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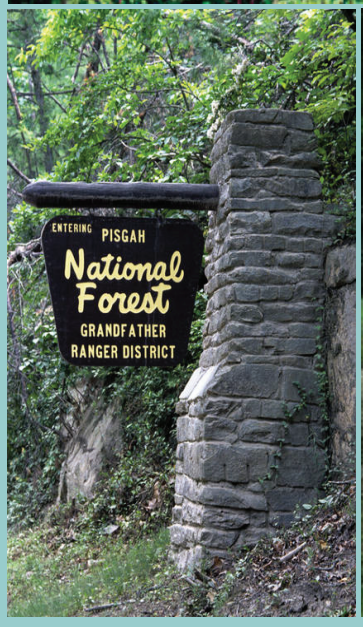
The Status of North Carolina's National Forests, 2002

Sonja N. Oswalt and Tony G. Johnson



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Foreword

This resource bulletin describes the principal findings of the seventh inventory of North Carolina's National Forest resources. Data on the extent, condition, and classification of forest land and associated timber volumes, growth, removals, and mortality are described and interpreted. Data on selected nontimber forest attributes are also presented and interpreted. Field work for the seventh inventory began in January 1998 and was completed in December 2002.

Surveys of our Nation's forest resources are mandated by the Forest and Rangeland Renewable Resources Research Act of 1978. These surveys are part of a continuing, nationwide undertaking by the regional experiment stations of the U.S. Department of Agriculture Forest Service. Inventories of the 13 Southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia) and the Commonwealth of Puerto Rico and U.S. Virgin Islands are conducted by the Southern Research Station, Forest Inventory and Analysis Research Work Unit (FIA) operating from its headquarters in Knoxville, TN, and from offices in Asheville, NC, and Starkville, MS. The primary objective of these appraisals is to develop and maintain the resource information needed to formulate sound forest policies and programs. More information about Forest Service resource inventories is available in "Forest Service Resource Inventories: An Overview" (U.S. Department of Agriculture Forest Service 1992).

Tabular data included in FIA reports are designed to provide an array of forest resource statistics, but additional data can be obtained for those who require more specialized information. The forest resource data for Southern States can be accessed directly via the internet at: http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm.

Additional information concerning any aspect of this survey may be obtained from:

Forest Inventory and Analysis
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Bill Burkman
Program Manager

Acknowledgments

The combined efforts of many people have made this evaluation of North Carolina's National Forests possible. The Southern Research Station sincerely appreciates the dedication of Research Work Unit and Station personnel who participated in field and office work for this survey. The FIA gratefully acknowledges the cooperation and assistance provided by the North Carolina Division of Forest Resources in collecting field data. Appreciation is also expressed for the cooperation of the National Forests for providing access to sample locations.

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Abstract

This bulletin describes forest resources of the Pisgah/Cherokee, Nantahala, Croatan, and Uwharrie National Forests in the State of North Carolina. It is based on sampling conducted by the U.S. Department of Agriculture Forest Service, Southern Research Station, Forest Inventory and Analysis Research Work Unit. This bulletin addresses forest area estimates; timber growth, removals, and mortality; and timber product output.

Keywords: Annual removals, Croatan National Forest, forest land area, forest productivity, Nantahala National Forest, Pisgah/Cherokee National Forests, Uwharrie National Forest.

Highlights

- National forests occupy 1.2 million acres of North Carolina's forest land, and include portions of 25 counties.
- In the Pisgah/Cherokee and Nantahala National Forests, red maple is the most numerous tree species; in the Uwharrie and Croatan National Forests, loblolly pine is the most numerous tree species.
- Most forest stands in North Carolina's national forests are at least 50 years old, and mean stand age is greater in the Pisgah/Cherokee and Nantahala National Forests than in the Uwharrie and Croatan National Forests.
- Live tree and growing-stock growth exceeds removals by 5 to 1, and sawtimber growth exceeds removals by 7 to 1.
- Live tree and growing-stock mortality exceeds removals by 3 to 1.
- Less than one-half of 1 percent of the total timber volume on national forest land in North Carolina is now harvested annually.

Issues to Watch

Increases in stand age and reductions in harvesting in North Carolina's national forests may result in an increase in dead woody material, thereby contributing to wildfire severity.

Scope and Intent

The Forest Service, U.S. Department of Agriculture, Southern Research Station, Forest Inventory and Analysis (FIA) Program collects data annually on the Nation's forest land. These data provide insight into the availability of domestic timber resources, and they help identify and describe forest health issues, wildlife habitat availability, and the overall structure and composition of America's forests. Data are combined at a statewide level on a cyclic schedule to produce summary reports about the condition of forest resources.

Several laws require the Agency to administer National Forest System (NFS) lands for multiple uses, including recreation, range, timber, watershed health, and wildlife and fisheries (National Forest Management Act of 1976, Public Law 94–588). Inventory data are used to guide management decisions, communicate our understanding of the public's forest resources, and describe the health of public lands across forested areas, States, and regions. On the basis of those concepts, we have prepared this summary of FIA data relating to NFS resources in the State of North Carolina. Statewide national forest data provide the highest level of statistical accuracy, and summaries of data for individual national forests will be less accurate than aggregate data summaries. At the end of this report we discuss data collection methods and statistical reliability.

Introduction

The Forest Service administers four national forests in North Carolina: the Pisgah/Cherokee National Forest, the Nantahala National Forest, the Uwharrie National Forest, and the Croatan National Forest (fig. 1). The Cherokee National Forest lies mostly in Tennessee, but a small part of it is in North Carolina. In this report

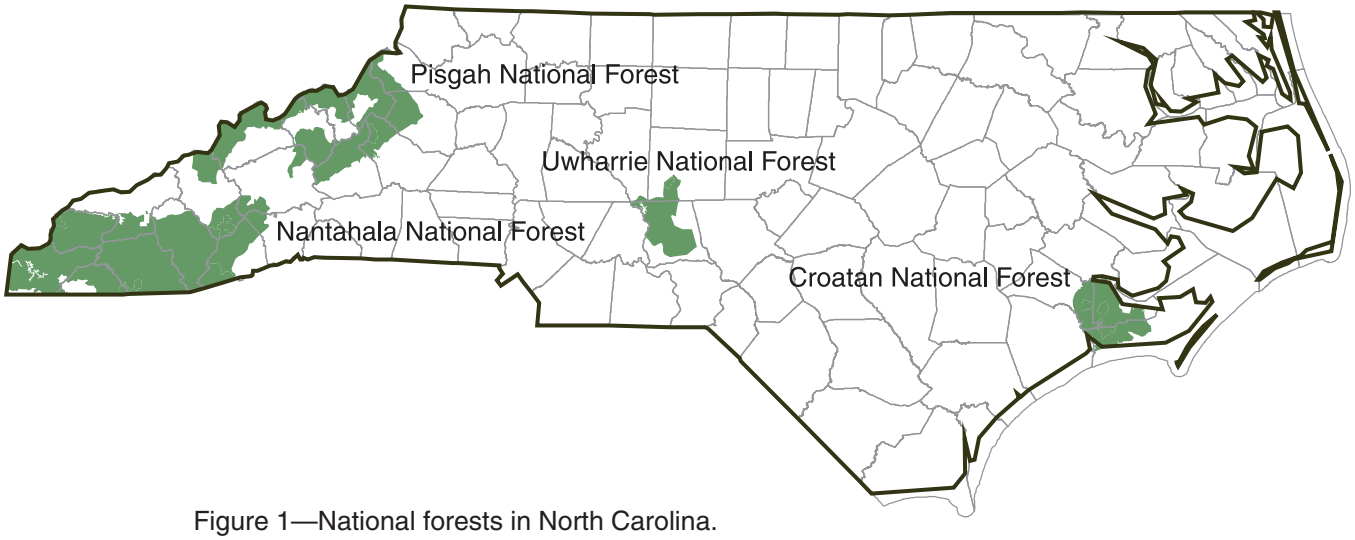


Figure 1—National forests in North Carolina.

and in the report maps we have grouped this small section of the Cherokee National Forest with the Pisgah National Forest.

Forest Attributes

National Forest Land Area

Background—Quantifying the amount of forest land that falls under Forest Service jurisdiction within a State is crucial for understanding the resource available for public use for wildlife, recreation, and timber supply.

What we found—FIA collects data on four national forests in the State of North Carolina: the Pisgah National Forest, the Nantahala National Forest, the Uwharrie National Forest, and the Croatan National Forest. These four national forests occupy portions of 25 counties and comprise about 7 percent of the total forested acreage in North Carolina. The NFS administers about 1.2 million acres of national forest in North Carolina. Most of North Carolina's national forest land occupies moist slopes, coves, and small drains (fig. 2).

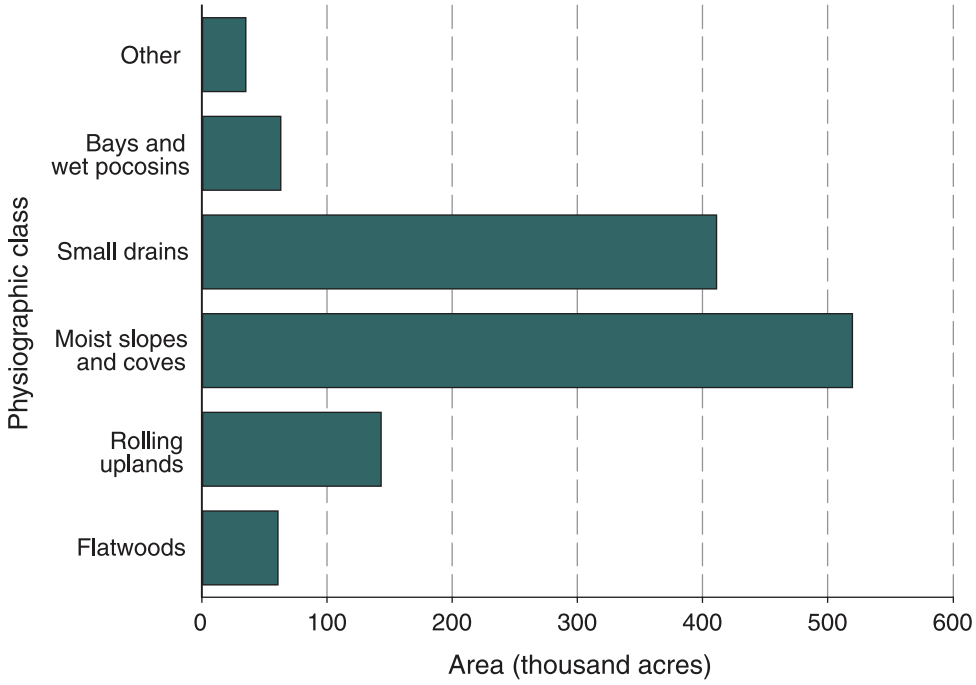


Figure 2—Area of forest land by physiographic class, North Carolina national forests, 2002.

Forest Composition and Tree Species Diversity

Background—Forest composition is a key to understanding ecosystem processes in a given area. Tree species composition and diversity are related to site productivity, moisture, aspect, topography, and local climate (Barnes and others 1998). The presence or absence of tree species determines, in part, what types of animals, insects, and herbaceous plants can colonize a forest.

What we found—We detected 86 tree species on all North Carolina national forests combined, or about 69 percent of the species detected on all forest land in North Carolina for the 2002 cycle. A total of 53 species were found on the Pisgah/Cherokee National Forests combined, 57 species were recorded on the Nantahala National Forest, 39 species were recorded on the Uwharrie National Forest, and 35 species were recorded on the Croatan National Forest. Species detected often in the statewide inventory

Trumpet pitcher plants are part of the fascinating flora growing on the Croatan National Forest. (Photo by Bill Lea, USDA Forest Service, 1983.)

but not detected on the national forests included water tupelo, willow oak, slash pine, and various riparian and ornamental species.

The forest cover on most of the combined national forest acreage belonged to the oak-hickory forest-type group (fig. 3). Red maple was the most frequently recorded individual species, and occurred in 85 percent of all forested plots sampled. Chestnut oak and yellow-poplar were common also, and occurred in 60 and 47 percent of all forested plots, respectively.

In the Pisgah/Cherokee and Nantahala National Forests, red maple was the most numerous tree species; in the Uwharrie and Croatan National Forests, loblolly pine was the most numerous tree species.

