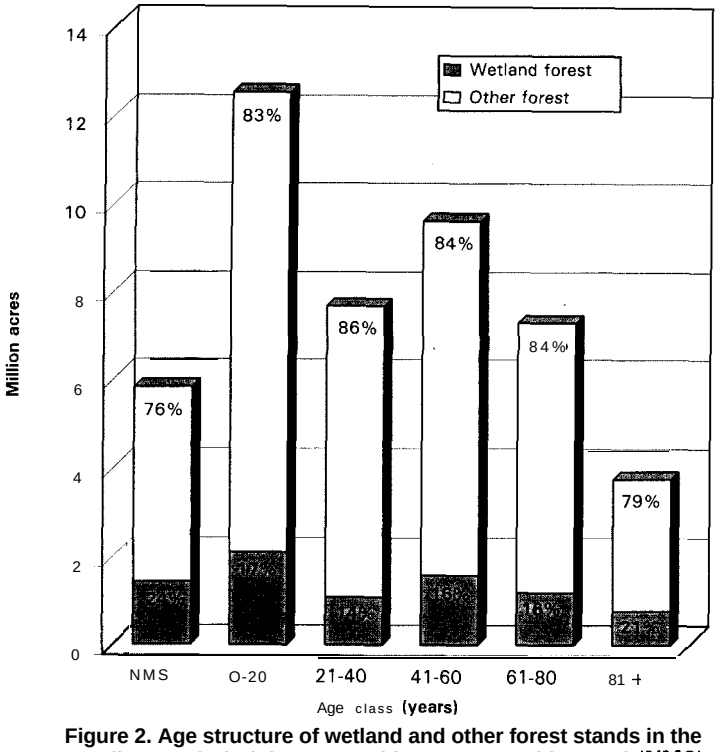

Figure 2. Age structure of wetland and other forest stands in the Carolinas and Virginia. Areas with no manageable stand (NMS) present are included.

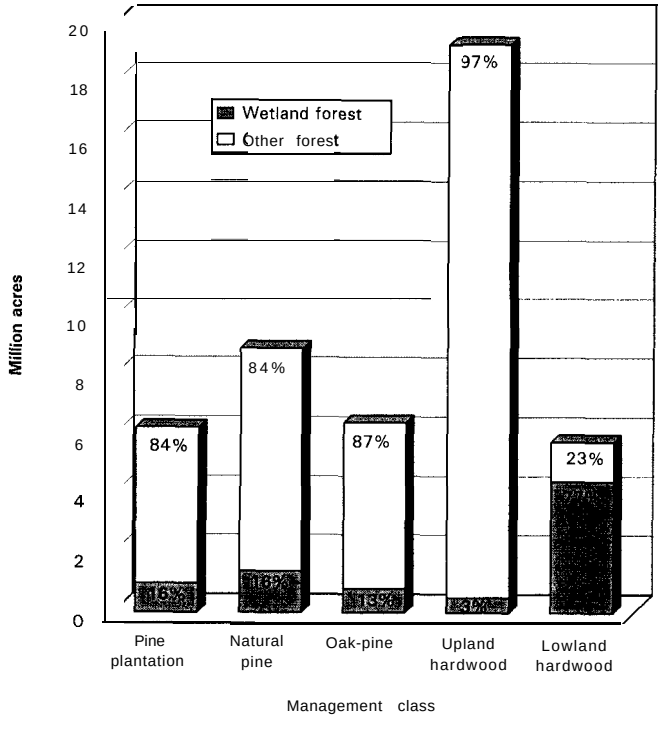

Figure 3. Management class distribution of wetland and other forests in the Carolinas and Virginia.

in natural pines. These pine plantations continue to exhibit the presence of hydric vegetation (usually a preponderance of hydric vegetation in the understory), hydric soils, and a wetland hydrology, thereby still qualifying as wetlands by definition. In some cases, site preparation has created microsites similar to naturally occurring hummocks, suitable for nonhydric species survival, within otherwise predominantly wetland areas. Oak-pine forest types account for 10% (0.8 million ac) of all wetland forests. Six percent (0.5 million ac) of wetland forests are in the upland hardwood class, mainly in transition zones between distinct forest types or around seepages below slopes. Upland hardwood types occur throughout the Coastal Plain where sometimes minor differences in elevation and drainage permit them to exist. These borderline conditions create numerous interfaces with contrasting growing conditions.