What this means—Tree species composition in North Carolina's national forests reflects the diverse soils and topography across the State. The oak-hickory forests of the Pisgah/Cherokee and Nantahala National Forests are typical of the rugged terrain of the Appalachian Mountains and the rolling foothills of the Piedmont, while the pine forests of the Croatan and Uwharrie National Forests are typical of the transition into the sandy, rolling hills and

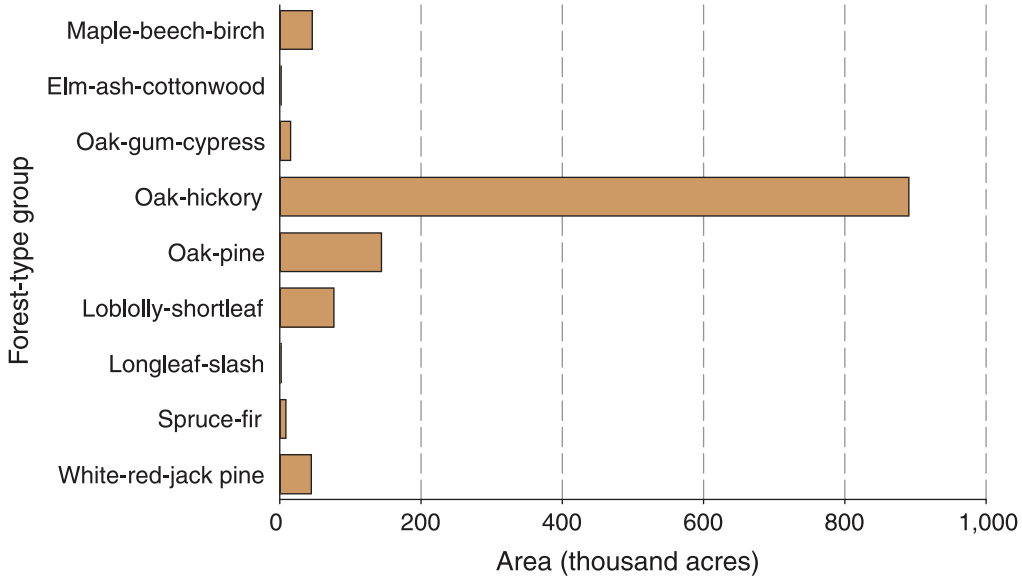


Figure 3—Area of forest land by forest-type group, North Carolina national forests, 2002.

flat soils of the Atlantic Coastal Plain. Species not detected on the national forests, but detected statewide, are typical of linear or patchy landscape features like ridges, river drains, bays, and pocosins. These features may be underrepresented in North Carolina's national forests, or they may be underrepresented in the sample because linear features are more difficult to detect using the FIA systematic sample design.

The preponderance of red maple in the national forests of western North Carolina may be of interest to forest managers in the future. Researchers have noted the expansion of red maple in eastern forests in this century (Abrams 1998, Abrams and others 1995). Some researchers have documented increases in red maple basal area in stands where oak species have been attacked by the defoliating gypsy moth (Fajvan and Wood 1996). The competitive abilities of red maple and well-documented decreases in oak regeneration (Lorimer 1989, Oswalt and others 2004, Spetich and others 2001) in the Eastern United States may combine to produce changes in forest composition over time, and further expansion of red maple (Abrams 1998).

Trail riding is one way to experience the Uwharrie National Forest. (Photo by Bill Lea, USDA Forest Service, 2004.)

Forest Structure and Stand Density

Background—National forest managers and others sometimes describe forests by the number and species of trees present within a designated boundary. They can use data about the diversity, size classes, and proportions of species present in a forest to determine which species are and are not regenerating, and this knowledge enables them to project future forest composition. They also can identify resources available for wildlife habitat, recreational activities, and timber harvesting. Information about forest structure and stand diversity, when combined with data about tree age, crown health, and damaged or deadwood, helps managers better describe and understand site productivity, forest health, and the status of wildlife resources.

What we found—There were 699.6 million live trees in North Carolina national forests in survey year 2002. This translates to an average of 567 trees per acre—slightly fewer than the State average of 741 trees per acre of forest land. The majority of the

Visitors to North Carolina's Uwharrie National Forest participate in a variety of recreational activities—even panning for gold. (Photo by Bill Lea, USDA Forest Service, 1993.)

trees on the national forests were members of the soft hardwood species group (fig. 4). There were more live trees (368.4 million) in the smallest diameter class [1.0 to 2.9 inches diameter at breast height (d.b.h.)] than in any other. Abundance of live trees decreased dramatically with increasing size class. For example, there were only 134.0 million trees in the next larger size class (3.0 to 4.9 inches). Ninety-two percent of live trees on North Carolina's national forests were <11.0 inches d.b.h., and 72 percent were <5.0 inches d.b.h. (fig. 5).

Patterns of forest structure and stand density in individual national forests were similar to these overall patterns. Seventy percent of live trees on the Pisgah/Cherokee National Forests, 72 percent on the Nantahala National Forest, and 72 percent on the Croatan National Forest were <5.0 inches in diameter, while 81 percent of live trees on the Uwharrie National Forest were <5.0 inches in diameter.

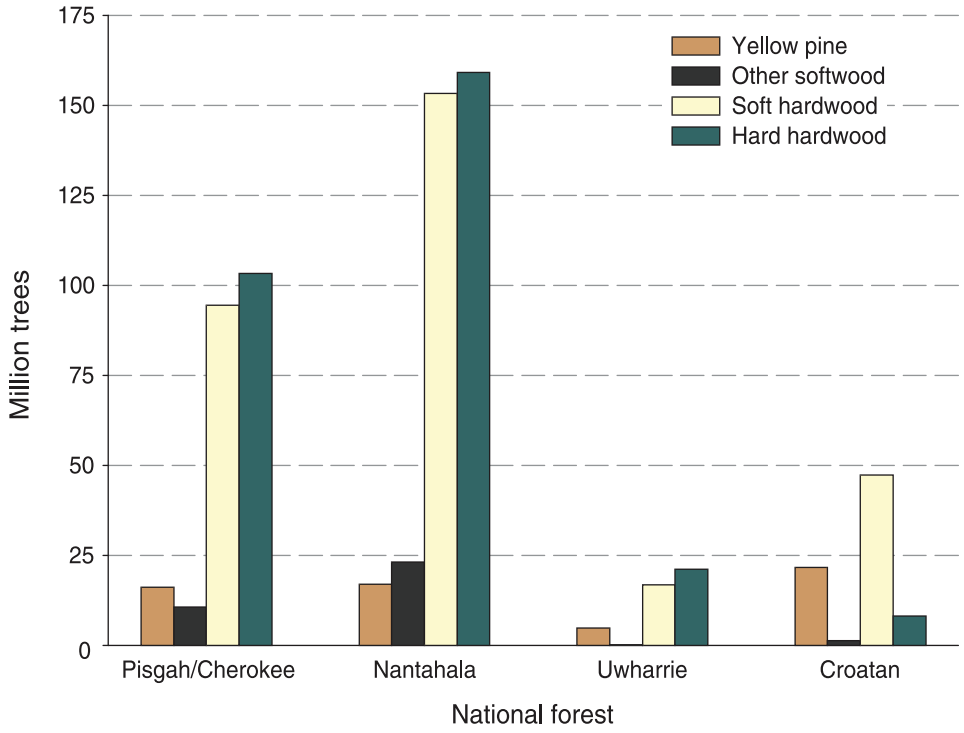


Figure 4—Number of live trees on forest land by national forest and species group, North Carolina national forests, 2002.

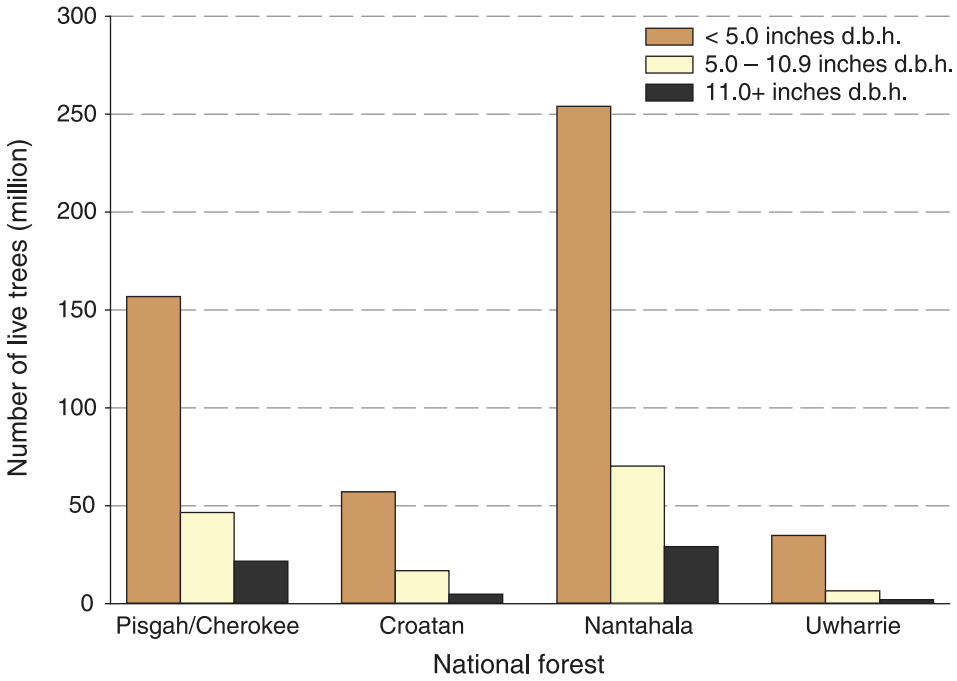
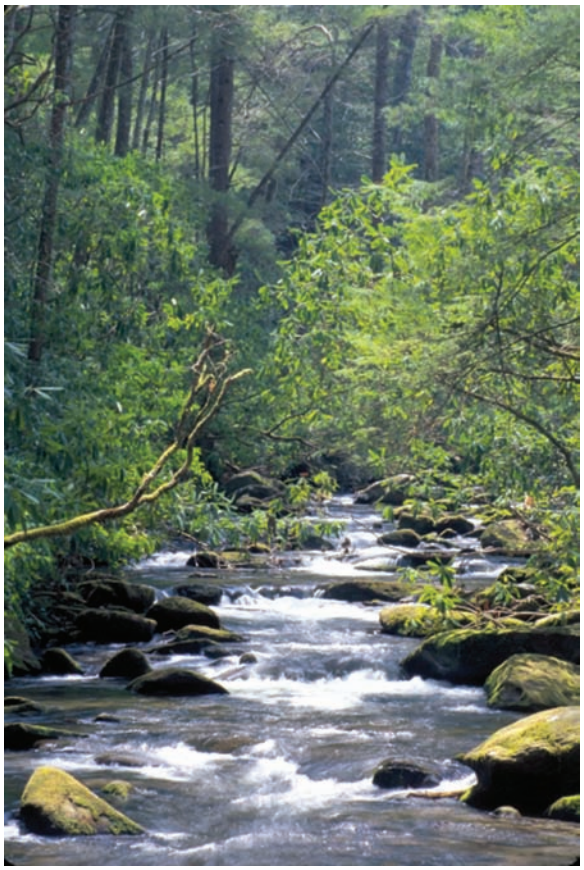


Figure 5—Number of live trees on forest land by national forest and diameter class, North Carolina national forests, 2002.

Numbers of most species on North Carolina's national forests decreased with increasing diameter class. Numbers of live loblolly-shortleaf pine trees peaked at the 5.0 to 6.9 inches diameter class, with lower numbers in both smaller and larger diameter classes. Numbers of cypress, spruce-balsam fir, and longleaf-slash pine also were not inversely related to diameter class, but these species are patchily distributed on the landscape, so the patterns observed may be a result of undersampling in those species groups on the national forests. Statewide data for these three species groups revealed more typical patterns.

What this means—Inverse relationships between abundance and size class are common and expected; nutrient, water, and light requirements increase as trees grow, and competition for these resources results in high mortality rates for seedlings and saplings.



Rhododendron thrive in the cool, humid air of Little Santeetlah Creek on the Nantahala National Forest. (Photo by Bill Lea, USDA Forest Service, 2002.)

Large numbers of small-diameter trees in individual species groups indicates successful regeneration across the landscape. In North Carolina's national forests, most species groups follow the expected pattern of regeneration. The deviation from the typical pattern in the loblolly-shortleaf species group could be a result of management techniques, or a result of pine to hardwood forest conversion.

Although three other groups deviated from the inverse pattern, those three species groups are not evenly distributed on the landscape and our sampling design may not be able to adequately measure regeneration patterns in small populations at scales smaller than statewide. Comparisons with statewide diameter distributions support this argument. Statewide, all three species groups present typical diameter distribution patterns, although the diameter distribution curve for the cypress species group is not as smooth as that for other species groups. Cypress regeneration, however, is partially dependent on local hydrologic regimes in the river and wetland systems where the trees grow. Therefore, regeneration may be less predictable for this species group than for others.

Forest Age and Stand Development

Background—Information about stand age, when combined with data on structure, density, regeneration, and health, helps managers understand a forest's stage of development.

What we found—Seventy-five percent of the forest land in North Carolina's national forests is occupied by stands 51 years old or older (fig. 6). More forest land is occupied by stands in the 61- to 70-year age class than by stands in any other 10-year age class. In the Croatan and Uwharrie National Forests, the percentage of acreage in stands 1 to 50 years old is a little larger than the percentage of acreage in older stands (fig. 7). In the Pisgah/Cherokee and Nantahala National Forests, however, the percentage of acreage in older stands is much greater than the percentage of acreage in stands that are 1 to 50 years old (fig. 7). About two-thirds of the forest land acreage on other public and private lands across North Carolina is occupied by stands < 51 years old (fig. 6).

About 26 percent of loblolly-shortleaf pine acreage was planted and only 4 percent of mixed oak-pine acreage was planted. Planted stands of all forest types constituted only 2 percent of North Carolina's national forest lands acreage.

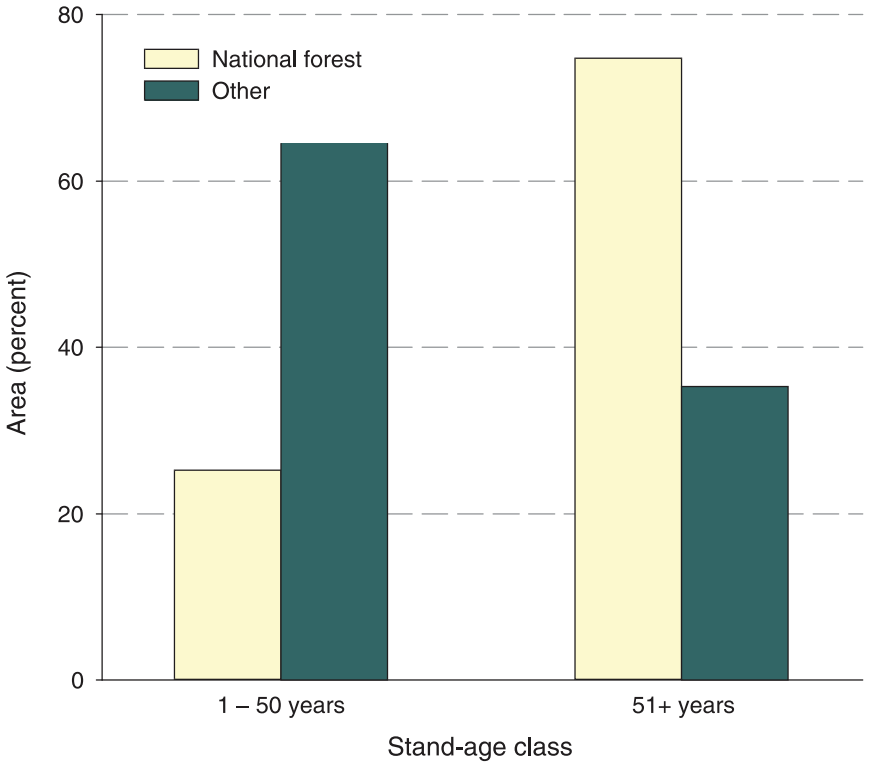


Figure 6—Area of forest land by ownership and stand-age class, expressed as a percentage, North Carolina national forests, 2002.

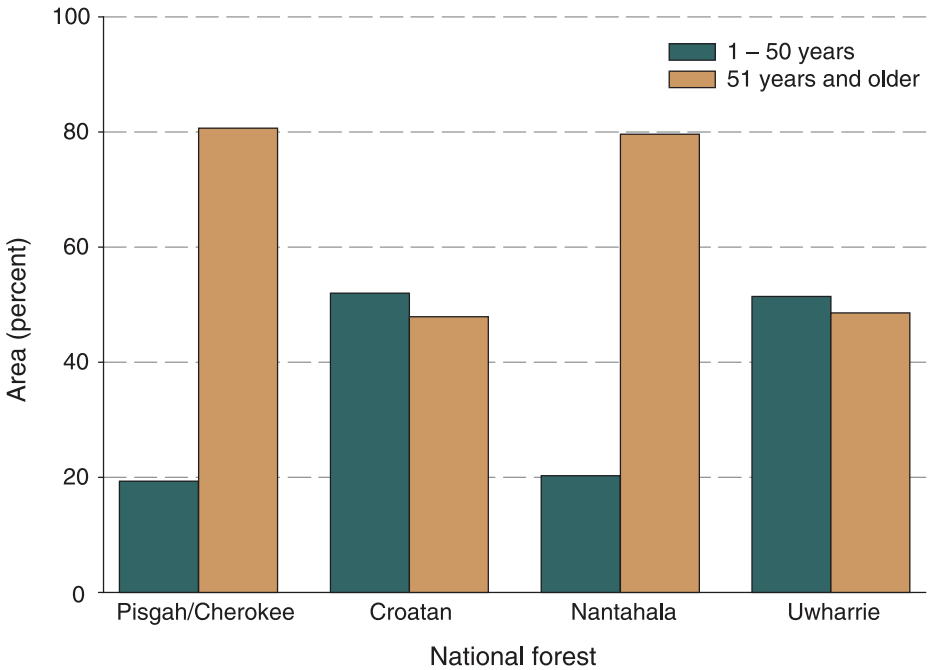


Figure 7—Area of North Carolina's national forests by stand-age class, expressed as a percentage, North Carolina national forests, 2002.

National forest visitors enjoy the solitude in a grove of mature trees in the Joyce Kilmer Memorial Forest on the Cheoah District of the Nantahala National Forest. (Photo by Barry Nehr, USDA Forest Service, 1986.)

What this means—Forest stands in the Pisgah/Cherokee and Nantahala National Forests are older than those in the Croatan and Uwharrie National Forests and those on private and other public forest land. Steep terrain may limit harvesting in mountainous areas, and this may allow stands in these areas to grow older than stands on the gentle terrain of the foothills and Coastal Plain. Also, the larger proportion of softwoods to hardwoods in the Coastal Plain may favor short-rotation harvesting of softwood pulpwood and poletimber over longer rotation harvesting of hardwood sawtimber. Moreover, the proximity of the two western North Carolina national forests to the Great Smoky Mountains National Park may influence management decisions favoring the pleasing aesthetics of a mature forest, while proximity to that park may have less influence on decisions about the management of private lands.

Forest Productivity

Forest Biomass

Background—Forest biomass is the living material present in a forest system, and is a useful measure of tree and forest productivity. The amount of biomass present in a forest is an indication of the amount of carbon that may be available for release into the atmosphere by burning or sequestration through forest management (Brown and others 1999). The importance of measuring biomass has increased with rising global atmospheric carbon levels, and as the public has become increasingly concerned with air quality. The ability of living material to sequester carbon by capturing it from the atmosphere, thereby offsetting carbon produced by emissions from combustibles, is receiving much attention in the scientific community (Johnsen and others 2001). Biomass estimates also provide information about the ability of individual species to collect nutrients and other resources, offering managers another measure of those species' influence within particular forest communities (Spetich and Parker 1998).

What we found—North Carolina's national forests contain a combined total of 88 million tons (gross dry weight) of aboveground biomass. This amounts to about 72 tons per acre of forest land, or 9 percent of the statewide total. Sixty percent of total aboveground biomass in North Carolina's national forests is in species in the hard hardwood major species group. In the Pisgah/Cherokee, Nantahala, and Uwharrie National Forests, the hard hardwoods have more biomass than any other major species group. In the Croatan National Forest, yellow pines have more biomass than any other major species group. The Pisgah/Cherokee National Forests have more aboveground biomass per acre than the other national forests, while the Croatan National Forest has least aboveground biomass (fig. 8).

What this means—Per-acre biomass levels in the Pisgah/Cherokee, Nantahala, and Uwharrie National Forests are higher than the State forest land average of 53 tons (fig. 8). Differences

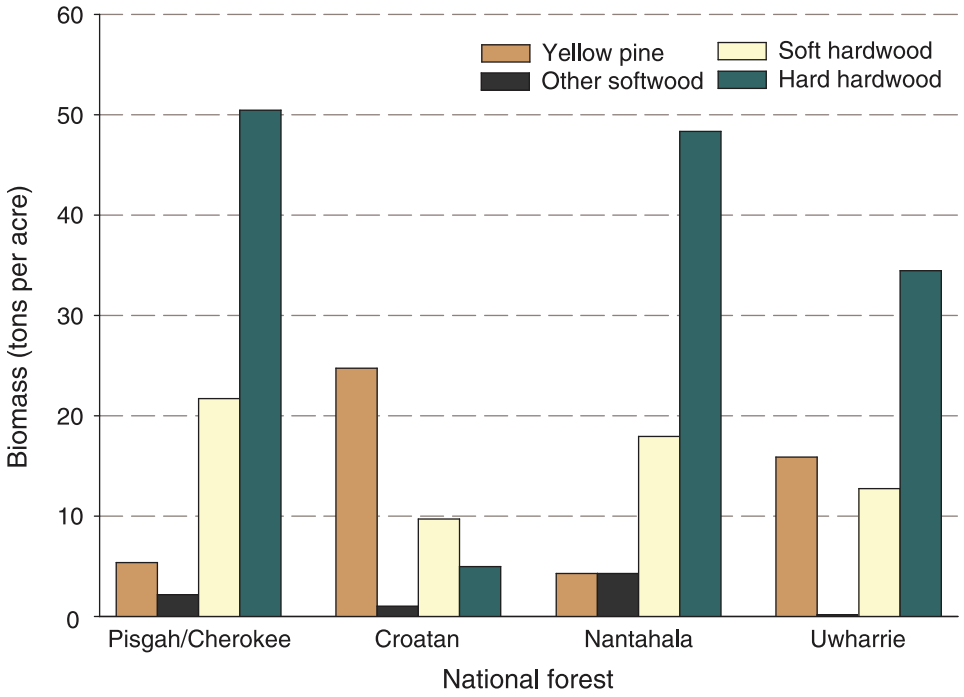
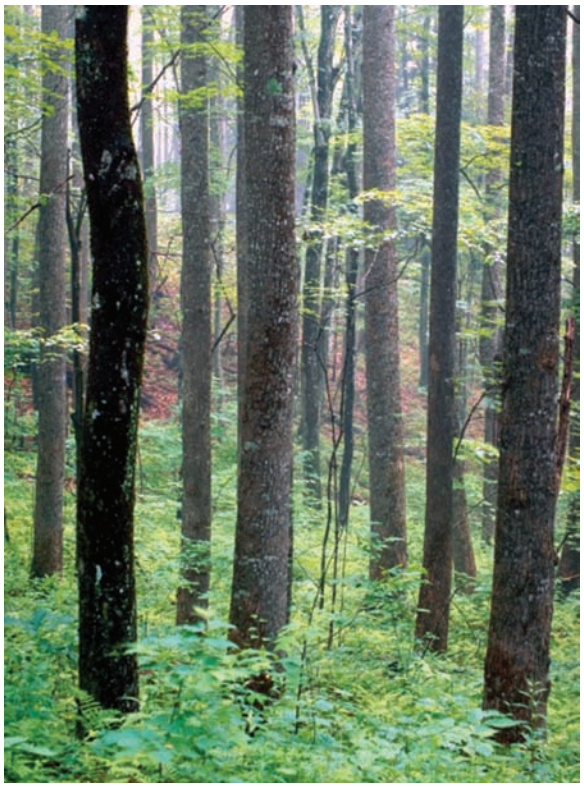


Figure 8—Aboveground biomass on forest land by national forest and major species group, North Carolina national forests, 2002.