Wetland forests occur in varying degrees in all management classes, but none are exclusively wetland. Although more than three-fourths of the acreage in the lowland hardwood class is in wetlands (Figure 3), it would be incorrect to assume that all lowland hardwood stands are in wetlands. Equally incorrect would be to assume that pines are an insignificant component of wetland forests. Even when including the Mountain and Piedmont provinces with the Coastal Plain, 13% of the oak-pine class and 16% of pine plantations and natural pine stands are in wetlands. Less than 3% of the upland hardwood class are in wetlands.

Detailed Forest Types

The distribution of wetland forests by detailed forest type follows the pattern of distribution along management classes (Figure 4). The sweetbay/blackgum/red maple forest type accounts for 21% of wetland forest acreage, followed by the loblolly pine type with 20% of the acreage, and the sweetgum/water oak/willow oak type with 16%. The cypress/water tupelo type, traditionally perceived as a major wetland forest type, only accounts for 8%. However, it is the largest type that was found only in wetlands. Pond pine, a natural pine type, actually accounts for as much or more of the wetland timberland acreage than does the cypress-water tupelo type.

The wetland component of each individual forest type varies widely. Atlantic white cedar, cypress/water tupelo, and overcup oak/water hickory types have all their acreage in wetlands. The sweetbay/blackgum/red maple type and willow types are nearly as consistent with 93% of their acreage in wetlands, followed by the pond pine type with 90% (the highest for pine), the sugarberry/American elm/green ash with 71%, sweetgum/water oak/willow oak with 64%, swamp chestnut oak/cherrybark oak with 59%, and sycamore/pecan/American elm with 54%. Although not high in percentages but high in acreage are the loblolly pine/hardwood type with 19% (0.6 million ac) and loblolly pine type with 16% (1.6 million ac) of forestland in wetlands. These findings suggest that wetland status can be automatically assigned to only a limited number of forest cover types with a high percentage of their forests in wetlands.