Verdant hardwood forests are lush and diverse in the summer on the Nantahala National Forest. (Photo by Bill Lea, USDA Forest Service, 1999.)

between the national forest values and the State average may be caused by differences in site productivity (Brown and others 1999), but they may also reflect differences in stage of ecosystem development. Forests that have just become established generally have little living plant biomass, whereas older forests typically have higher biomass levels (Barnes and others 1998, Brown and others 1999). Thus, if harvesting frequencies are lower for North Carolina's national forests than for other forests in the State, the national forests may have more aboveground biomass even if their overall productivity is similar to that of other forests.

Basal Area and Tree Volume on National Forest Timberland

Background—In addition to biomass measurements, basal area and tree volume measurements can be used to understand forest composition and productivity. Basal area is the cross sectional area of a tree at 4.5 feet above the ground, and is generally expressed in square feet per acre. When measured across a forest stand, basal area can be used to gauge density per unit area (Barnes and others 1998). In practical application, silviculturists use basal area and site quality to determine the appropriate stocking density of forest stands.

A pink ladyslipper orchid (*Cypripedium acaule*) is a botanical gem in the Pisgah National Forest. (Photo by Bill Lea, USDA Forest Service, 2002.)

Tree volume, like basal area and biomass, gauges tree or stand productivity. However, volume estimates typically quantify potential wood products. Individual tree volume is negatively related to the number of stems present in a stand. Typically, dense stands are composed of large numbers of small stems. As trees grow, competition for light, moisture, and nutrients results in the mortality of many seedlings and saplings. The surviving trees gain volume through growth (Barnes and others 1998).

What we found—Basal area on North Carolina's national forests averages about 122 square feet per acre of timberland. Of this, hardwoods account for about 96 square feet per acre and softwoods about 26 square feet per acre (fig. 9). Thirty-eight percent of national forest timberland is classified as fully stocked. Twenty-three percent is partially stocked, and 2 and 38 percent are poorly stocked and overstocked, respectively (fig. 10).

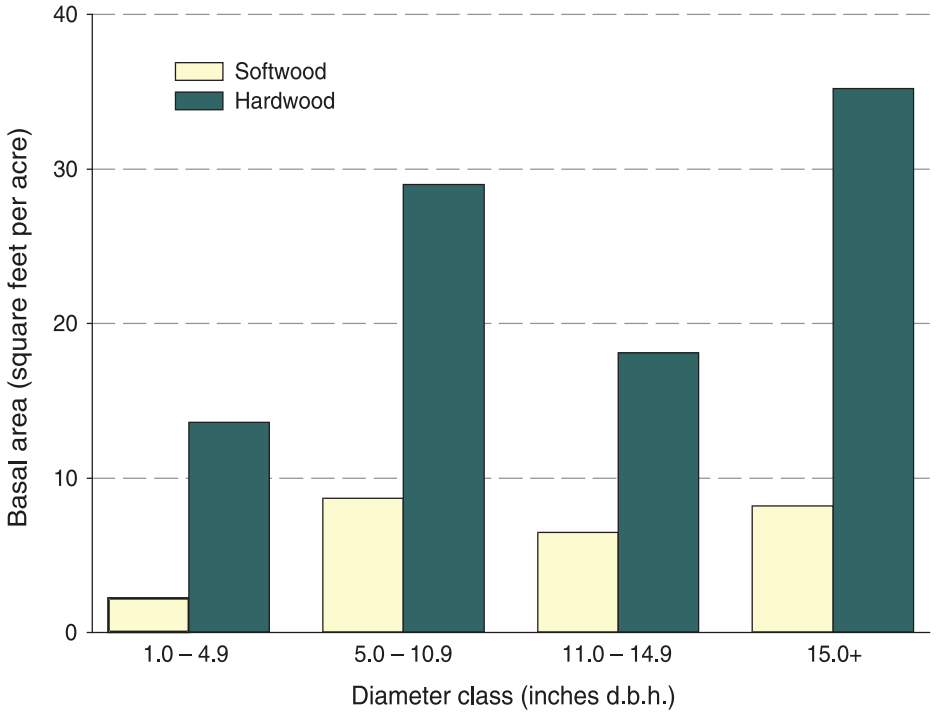


Figure 9—Basal area on national forest timberland by species group and diameter class, North Carolina national forests, 2002.

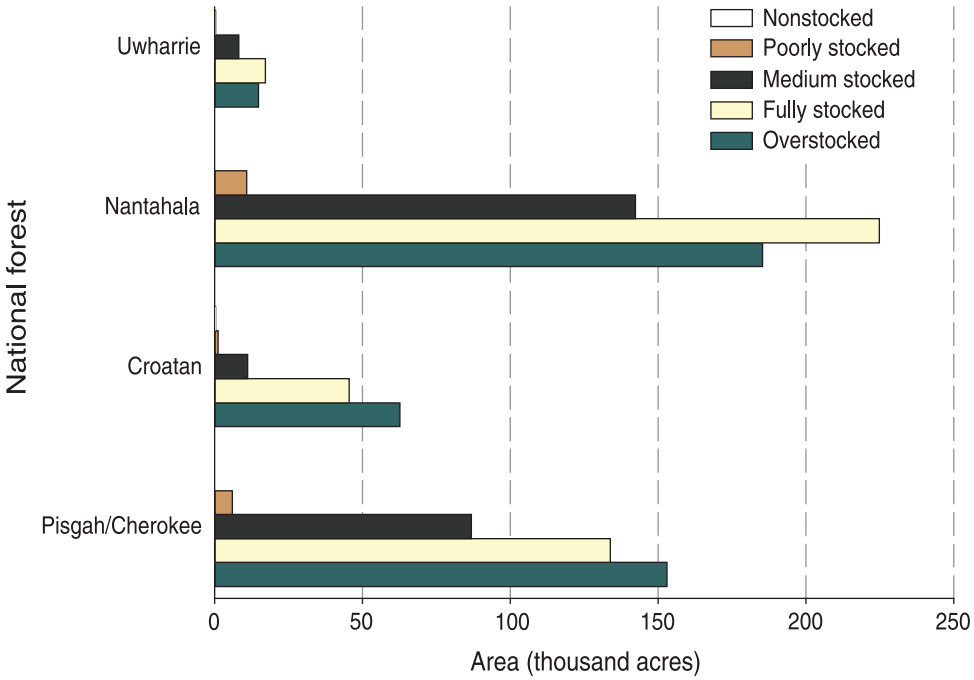


Figure 10—Area of timberland by national forest and stocking class, North Carolina national forests, 2002.

The total volume of all live trees on North Carolina's national forest timberland is about 2.8 billion cubic feet. Hard hardwoods comprise most of the total volume. North Carolina's national forests contribute 8 percent of the State's total live-tree volume. Growing stock on timberland accounts for 2.6 billion cubic feet, or 8 percent of total statewide growing-stock volume. Sawtimber volumes on national forest timberland equal 9.7 billion cubic feet, or about 9 percent of North Carolina's sawtimber volume.

Overall growing-stock volume on North Carolina's national forests has increased by about 5 percent since 1990 (fig. 11). Overall sawtimber volume has increased by 11 percent since that time. Table 1 shows volume, basal area, and biomass estimates for primary species groups on North Carolina's national forest timberland.

What this means—National forests contribute a relatively large percentage of live-tree volume given the land base they occupy.

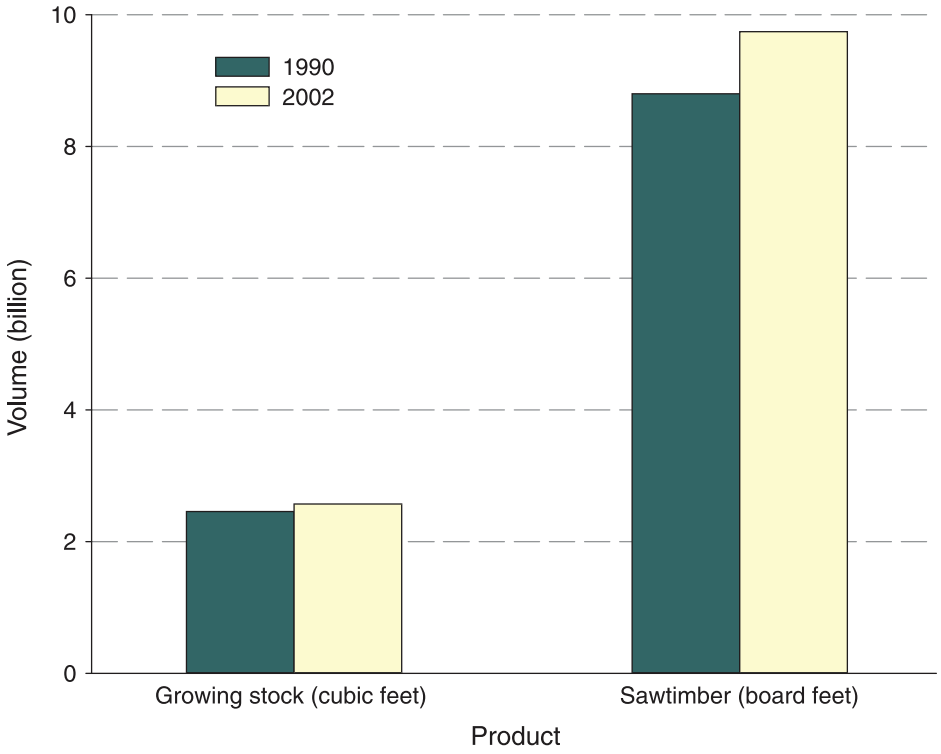


Figure 11—Growing- stock and sawtimber volume on timberland by year, North Carolina national forests, 2002.

Table 1—Estimates of volume, basal area, and biomass of all live trees on timberland by species group, North Carolina national forests, 2002

Species group	Volume	Basal area	Biomass
	million ft^3	*million ft^2*	*million tons*
Softwoods	567.3	25.6	12.5
Hardwoods	2,219.4	95.8	68.4
Total	2,786.7	121.4	80.9

Numbers in rows and columns may not sum to totals due to rounding.

Following statewide trends, both growing-stock and sawtimber volumes have increased substantially since the last survey, though care must be taken to allow for error due to sample design changes when considering the amount of total increase. This reflects a positive growth/removals relationship and suggests that harvesting in North Carolina's national forests has decreased. Live-tree volume has increased in the white-red-jack pine, spruce-fir, and oak-hickory forest-type groups but has declined in the

Longleaf pine reaches the edge of its natural growth range in North Carolina, growing here on the Uwharrie National Forest. (Photo by Bill Lea, USDA Forest Service, 2004.)

longleaf-slash pine, loblolly-shortleaf pine, oak-gum-cypress, and maple-beech-birch forest types.

Wildlife Habitat

Standing Dead Trees

Background— Standing dead trees (snags) are an important component of forested systems. Many wildlife species, particularly cavity-nesting birds, depend on the presence of snags to complete at least a portion of their life cycles (Fan and others 2003, Mannan and others 1996, Ohmann and others 1994). It is estimated that cavity-nesting species make up nearly 45 percent of the avifauna in some forests (Mannan and others 1996). In addition, snags are important food sources for foraging woodpeckers and other insectivores (Conner and others 1994). The importance of snags to wildlife varies across the landscape, as does the density and distribution of snags (Mannan and others 1996, McComb and others 1986). For example, live deciduous trees in eastern forests often contain cavities, decreasing the reliance of some species on snags (Mannan and others 1996). In contrast, cavity-nesting animals living in coniferous forests of the West and Southwestern States may be more dependent on snags for life history needs (Mannan and others 1996). Snag size, forest type, climate, surrounding

vegetation, and other characteristics also influence the suitability of snags for individual wildlife species.