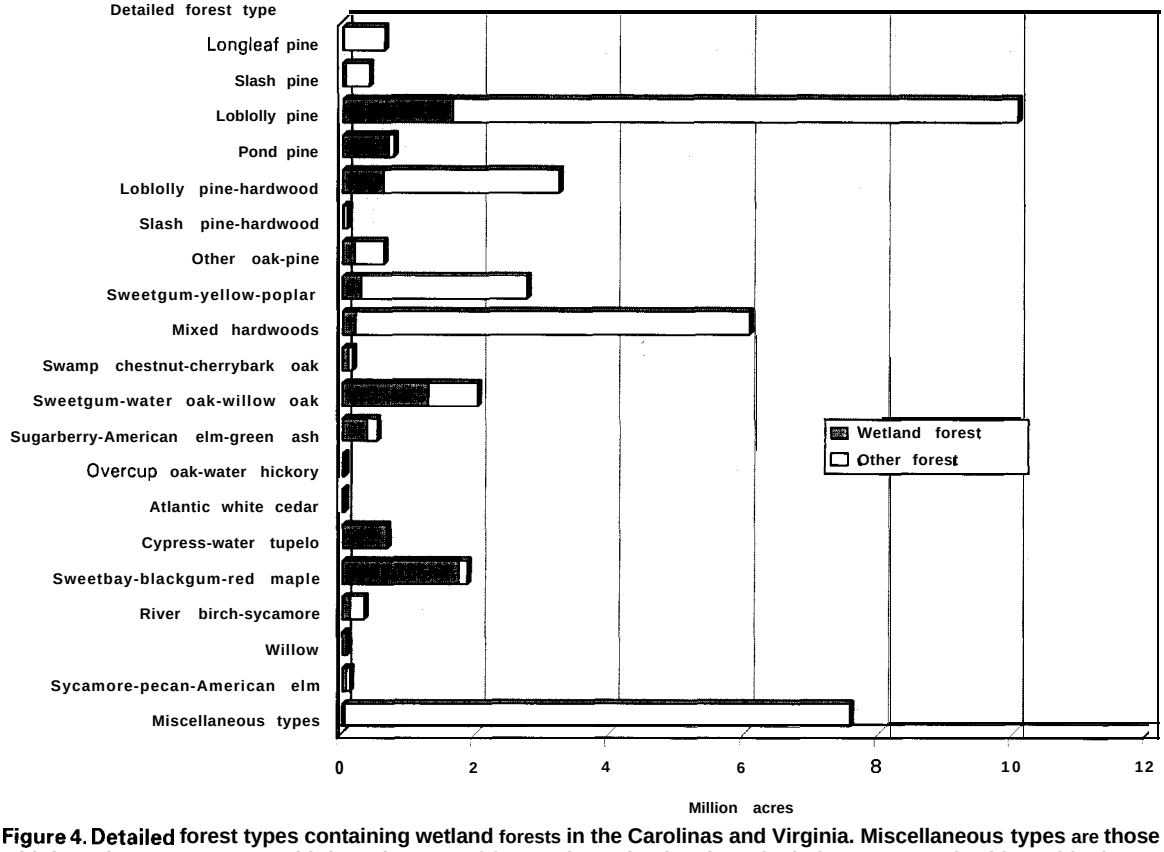

Figure 4. Detailed forest types containing wetland forests in the Carolinas and Virginia. Miscellaneous types are those with less than 25,000 ac or with less than 1% of forests in wetlands. These include cottonwood, white oak/red oak/hickory, yellow-poplar/white oak/red oak, and palms.

Physiography

For several inventory cycles, FIA has categorized sites as xeric, mesic, or hydric, and within these categories has assigned physiographic classes based on soil moisture and drainage, soil characteristics, aspect, and topography. Xeric sites are low or deficient in soil moisture availability, such as those with deep sands. Mesic sites are moderate to adequate in available soil moisture; they include flatwoods, moist mountain areas, and floodplains. Hydric sites have an abundance or overabundance of soil moisture; they include deep swamps, drains, and bays.

Wetland forests occur in a wide range of physiographic classes except for those with xeric conditions (Figure 5). Flatwoods dominate with 4 1% (nearly 3.4 million ac) of the total. The second largest portion (15%) is in bays and wet pocosins. Narrow and broad floodplains account for 11 and 10% of the wetland forests, respectively, and an assortment of small drains harbor 9%. To many people, deep swamps are the epitome of wetland forests. But surprisingly, only 7% (under 0.6 million ac) occurs in deep swamps. Actually, only 10% (over 0.8 million ac) of all wetland forests had surface water year round; 42% (3.4 million ac) had seasonal surface water; 3% (0.2 million ac) had mixed wet and dry areas such as braided streams and sloughs; and the remaining 45% (3.7 million ac) had no regular surface water conditions. The large area with no regular surface water conditions is possible under a definition of wetland hydrology that includes areas with soil saturation caused by a water table within a foot of the surface for 2 wk during the growing season of most years (US Army Corps of Engineers 1987).

Not surprisingly, all of the stands in deep swamps have wetland designation, the only physiographic class entirely in a wetland status. Following deep swamps are bays and wet pocosins with 98%, and "other hydric" with 97%. About 86% of forests in broad flood plains are wetlands. Although this is a high proportion, broad flood plains have been used in conjunction with other physiographic classes as wetland indicators, for which purpose wetland area would be overestimated. Narrow flood plains, in particular, appear to be unreliable indicators of wetland occurrence, with 53% of forests classed as wetland. Seventy-eight percent of forests in small drains have wetland designation, again a fairly high proportion, but perhaps less than expected. About a third of all forests in the flatwoods physiographic class have wetland designation- notable because of the acreage (nearly 3.4 million) involved. Many flatwoods are not discernible as wetlands to the passerby. However, they satisfy the 3 criteria common to wetlands definitions. Use of the flatwoods physiographic class as a wetland indicator is not feasible because only a third are wetlands, yet excepting it eliminates the numerous acres (4 1% of total wetlands) classed as wetlands. About 22% of the forests in areas classified as "other mesic" have wetland designation. Less than 1% of the forests in rolling uplands and moist mountain areas have wetland designation.

Inventory Volume, Growth, and Removals

Across the 3 states, 17% (4.7 billion ft^3) of the softwood volume and 20% (9.8 billion ft^3) of the hardwood volume occur on wetlands (Figure 6), representing 1/5 (14.5 billion ft^3) of the total volume. Ninety-five percent of the volume on wetland forests occurs in the Coastal Plain, where the importance of wetland forests to timber inventories escalates. In the Coastal Plain, 32% of the softwood volume and 56% of the hardwood volume is in stands growing on wetlands. Wetland forests account for 45% of the total volume in the Coastal Plain.

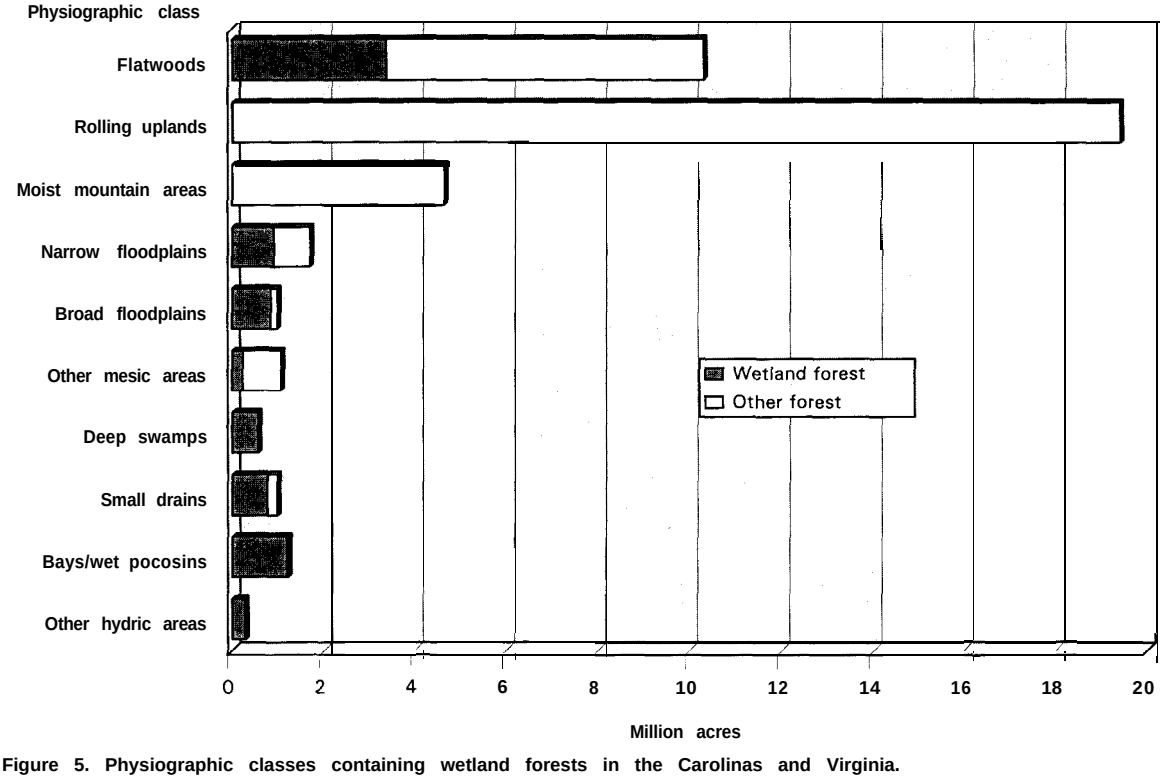

Figure 5. Physiographic classes containing wetland forests in the Carolinas and Virginia.