What we found—North Carolina's national forests contain 7 percent of all the snags on North Carolina forest land. There are a total of 23.5 million standing dead trees (19 snags per acre) on North Carolina's national forests. Seventy-nine percent of snags are <11.0 inches d.b.h. The majority of snags in the Pisgah/ Cherokee, Croatan, and Uwharrie National Forests are yellow pines, while the majority of snags in the Nantahala National Forest are hard hardwoods (fig. 12).

What this means—The large proportion (19 snags per acre) of standing dead trees on North Carolina's national forest land is probably related to a combination of reduced removals and aging stands. While structural diversity is important, and standing dead trees enhance the structural diversity of the forest, high numbers of standing dead trees coupled with large amounts of deadwood on the ground may result in increased risk of wildfire. Additionally,

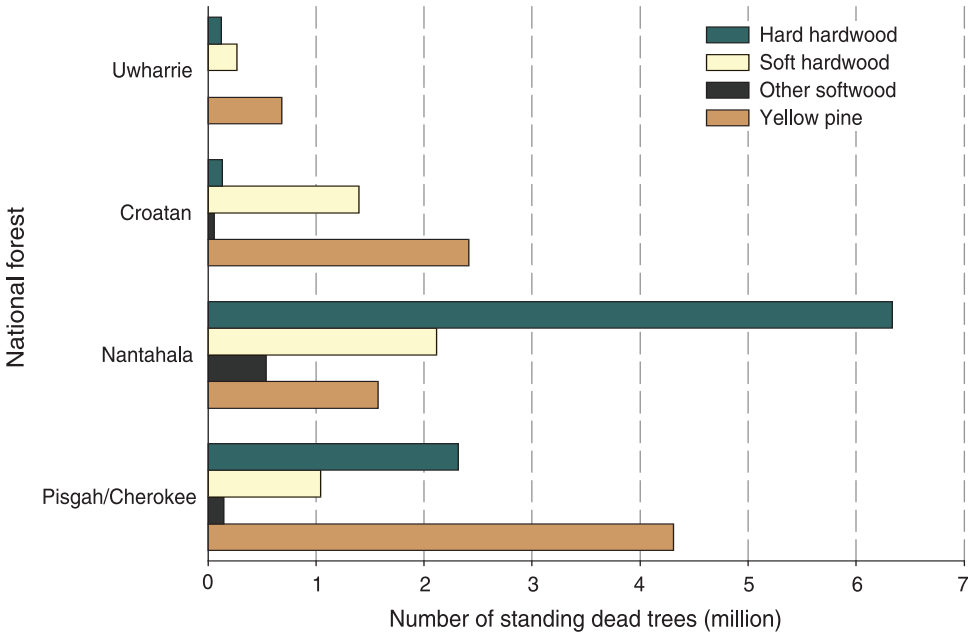


Figure 12——Number of standing dead trees (snags) on forest land by national forest and species group, North Carolina national forests, 2002.

Regrowth results in a lush understory 5 weeks after a large fire event on the Croatan National Forest. (Photo by Bill Lea, USDA Forest Service, 1994.)

while the structural complexity provided by older forests is very important for some wildlife species, it may not be appropriate for species requiring the early successional habitat provided by disturbances.

Forest Products

Harvest and Product Output

Background—Timber and other forest products are among the most important agricultural commodities produced in North Carolina (Brown 2004). In 2000, wood-based industries across the State employed more than 56,000 individuals, had a payroll of $1.8 billion, and contributed $10.9 billion to the State's economy (U.S. Bureau of the Census 2003). The 25 counties in North Carolina that contain national forest land contribute significantly to the State's output of timber products. Two of the State's 7 pulpmills are situated in these counties, as well as nearly 80 sawmills and veneer mills (fig. 13).

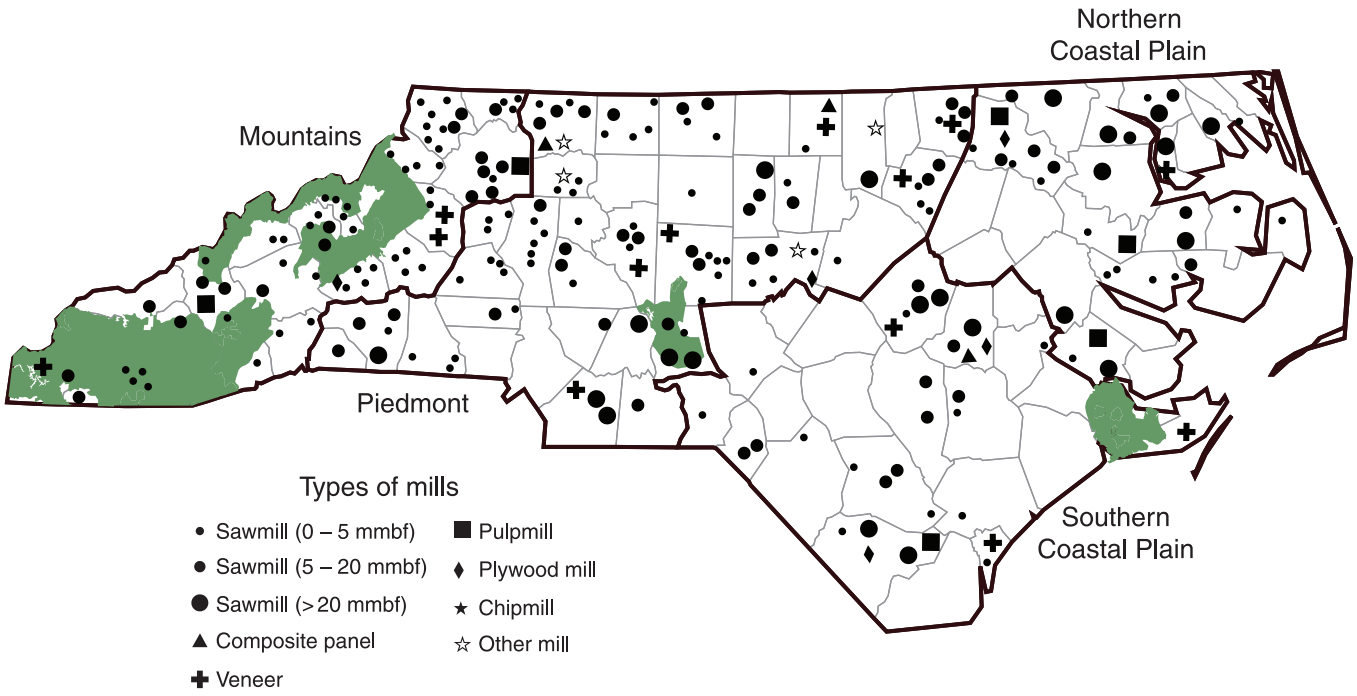


Figure 13—Primary wood-producing mills of North Carolina, 2003. (Mill locations are approximate. Some mills have been moved to facilitate visibility.)

What we found—There are two main sources of data about timber harvests and removals from national forests. National forests are unique in that they generate annual, publicly available timber cut and sold (NFS–TCS) reports for timber sales conducted on national forest lands. These reports track volume and value of timber sold, as well as volume of timber that is cut, loaded on a truck, and subsequently scaled at local mills. FIA estimates of removals are generated using a relatively small number of inventory plots, and estimates may differ significantly from harvest volumes reported in individual NFS–TCS reports. In addition, removals from inventory plots include volume that is cut and not utilized for a product, logging residues, and standing volume reclassified to a reserved status. Removals estimates from inventory data represent an average for the years 1990 through 2001, and are broad estimates only. NFS–TCS reports provide a much more accurate assessment of volumes sold or cut from national forests in any given year.

Timber product output and assessment reports published by the USDA Forest Service, Southern Research Station, between 1990

and 2001 show that average product output for softwoods and hardwoods combined amounted to nearly 139 million cubic feet per year for the 25-county area that includes North Carolina's national forests (Howell and Brown 2004, Johnson and Brown 1999). The 25 counties accounted for 27 percent of the State's timberland area and 16 percent of the State's total timber product output for that time period. Thirteen percent of the State's softwood product output and 21 percent of the hardwood output came from this area. Softwoods, mostly yellow pines, accounted for 51 percent of product output. Saw-log and veneer production combined made up 56 percent of total product output, while pulpwood and composite panel production made up 36 percent of product output. Fuel wood made up the remaining 8 percent of product output for the 25-county region.

NFS–TCS reports for 1990 through 2001 show an annual average of more than 6.9 million cubic feet (38.2 million board feet) harvested for products. This average amounted to 5 percent of total product output from the 25 counties containing national forest. Annual volumes ranged from 12.9 million cubic feet (71.1 million board feet) in 1990 to 1.9 million cubic feet (10.2 million board beet) in 2001 (table 2). Harvest volume averaged nearly 9.2 million cubic feet between 1990 and 1996 and then dropped to an average of just 3.8 million cubic feet between 1997 and 2001. Revenues generated from these sales averaged $1.7 million per year between 1990 and 2001. Sold and harvest reports indicated that 80 percent of this volume was harvested from the Nantahala/Pisgah National Forests in the western part of the State, 10 percent came from the Uwharrie National Forest, and 10 percent came from the Croatan National Forest. These reports also showed that 70 percent of the volume was harvested for saw logs or veneer and 30 percent for pulpwood. Only about 300,000 cubic feet per year is harvested for fuel wood.[1] Volume harvested from North Carolina national forests accounted for nearly 5 percent of

[1] Personal communication. 2005. Dale Remington, Forester, U.S. Department of Agriculture Forest Service, National Forests in North Carolina, 160A Zillicoa Street, Asheville, NC 28804.

Table 2—Timber sold on North Carolina national forests,[a] 1990 to 2001

Date	Volume		Value
	million bf	*million ft³*	*dollars*
1990	71,054.72	12,919.04	1,463,305.53
1991	55,996.06	10,181.10	1,204,632.01
1992	69,716.54	12,675.73	1,854,165.80
1993	50,675.19	9,213.67	2,007,153.55
1994	36,802.66	6,691.39	1,430,761.50
1995	37,912.68	6,893.21	2,370,285.23
1996	30,550.19	5,554.58	1,824,041.26
1997	24,458.73	4,447.04	1,979,965.60
1998	26,141.40	4,752.98	1,895,139.10
1999	26,095.52	4,744.64	2,260,469.09
2000	18,574.01	3,377.09	1,257,016.86
2001	10,196.67	1,853.94	768,921.31
Total	458,174.37	83,304.43	20,315,856.84
Average	38,181.20	6,942.04	1,692,988.07

Numbers in rows and columns may not sum to totals due to rounding.
[a] Data from U.S. Department of Agriculture Forest Service Timber Cut & Sold reports.

total national forest timber harvest volume from the entire southern region between 1990 and 2001.

According to FIA inventory data, annual live removals from North Carolina national forests totaled 11.2 million cubic feet, or 42.1 million board feet, of sawtimber from 1990 through 2001. The apparent discrepancy between this figure and the 6.9 million cubic feet figure obtained from the NFS–TCS reports probably results from differences in the way unutilized material and logging residues (1.4 million cubic feet) are handled and from reclassification of some volume as reserved. In addition, error rates associated with removals are normally higher than those associated with other inventory attributes such as area, volume, and growth even at the State level. Stratifying removals by county or ownership increases the error rate dramatically. For instance, the error rate for removals at the State level with no stratification is ± 3.7 percent, whereas the error rate for removals just for the national forests ownership category is ± 33.2 percent. If we keep these factors in mind, the differences between removals estimates that are based on NFS–TCS reports and those based on FIA inventory work do not seem unreasonable.

Timber harvesting on the Uwharrie National Forest. (Photo by Bill Lea, USDA Forest Service, 2004.)

At 6.6 million cubic feet, hardwood removals accounted for 59 percent of all live removals from the national forests. By comparison, hardwoods accounted for 41 percent of removals for all ownerships across North Carolina (Brown 2004). Removals of hard hardwoods such as red oak, white oak, and hickory amounted to 4.8 million cubic feet, or 73 percent of total hardwood removals. The average d.b.h. for hardwood removals on national forest land was 14.8 inches with 64 percent of hardwood removals coming from the 14.0-inch diameter class and above on national forest lands (fig. 14). Softwood removals on national forest land, made up almost exclusively of yellow pines such as loblolly, shortleaf, and Virginia pine, amounted to 4.6 million cubic feet. For softwoods, the average d.b.h. for all live removals was 11.9 inches, and only 32 percent of softwood removals were from the 14.0-inch and larger diameter classes.