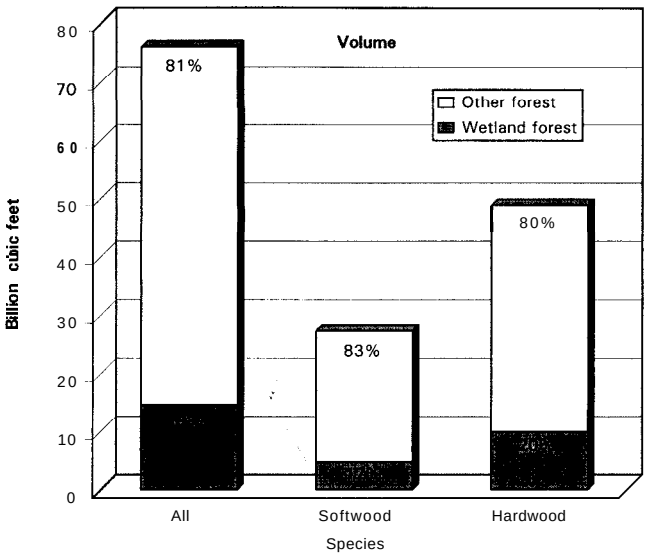

Figure 6. Inventory volume on wetland and other forests in the Carolinas and Virginia.

Wetland forests account for 15% of the softwood growth and 17% of the hardwood growth across the 3 states (Figure 7). With a little less than half from softwood and just over half from hardwood, average net annual growth of growing stock on wetland sites totals almost 400 million ft^3 and accounts for 16% of total growth. As with total volume, 95% of the wetland net annual growth occurs in the Coastal Plain, where wetlands contribute 25% of the softwood and 44% of the hardwood growth. Wetland forests account for 1/3 of the total growth in the Coastal Plain.

Wetland forests account for 17% of softwood removals and 25% of hardwood removals across the 3 states. With just under half from softwood and more than half from hardwood species, average annual removals from wetland sites total 472 million ft^3 and account for 21% of total removals. Like total volume and growth, 95% of the wetland removals come from the Coastal Plain, where wetlands contribute 28% of softwood and 47% of hardwood removals. Wetland forests account for 35% of all removals in the Coastal Plain.

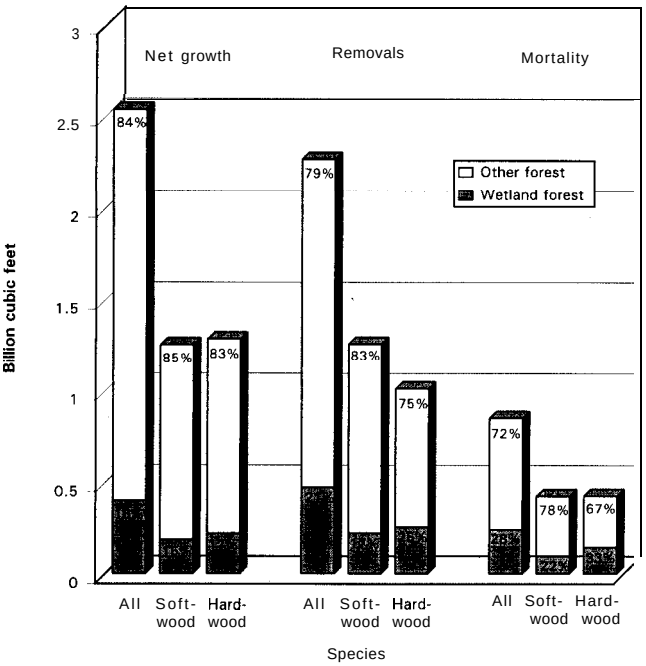

Figure 7. Net annual growth, average annual removals, and average annual mortality on wetland and other forests in the Carolinas and Virginia.

Overall, annual timber removals from wetland sites exceed growth (Figure 7). This imbalance is a result of damage that Hurricane Hugo inflicted on South Carolina in 1989 (Sheffield and Thompson 1992). Afterward, catastrophic levels of mortality drastically reduced net growth of wetland and other forests, while removals continued at normal or increasing levels. In contrast, growth exceeded removals on wetland and other forests in North Carolina and Virginia, a trend that may be more indicative of long-term balances throughout the 3 states.

Stand Conditions

FIA identified a variety of impacts to and conditions of the forests in the 3 states. The biggest impact to wetland forests was natural disturbance, averaging 288,000 ac annually, and includes the effects of weather, fire, animals, insects, and disease. Weather, primarily Hurricane Hugo, caused over 3/4 of the natural disturbance to wetland forests. Following natural disturbance in severity were the annual impacts of final harvesting (157,000 ac), natural regeneration (115,000 ac), site preparation (58,000 ac), and artificial regeneration (55,000 ac).

FIA found that 58% of wetland forests are in relatively good condition and in need of no further treatment. About 17% of the wetland forests were judged to be inadequately stocked and in need of regeneration. Possible causes for low stocking include natural disturbances like weather and flooding, as well as past high-grading logging. About 13% of the stands were determined to be mature or overmature and in need of harvest. The remainder were less significantly distributed across a variety of conditions.

Ownership

Nearly 2/3 (5.3 million ac) of the wetland forests in the 3 states are under nonindustrial private ownership (NIPF). Forest industry controls 1/4 (almost 2.1 million ac), and the remainder is under various public ownerships (under 0.8 million ac). Wetland forests account for 1/3 of forest industry's forestland, but just 15% of NIPF and public forestlands. However, these differences in relative amount of wetland are influenced by location of land holdings. For instance, most (7 1%) of the forest industry land base is concentrated in the Coastal Plain where wetlands are obviously more prevalent. In contrast, just 32% of the public land and 41% of NIPF land is located in the Coastal Plain.

Generally, the majority of wetland forests in each broad management class, individual forest type, and physiographic class are under NIPF ownership. However, some exceptions do exist. For instance, forest industry controls nearly 3/4 (0.7 million ac) of the wetlands in pine plantations. They own half of the loblolly pine type in wetlands, as well as nearly 1/3 of wetland forests in the flatwoods physiographic class. More than half of forest industry's wetland forests occur in the

flatwoods physiographic class. In addition, well over half of the wetland forests experiencing site preparation and artificial regeneration took place on forest industry lands. NIPF owners supply nearly 3/4 (340 million ft^3) of the removals from wetland forests, followed by forest industry which provides nearly 1/4 and public ownerships that contribute 4%. Of these, only forest industry had more softwood than hardwood removals on wetland forests due to their preponderance of pine type holdings.

Conclusion

In the Carolinas and Virginia, wetland forests account for a substantial percentage of the forested acreage, associated timber volumes, and timber harvested. Wetland forests are concentrated in the Coastal Plain, where their economic potential and contributions are especially significant. In the Coastal Plain, 38% of the forested area is on wetlands, 45% of all volume is on wetlands, and 35% of all removals come from wetland forests. Over 90% of wetland forests are privately owned. Forest industry is vested to a large extent in flatwoods where many pine stands qualify as wetlands. That the accepted wetland defining criteria capture many acres typically not perceived as wetlands (Figures 3, 4, and 5) is shown by the relatively small proportion actually in deep swamps and small drains. Because wetland forests are largely under private ownership, it appears that current silvicultural exemptions are vital to the timber supply and local economies.

The distribution of wetland forests by management class, detailed forest type, and physiographic class shows the error of using only these parameters as wetland indicators. For example, using the lowland hardwood class as an indicator of wetland area captures only 55% of the wetland resource. In fact, only 77% of lowland hardwoods occur on wetlands. The detailed forest type findings rank individual forest types by percent wetland. Certain individual types with high percentages (cypress/water tupelo, Atlantic white cedar, overcup oak/water hickory) can be reliable wetland indicators, but again they would not capture all wetland acres over a large area that contained varied forest types. Physiographic classes that are identified with high percentages of wetlands (deep swamps, bays/wet pocosins, other hydric areas) would be reliable indicators of wetland, but again they are not all inclusive for large areas of varied terrain. These findings make it clear that there is no accurate shortcut to the identification of all wetland defining criteria over large expanses. These classifications (management class, physiographic class, and forest type) combined with detailed tree level inventory data are vital to conducting broad-scale assessments of the extent, trends, and importance of forested wetlands at the regional and national level.

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