What this means—North Carolina's national forests occupy only 7 percent of timberland statewide, but they continue to contribute significantly to the State's timber products industry, especially

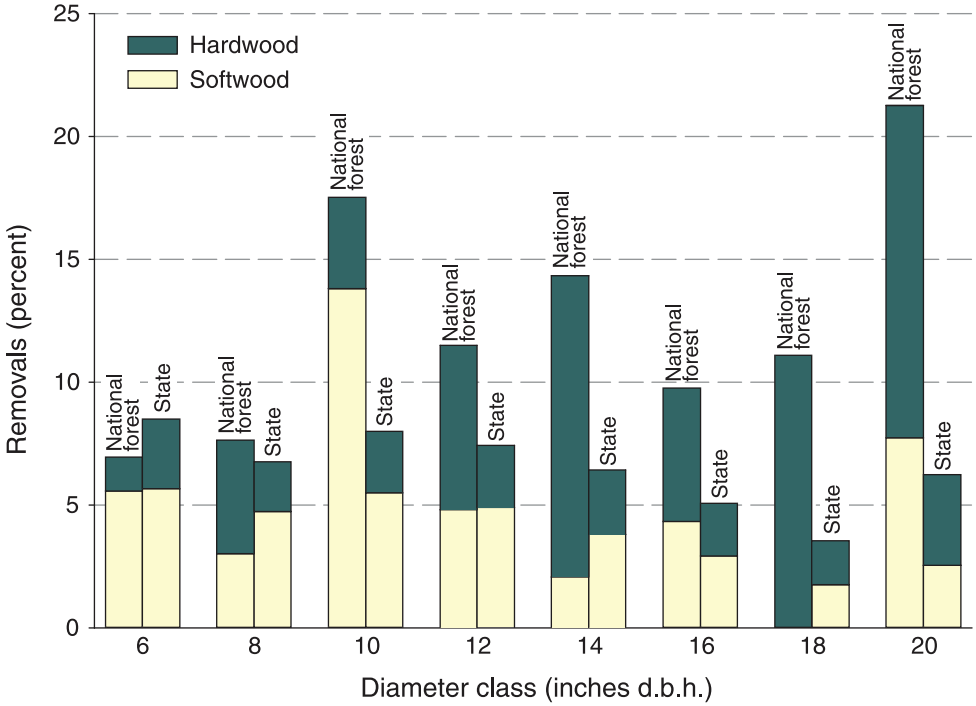


Figure 14—Removals of all live trees on national forest and State-owned land by diameter class and species group, North Carolina, 2002.

in the mountainous region. North Carolina national forests in the western portion of the State, which contribute primarily to the hardwood industry, generate high-value red oak, white oak, and yellow-poplar. Harvesting of hardwoods in the national forests leaves some deadwood on the ground for wildlife habitat. Hardwood diameter removals numbers are indicative of longer rotations for the high-value hardwood products, while softwood removals are very similar to those for land in the other ownership categories and include both saw-log and pulpwood products. The current rate of harvesting in the State's national forests, whether we use FIA results or volume information from the NFS–TCS reports, is less than one-half of 1 percent of total volume per year.

Growth, Removals, and Mortality

Background—Growth, removals, and mortality estimates help managers and interested parties better understand forest

resources and the changes that occur during any given year. The FIA Program uses data from a relatively small number of sample plots to estimate growth, removals, and mortality in the national forests. It is likely, therefore, that removals estimates generated using FIA data will differ from harvest volumes listed in sold and harvest reports for individual national forests. In addition, growth, removals, and mortality estimates are annual averages for the period since the previous inventory. So, the values we report are averages for years 1990 through 2001 and should not be expected to match harvest volumes for any single year. The following estimates are broad approximations only; those who are looking for more accurate assessments of timber utilization should refer to the sold and harvest reports. National forest sold and harvest reports are available on the USDA Forest Service Internet site under the category “Forest Management.”

What we found—The average net annual growth of all live trees on national forest timberland in North Carolina exceeded live-tree removals by 5 to 1. Also, average net annual growth of growing stock on the national forest timberland exceeded removals of growing-stock trees by a little over 5 to 1. Average sawtimber net annual growth exceeded sawtimber removals by a rate of nearly 7 to 1. Additionally, average annual mortality rates were higher than rates of removal of both growing stock and sawtimber. Mortality exceeded removals in both growing stock and sawtimber by a little over 3 to 1. Mortality was highest in the oak-hickory forest-type group, but mortality and removals combined exceeded growth in the oak-cypress-gum forest type. On national forest timberland, the total volume of all live trees lost to mortality was 1.6 percent of the total live-tree inventory volume. In comparison, all live-tree wood volume lost to mortality statewide was equivalent to 1.3 percent of total statewide live-tree inventory volume. There was more growing-stock growth in naturally regenerated oak-hickory and naturally regenerated white-red-jack pine forest-type groups than in any other naturally regenerated or planted forest-type group, and more growing-stock removals came from the naturally regenerated oak-hickory forest-type group than from any other.

Fishing is a relaxing way to spend a day in the shade on the Nantahala National Forest. (Photo by Bill Lea, USDA Forest Service, 1999.)

The national forests contributed 4.6 percent of all live-tree average net annual growth, statewide, and <1 percent of all live-tree average annual removals.

What this means—North Carolina's national forests are growing faster than they are being harvested. As a result, stands are getting older, large numbers of standing dead trees are present, stocking is often higher than it would be for maximum sustainable timber production, and mortality rates frequently exceed removals. Aging forests can provide structurally complex habitat for wildlife and aesthetically pleasing backdrops for recreation. However, older forests may be prone to wildfire outbreaks as deadwood accumulates, and to disease outbreaks as older trees succumb to environmental stress.

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Appendix

Glossary

Afforestation. Area of land previously classified as nonforest that is converted to forest by tree planting or by natural reversion to forest.

Average annual mortality. Average annual volume of trees 5.0 inches d.b.h. and larger that died from natural causes during the intersurvey period.

Average annual removals. Average annual volume of trees 5.0 inches d.b.h. and larger removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

Average net annual growth. Average annual net change in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting (gross growth minus mortality) during the intersurvey period.

Basal area. The area in square feet of the cross section at breast height of a single tree or of all the trees in a stand, usually expressed in square feet per acre.

Biomass. The aboveground fresh weight of solid wood and bark in live trees 1.0 inch d.b.h. and larger from the ground to the tip of the tree. All foliage is excluded. The weight of wood and bark in lateral limbs, secondary limbs, and twigs under 0.5 inch in diameter at the point of occurrence is included for sapling-size trees but is excluded for poletimber and sawtimber-size trees.

Bole. That portion of a tree between a 1-foot stump and a 4-inch top d.o.b. in trees 5.0 inches d.b.h. and larger.

Census water. Streams, sloughs, estuaries, canals, and other moving bodies of water 200 feet wide and greater, and lakes, reservoirs, ponds, and other permanent bodies of water 4.5 acres in area and greater.

Commercial species. Tree species currently or potentially suitable for industrial wood products.

D.b.h. Tree diameter in inches (outside bark) at breast height (4.5 feet aboveground).

Diameter class. A classification of trees based on tree d.b.h. The Forest Inventory and Analysis Program commonly uses 2-inch diameter classes, with the even inch as the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

D.o.b. (diameter outside bark). Stem diameter including bark.

Forest land. Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120 feet wide.

Forest management type. A classification of timberland based on forest type and stand origin.

Pine plantation. Stand that (a) has been artificially regenerated by planting or direct seeding, (b) is classed as a member of the pine or other softwood forest type, and (c) has at least 10 percent stocking.

Natural pine. Stand that (a) has not been artificially regenerated, (b) is classed as a member of the pine or other softwood forest type, and (c) has at least 10 percent stocking.

Oak-pine. Stand that has at least 10 percent stocking and is classed as a member of the oak-pine forest type.

Upland hardwood. Stand that has at least 10 percent stocking and classed as a member of the oak-hickory or maple-beech-birch forest type.

Lowland hardwood. Stand that has at least 10 percent stocking and is classed as a member of the oak-gum-cypress, elm-ash-cottonwood, palm, or other tropical forest type.

Nonstocked stands. Stands < 10 percent stocked with live trees.

Forest type. A classification of forest land based on the species forming a plurality of live-tree stocking. Major eastern forest-type groups are:

White-red-jack pine. Forests in which eastern white pine, red pine, or jack pine, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, birch, and maple.)

Spruce-fir. Forests in which spruce or true firs, singly or in combination, constitute a plurality of the stocking. (Common associates include maple, birch, and hemlock.)

Longleaf-slash pine. Forests in which longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Loblolly-shortleaf pine. Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Oak-pine. Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Oak-hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent of stocking, in which case the stand is classified as oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-gum-cypress. Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent of stocking, in which case the stand is classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Elm-ash-cottonwood. Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

Maple-beech-birch. Forests in which maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, elm, basswood, and white pine.)

Nonstocked stands. Stands < 10 percent stocked with live trees.

Forested tract size. The area of forest within the contiguous tract containing each Forest Inventory and Analysis Program sample plot.

Fresh weight. Mass of tree component at time of cutting.

Gross growth. Annual increase in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting and mortality. (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

Growing-stock trees. Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Trees must contain at least one 12-foot or two 8-foot logs in the saw-log portion, currently or potentially (if too small to qualify), to be classed as growing stock. The log(s) must meet dimension and merchantability standards to qualify. Trees must also have, currently or potentially, one-third of their gross board-foot volume in sound wood.

Growing-stock volume. The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Hardwoods. Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods. Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods. Hardwood species with an average specific gravity > 0.50, such as oaks, hard maples, hickories, and beech.

Industrial wood. All roundwood products except fuel wood.

Land area. The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals < 200 feet wide, and lakes, reservoirs, and ponds < 4.5 acres in area.

Live trees. All living trees. All size classes, all tree classes, and both commercial and noncommercial species are included.

Log grade. A classification of logs based on external characteristics indicating quality or value.

Logging residues. The unused merchantable portion of growing-stock trees cut or destroyed during logging operations.

Net annual change. Net annual increase or decrease in volume of live trees at least 5.0 inches d.b.h. Net annual change is equal to net annual growth minus average annual removals.

Noncommercial species. Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land. Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.

Nonstocked stands. Stands < 10 percent stocked with live trees.

Other forest land. Forest land other than timberland and productive reserved forest land. It includes available and reserved forest land incapable of producing annually 20 cubic feet per acre

of industrial wood under natural conditions, because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other removals. The growing-stock volume of trees removed from the inventory by cultural operations such as timber stand improvement, land clearing, and other changes in land use, resulting in the removal of the trees from timberland.

Ownership. The property owned by one ownership unit, including all parcels of land in the United States.

National forest land. Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including experimental areas and Bankhead–Jones Title III land.

Forest industry land. Land owned by companies or individuals operating primary wood-using plants.

Nonindustrial private forest land (NIPF). Privately owned land that is not forest industry land.

Corporate. Owned by corporations, including incorporated farm ownerships.

Individual. All lands owned by individuals, including farm operators.

Other public. An ownership class that includes all public lands except national forests.

Miscellaneous Federal land. Federal land other than national forests.

State, county, and municipal land. Land owned by States, counties, and local public agencies or municipalities or land leased to these governmental units for 50 years or more.

Plant residues. Wood material generated in the production of timber products at primary manufacturing plants.

Coarse residues. Material, such as slabs, edgings, trim, veneer cores and ends, suitable for chipping.

Fine residues. Material, such as sawdust, shavings, and veneer chippings, not suitable for chipping.

Plant byproducts. Residues (coarse or fine) used in the manufacture of industrial products or for consumer use or as fuel.

Unused plant residues. Residues (coarse or fine) not used for any product, including fuel.

Poletimber-size trees. Softwoods 5.0 to 8.9 inches d.b.h. and hardwoods 5.0 to 10.9 inches d.b.h.

Primary wood-using plants. Industries receiving roundwood or chips from roundwood for the manufacture of products, such as veneer, pulp, and lumber.

Productive-reserved forest land. Forest land sufficiently productive to qualify as timberland but withdrawn by statute or administrative regulation from production of timber that is utilized.

Reforestation. Area of land previously classified as forest that is regenerated by tree planting or natural regeneration.

Rotten trees. Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet in length or longer, now or prospectively, primarily because of rot or missing sections, and with less than one-third of the gross board-foot tree volume in sound material.

Rough trees. Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet in length or longer, now or prospectively, primarily because of roughness, poor form, splits, and cracks, and with less than one-third of the gross board-foot tree volume in sound material; and live trees of noncommercial species.

Roundwood chipped. Any timber cut primarily for pulpwood, delivered to nonpulpmills, chipped, and then sold to pulpmills as

residues, including chipped tops, jump sections, whole trees, and pulpwood sticks.

Roundwood products. Any primary product such as lumber, poles, pilings, pulp, or fuel wood that is produced from roundwood.

Roundwood (roundwood logs). Logs, bolts, or other round sections cut from trees for industrial or consumer uses.

Salvable dead trees. Standing or downed dead trees that were formerly growing stock and are considered merchantable. Trees must be at least 5.0 inches d.b.h. to qualify.

Saplings. Live trees 1.0 to 5.0 inches d.b.h.

Saw log. A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, with a minimum diameter inside bark for softwoods of 6 inches (8 inches for hardwoods).

Saw-log portion. The part of the bole of sawtimber trees between a 1-foot stump and the saw-log top.

Saw-log top. The point on the bole of sawtimber trees above which a conventional saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber-size trees. Softwoods 9.0 inches d.b.h. and larger and hardwoods 11.0 inches d.b.h. and larger.

Sawtimber volume. Growing-stock volume in the saw-log portion of sawtimber-size trees in board feet (International 1/4-inch rule).

Seedlings. Trees < 1.0 inch d.b.h. and > 1 foot tall for hardwoods, > 6 inches tall for softwood, and > 0.5 inch in diameter at ground level for longleaf pine.

Select red oaks. The group consisting of cherrybark, Shumard, and northern red oaks. Other red oak species are included in the "other red oaks" group.

Select white oaks. The group consisting of white, swamp chestnut, swamp white, chinkapin, Durand, and bur oaks. Other white oak species are included in the “other white oaks” group.

Site class. A classification of forest land in terms of potential capacity to grow crops of industrial wood based on fully stocked natural stands.

Softwoods. Coniferous trees, usually evergreen, having leaves that are needles or scalelike.

Yellow pines. Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

Other softwoods. Cypress, eastern redcedar, white-cedar, eastern white pine, eastern hemlock, spruce, and fir.

Stand age. The average age of dominant and codominant trees in the stand.

Stand origin. A classification of forest stands describing their means of origin.

Planted. Planted or artificially seeded.

Natural. No evidence of artificial regeneration.

Stand-size class. A classification of forest land based on the diameter class distribution of live trees in the stand.

Sawtimber stands. Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Poletimber stands. Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in poletimber and sawtimber trees, and with poletimber stocking greater than sawtimber stocking.

Sapling-seedling stands. Stands at least 10 percent stocked with live trees and with more than one-half of total stocking in saplings and seedlings.

Nonstocked stands. Stands < 10 percent stocked with live trees.

Stocking. The degree of occupancy of land by trees, measured by basal area or the number of trees in a stand and spacing in the stand, compared with a minimum standard, depending on tree size, required to fully utilize the growth potential of the land.

Density of trees and basal area per acre required for full stocking:

D.b.h. class	Trees per acre for full stocking	Basal area (ft^2) per acre
Seedlings	600	—
2	560	—
4	460	—
6	340	67
8	240	84
10	155	85
12	115	90
14	90	96
16	72	101
18	60	106
20	51	111

— = not applicable.

Timberland. Forest land capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

Timber products. Roundwood products and byproducts.

Tree. Woody plant having at maturity one erect perennial stem or trunk at least 3.0 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet.

Tree grade. A classification of the saw-log portion of sawtimber trees based on: (a) the grade of the butt log or (b) the ability of the tree to produce at least one 12-foot or two 8-foot logs in the upper section of the saw-log portion. Tree grade is an indicator of quality; grade 1 is the best quality.

Upper-stem portion. The part of the main stem or fork of sawtimber trees above the saw-log top to a minimum top diameter of 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Volume of live trees. The cubic-foot volume of sound wood in live trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Volume of saw-log portion of sawtimber trees. The cubic-foot volume of sound wood in the saw-log portion of sawtimber trees. Volume is the net result after deductions for rot, sweep, and other defects that affect use for lumber.

Public Access to Forest Inventory and Analysis Data

Data collected by the Forest Service FIA Program are made available to the public via the Internet. To access data, go to the Forest Service FIA Web site at http://www.fia.fs.fed.us and enter the "Online Databases" section. The data are stored in a way that permits individual users to select and download data so they can produce their own estimates and summaries. Users can also access an online table generator to easily query the data within the Internet forum.

Inventory Methods

Data collection for the 2002 inventory was based on a statistically valid fixed-radius plot design that is described in Forest Service FIA manual version 3.[1] Sampling for the 2002 inventory was in multiple parts or "phases." Phase 1 sampling utilized aerial photographs and geographic information systems to generate initial estimates of forest and nonforest areas. For national forests, initial area estimates were enumerated based on national forest records to ensure maximum accuracy. Global Positioning System devices were then used to locate and record the center of each ground sample plot.

Phase 2 of the data collection process involved field measurements made at each sample location where the plot design sampled forest land. The plot design consisted of a cluster of four 24.0-foot radius subplots spaced and arranged to form an equilateral triangle, with subplot 1 falling in the center (fig. A.1). Subplots were spaced 120 feet from the center of subplot 1. Each subplot was mapped for forest conditions, including land use, forest type, stand-size class, stand origin, stand density, and broad ownership category. All trees 5.0-inches d.b.h. and larger were measured within each subplot. Plots and subplot locations were fixed, and plots were not rotated or moved for any reason. Plots straddling forest and nonforest conditions were mapped, and trees in the forested area were measured. Each plot contained four

[1] U.S. Department of Agriculture Forest Service. 1998. Field Instructions for the southern forest inventory. Version 3. On file with: Southern Research Station, Forestry Inventory and Analysis, 4700 Old Kingston Pike, Knoxville, TN 37919.

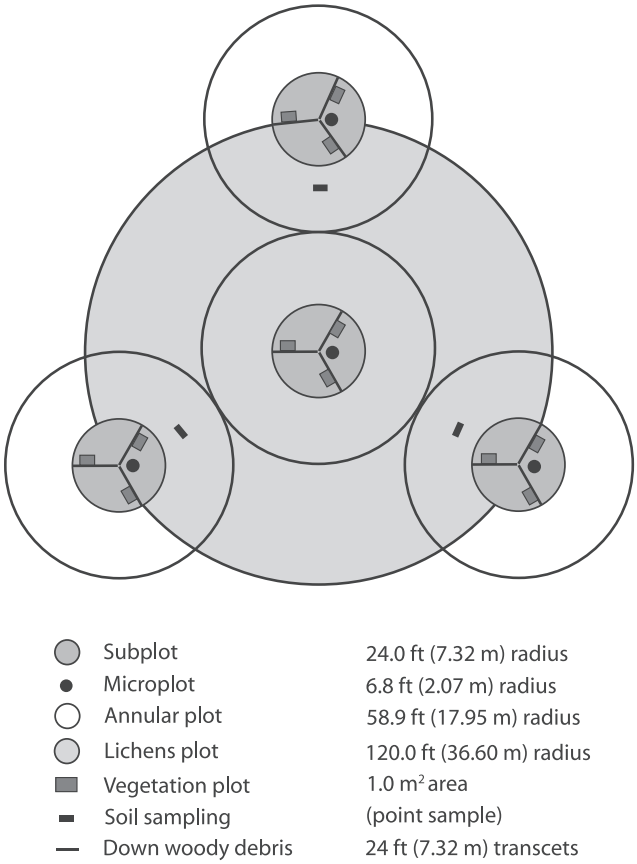

Figure A.1—Layout of fixed-radius plot used in 2002 North Carolina survey.

microplots, which were located at subplot centers. In the microplots, crew members collected data about all live trees 1.0 inches in diameter through 4.9 inches in diameter. Equations for each of the major species in the State were used to compute individual tree volumes.

Growth, removal, and mortality estimates were determined based on the remeasurement of permanent sample plots established in the 1990 inventory. The plot design for the 1990 inventory was based on a cluster of 10 points. In that inventory, variable plots were systematically spaced within a single forest condition at three to five points. At each point, trees 5.0 inches d.b.h. and larger were selected for measurement on a variable-radius plot defined by a 37.5-factor prism. Trees <5.0 inches d.b.h. were tallied on a fixed-radius plot around points 1 through 3. Thus, the values we report for the latest inventory are an average yearly mean for 1993 through 1999.

All field data were submitted to the Southern Research Station in Asheville, NC, for editing, processing, and storage. Final estimates were based on statistical summaries of the data and represent only a portion of the data collected.

Sample Accuracy

FIA data are collected nationwide to provide reliable statistics for forest resources at the State and survey unit levels. Because sample sizes for the individual national forests and species groups were small, readers should regard the summary statistics presented in this report as estimates only and should understand that the summary calculations involved sampling error.

Sampling errors are a measure of the reliability of inventory statistics. These sampling errors mean that the chances are two out of three that the true population value is within the limits indicated by a confidence interval. Sampling errors (in percent) and associated confidence intervals around the sample estimates for timberland area, inventory volumes, and components of change are presented in the following tabulation:

Item	Sample estimate and confidence interval			Sampling error
				percent
All live (million cubic feet)				
Inventory	2,786.7	±	90.4	3.24
Net annual growth	56.4	±	6.1	10.75
Annual removals	11.2	±	3.7	33.20
Annual mortality	43.8	±	3.7	8.46
Growing stock (million cubic feet)				
Inventory	2,569.5	±	89.8	3.49
Net annual growth	59.1	±	5.9	9.94
Annual removals	11.0	±	1.2	10.51
Annual mortality	34.8	±	3.5	10.10
Sawtimber (million board feet)				
Inventory	9,737.9	±	476.2	4.89
Net annual growth	282.6	±	27.5	9.73
Annual removals	42.1	±	14.6	34.78
Annual mortality	121.7	±	13.5	11.08

Sampling error increases as the area or volume considered decreases in magnitude. Sampling errors and associated confidence intervals are often unacceptably high for small components of the total resource. Statistical confidence may be computed for any subdivision of survey unit or State totals using the following formula. Sampling errors obtained by this method are only approximations of reliability because this process assumes constant variance across all subdivisions of totals.

$$SE_S = SE_t \frac{\sqrt{X_t}}{\sqrt{X_S}}$$

where

SE_s = sampling error for subdivision of survey unit or State total

SE_t = sampling error for survey unit or State total

X_s = sum of values for the variable of interest (area or volume) for subdivision of survey unit or State

X_t = total area or volume for survey unit or State

For example, the estimate of sampling error for softwood live-tree volume on North Carolina national forest timberland is computed as:

$$SE_s = 3.24 \frac{\sqrt{2{,}786.7}}{\sqrt{567.3}} = 7.19$$

Thus, the sampling error is 7.19 percent, and the resulting confidence interval (two times out of three) for softwood live-tree volume on North Carolina's national forest timberland is 567.3 ± 40.8 million board feet.

Forest areas of the Pisgah/Cherokee, Nantahala, Croatan, and Uwharrie National Forests are reported without associated error values because forest area for each of these national forests are taken from known NFS land area records. The subdivisions and classifications associated with forest area (forest type, stand age, etc.) do have some measurement/classification error; however, this error may not be measured with the above formula.

Metric Equivalents

1 acre = 4 046.86 m^2 or 0.404 686 ha

1 cubic foot = 0.028 317 m^3

1 inch = 2.54 cm or 0.0254 m

Breast height = 1.4 m above the ground level

1 square foot = 929.03 cm^2 or 0.0929 m^2

1 square foot per acre basal area = 0.229 568 m^2/ha

1 pound = 0.454 kg

1 ton = 0.907 mt

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Table A.1—Area of forest land by national forest and forest-type group, North Carolina national forests, 2002

National forest	All groups	Forest-type group								
		White-red-jack pine	Longleaf-slash pine	Spruce-fir	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Maple-beech-birch
	thousand acres									
Pisgah/Cherokee	419.2	19.1	—	3.8	8.2	39.7	324.2	—	—	24.4
Nantahala	608.9	25.8	—	5.5	4.5	29.3	522.1	—	—	21.7
Croatan	158.9	—	2.5	—	55.5	66.0	17.0	15.6	2.4	—
Uwharrie	45.9	—	—	—	8.9	9.5	27.5	—	—	—
Total	1,233.0	44.9	2.5	9.2	77.2	144.5	890.8	15.6	2.4	46.1

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.2—Area of forest land by forest-type group and stand origin, North Carolina national forests, 2002

Forest-type group	All	Stand origin	
		Planted	Natural
	thousand acres		
Softwood types			
White-red-jack pine	44.9	2.6	42.3
Longleaf-slash pine	2.5	—	2.5
Loblolly-shortleaf pine	77.2	20.2	57.0
Spruce-fir	9.2	—	9.2
Total softwoods	133.7	22.8	110.9
Hardwood types			
Oak-pine	144.5	5.8	138.6
Oak-hickory	890.8	—	890.8
Oak-gum-cypress	15.6	—	15.6
Elm-ash-cottonwood	2.4	—	2.4
Maple-beech-birch	46.1	—	46.1
Total hardwoods	1,099.2	5.8	1,093.4
All groups	1,232.9	28.6	1,204.3

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.3—Number of live trees on forest land by species group and diameter class, North Carolina national forests, 2002

Species group	All classes	Diameter class *(inches at breast height)* 1.0 – 2.9	3.0 – 4.9	5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
	thousand trees												
Softwood													
Yellow pine	59,997	19,657	12,155	9,375	6,257	4,256	3,194	2,049	1,212	745	684	348	65
Other softwoods	35,511	15,705	9,006	4,198	2,651	1,168	968	465	438	326	189	285	112
All softwoods	95,508	35,362	21,161	13,573	8,908	5,424	4,162	2,514	1,650	1,071	873	633	177
Hardwood													
Soft hardwood	312,031	195,188	54,762	24,663	14,075	8,701	4,999	3,503	2,062	1,591	956	1,290	241
Hard hardwood	292,024	137,801	58,057	29,335	21,325	14,002	10,142	7,080	4,523	3,965	2,076	2,973	745
All hardwoods	604,055	332,989	112,819	53,998	35,400	22,703	15,141	10,583	6,585	5,556	3,032	4,263	986
All species	699,563	368,351	133,980	67,571	44,308	28,127	19,303	13,097	8,235	6,627	3,905	4,896	1,163

Numbers in rows and columns may not sum to totals due to rounding.

Table A.4—Number of growing-stock trees on forest land by species group and diameter class, North Carolina national forests, 2002

Species group	All classes	*Diameter class (inches at breast height)* 1.0 – 2.9	3.0 – 4.9	5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
	thousand trees												
Softwood													
Yellow pine	46,651	10,379	9,332	8,629	5,872	4,192	3,163	2,049	1,212	726	684	348	65
Other softwoods	25,279	6,903	8,188	3,878	2,588	1,122	944	444	354	326	189	285	58
All softwoods	71,930	17,282	17,520	12,507	8,460	5,314	4,107	2,493	1,566	1,052	873	633	123
Hardwood													
Soft hardwood	136,109	51,901	32,344	18,998	11,844	7,553	4,430	3,231	1,947	1,544	926	1,171	220
Hard hardwood	141,337	35,307	28,576	20,820	17,102	11,668	8,627	6,274	4,178	3,609	1,896	2,694	586
All hardwoods	277,446	87,208	60,920	39,818	28,946	19,221	13,057	9,505	6,125	5,153	2,822	3,865	806
All species	349,376	104,490	78,440	52,325	37,406	24,535	17,164	11,998	7,691	6,205	3,695	4,498	929

Numbers in rows and columns may not sum to totals due to rounding.

Table A.5—Aboveground dry weight biomass estimates on forest land by species group and national forest, North Carolina national forests, 2002

Species group	National forest			
	Pisgah/ Cherokee	Nantahala	Croatan	Uwharrie
	tons			
Softwood				
Yellow pine	2,243,329	2,607,463	3,931,262	727,906
Other softwoods	909,258	2,600,690	158,611	5,712
All softwoods	3,152,587	5,208,153	4,089,873	733,618
Hardwood				
Soft hardwood	9,084,609	10,915,088	1,541,196	583,655
Hard hardwood	21,147,199	29,407,956	786,147	1,579,653
All hardwoods	30,231,808	40,323,044	2,327,343	2,163,308
All species	33,384,395	45,531,197	6,417,217	2,896,926

Numbers in rows and columns may not sum to totals due to rounding.

Table A.6—Volume of sawtimber on timberland by species group and diameter class > 9.0 inches d.b.h., North Carolina national forests, 2002

Species group	All classes	Diameter class *(inches at breast height)*							
		9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
	million board feet								
Softwood									
Yellow pine	1,852.9	182.2	262.2	306.0	282.3	225.6	288.0	249.0	57.6
Other softwoods	707.3	33.8	59.7	48.0	71.3	84.6	72.3	176.5	161.1
All softwoods	2,560.2	216.0	321.9	354.0	353.6	310.2	360.3	425.5	218.6
Hardwood									
Soft hardwood	2,700.2	—	267.7	378.3	347.7	406.5	357.6	718.3	224.1
Hard hardwood	4,477.5	—	480.9	548.1	595.5	682.4	503.9	1,117.6	549.3
All hardwoods	7,177.7	—	748.6	926.3	943.2	1,088.8	861.4	1,835.9	773.4
All species	9,737.8	216.0	1,070.6	1,280.3	1,296.8	1,399.1	1,221.7	2,261.4	992.0

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.7—Volume of growing stock on timberland by species group and diameter class > 5.0 inches d.b.h., North Carolina national forests, 2002

Species group	All classes	Diameter class (*inches at breast height*) 5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
						million cubic feet					
Softwood											
Yellow pine	407.5	21.7	35.9	49.4	58.1	60.1	50.4	38.6	46.7	38.0	8.5
Other softwoods	148.3	7.6	12.5	9.7	14.1	10.0	13.8	15.4	12.7	29.0	23.6
All softwoods	555.9	29.2	48.4	59.1	72.2	70.1	64.3	54.0	59.5	67.0	32.1
Hardwood											
Soft hardwood	756.4	53.2	73.5	85.9	78.0	91.4	75.1	79.1	65.5	119.3	35.3
Hard hardwood	1,257.2	54.6	96.4	123.4	140.6	139.9	138.1	148.0	103.4	214.9	97.9
All hardwoods	2,013.6	107.8	170.0	209.3	218.6	231.4	213.1	227.1	169.0	334.2	133.2
All species	2,569.5	137.0	218.4	268.5	290.8	301.4	277.4	281.2	228.4	401.2	165.3

Numbers in rows and columns may not sum to totals due to rounding.

Table A.8—Area of forest land by stand–age class and forest–type group, North Carolina national forests, 2002

Stand-age class	All groups	Forest-type group White-red-jack pine	Spruce-fir	Longleaf-slash pine	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Oak-gum cypress	Elm-ash-cottonwood	Maple-beech-birch
					thousand acres					
0 – 10	37.5	3.6	—	—	1.0	7.8	21.0	4.1	—	—
11 – 20	84.1	1.4	—	—	11.3	16.8	47.3	—	—	7.2
21 – 30	52.1	—	—	—	7.3	29.6	14.3	0.3	—	0.6
31 – 40	56.5	8.4	—	—	14.0	1.2	27.8	1.6	—	3.5
41 – 50	81.0	8.2	—	—	16.3	5.9	44.1	1.0	—	5.5
51 – 60	150.4	7.5	9.2	0.2	13.1	23.6	91.1	4.4	—	1.3
61 – 70	227.3	8.1	—	1.3	1.6	32.5	176.7	—	—	7.2
71 – 80	138.4	3.1	—	—	4.7	9.4	110.1	—	2.4	8.7
81 – 90	160.0	2.3	—	1.0	—	12.9	143.8	—	—	—
91 – 100	69.4	—	—	—	7.8	1.2	46.7	4.1	—	9.6
> 100	176.2	2.4	—	—	—	3.5	167.8	—	—	2.4
All classes	1,233.0	44.9	9.2	2.5	77.2	144.5	890.8	15.6	2.4	46.1

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.9—Number of standing dead trees on forest land by species group and diameter class, North Carolina national forests, 2002

Species group	All classes	Diameter class[a] 5.0 – 10.9	Diameter class[a] > 11.0
	million trees		
Softwood			
Yellow pine	8.98	7.32	1.65
Other softwoods	0.75	0.59	0.16
All softwoods	9.72	7.91	1.81
Hardwood			
Soft hardwood	4.83	4.38	0.45
Hard hardwood	8.91	6.35	2.56
All hardwoods	13.74	10.73	3.00
All species	23.46	18.65	4.81

[a] Inches at breast height.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.10—Area of timberland by national forest and forest-type group, North Carolina national forests, 2002

National forest	All groups	Forest-type group: White-red-jack pine	Spruce-fir	Longleaf-slash pine	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Maple-beech-birch
	thousand acres									
Pisgah/Cherokee	380.0	19.1	3.8	—	8.2	39.7	292.1	—	—	17.2
Nantahala	563.6	25.8	5.5	—	4.5	27.5	480.9	—	—	19.4
Croatan	121.1	—	—	2.5	51.8	31.9	17.0	15.6	2.4	—
Uwharrie	40.7	—	—	—	8.9	9.5	22.3	—	—	—
Total	1,105.4	44.9	9.2	2.5	73.4	108.6	812.3	15.6	2.4	36.5

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.11—Area of timberland by national forest and stand-size class, North Carolina national forests, 2002

National forest	All classes	Stand-size class		
		Sawtimber	Poletimber	Sapling-seedling
	thousand acres			
Pisgah/Cherokee	380.0	262.4	51.3	66.3
Nantahala	563.6	365.1	131.1	67.4
Croatan	121.1	49.0	26.7	45.4
Uwharrie	40.7	24.4	10.1	6.2
Total	1,105.4	700.9	219.1	185.4

Numbers in rows and columns may not sum to totals due to rounding.

Table A.12—Area of timberland by national forest and site class, North Carolina National forests, 2002

National forest	All classes	Site class				
		20 to 49 cf/ac/yr	50 to 84 cf/ac/yr	85 to 119 cf/ac/yr	120 to 164 cf/ac/yr	165 to 224 cf/ac/yr
	thousand acres					
Pisgah/Cherokee	380.0	77.8	158.4	100.4	39.9	3.5
Nantahala	563.6	168.8	192.8	112.5	80.5	9.0
Croatan	121.1	46.5	19.7	37.6	16.2	1.2
Uwharrie	40.7	5.4	18.4	15.4	1.6	—
Total	1,105.4	298.6	389.2	265.8	138.2	13.7

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table A.13—Net annual growth and removals of live trees, growing stock, and sawtimber on timberland by species group, North Carolina national forests, 1990 to 2001

Species group	All live trees	Growing stock	Sawtimber
	million cubic feet		*mmbf*
Growth			
Softwood	15.5	15.9	84.5
Hardwood	40.9	43.2	198.1
Removals			
Softwood	4.6	4.6	42.1
Hardwood	6.6	6.3	24.7

Table A.14—Mortality of growing stock and sawtimber on timberland by species group, North Carolina national forests, 2002

Species group	Growing stock	Sawtimber
	mmcf	*mmbf*
Softwood	14.5	50.1
Hardwood	20.3	71.6

Oswalt, Sonja N.; Johnson, Tony G. 2007. The status of North Carolina's national forests, 2002. e-Resour. Bull. SRS–115. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 57 p.

This bulletin describes forest resources of the Pisgah/Cherokee, Nantahala, Croatan, and Uwharrie National Forests in the State of North Carolina. It is based on sampling conducted by the U.S. Department of Agriculture Forest Service, Southern Research Station, Forest Inventory and Analysis Research Work Unit. This bulletin addresses forest area estimates; timber growth, removals and mortality; and timber product output.

Keywords: Annual removals, Croatan National Forest, forest land area, forest productivity, Nantahala National Forest, Pisgah/Cherokee National Forests, Uwharrie National Forest.

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