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North Carolina's Forests, 2002

Mark J. Brown, Barry D. New, Sonja N. Oswalt, Tony G. Johnson, and Victor A. Rudis

Front cover:

Left: high elevation red spruce (*Picea rubens* Sarg.); top right: oak-hickory forest; bottom right: pond pine (*Pinus serotina* Michx.) forest. (photos by Bill Lea)

Back cover:

Catawba rhododendron (*Rhododendron catawbiense* Michx.). (photo by Bill Lea)

Cedar Point tidal creek. (photo by Bill Lea)

November 2006

Southern Research Station
200 WT Weaver Blvd.
Asheville, NC 28804

North Carolina's Forests, 2002

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Foreword

This resource bulletin describes the principal findings of the seventh inventory of North Carolina's forest resources. Data on the extent, condition, and classification of forest land and associated timber volumes, growth, removals, and mortality are described and interpreted.

Periodic 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 (Smith and others, 2004) 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 are conducted by the Southern Research Station Forest Inventory and Analysis (FIA) Work Unit operating from its headquarters in Knoxville, TN, and offices in Asheville, NC, and Starkville, MS. The primary objective of these periodic appraisals is to develop and maintain the resource information needed to formulate sound forest policies and programs as mandated by the Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill). More information is available about Forest Service resource inventories (U.S. Department of Agriculture Forest Service 1992) on the Web at http://fia.fs.fed.us/.

Field work for the seventh survey of North Carolina began in January 1998 and was completed in December 2002. Six previous surveys, completed in 1938, 1956, 1964, 1974, 1984, and 1990, provide statistics for measuring changes and trends over the past 64 years. This analysis focuses on current findings and includes some information about changes and trends in recent years and their implications for North Carolina's forests.

Data included in FIA reports are designed to provide a comprehensive 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://srsfia2.fs.fed.us. FIA data are also available for tabular and mapping output at http://ncrs2.fs.fed.us/4801/fiadb/.

Information concerning any aspect of this survey may be obtained from:

U.S. Department of Agriculture
Forest Service
Southern Research Station
Forest Inventory and Analysis
4700 Old Kingston Pike
Knoxville, TN 37919
Phone: 865-862-2000

Acknowledgments

The FIA gratefully acknowledges the cooperation and assistance provided by the North Carolina Division of Forest Resources in conducting the survey. Appreciation is also expressed for the cooperation of other public agencies and private landowners in providing access to measurement plots.

The following people completed field measurements for this survey; it is their dedication to the collection of quality data that is the foundation of the FIA program.

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Appreciation is also expressed to those who contributed their time in the form of extensive reviews, edits, and commentary in developing this resource bulletin. They are as follows: Jim Rosson, Rob Trickel, Chris Hopkins, KaDonna Randolph, Chris Woodall, Gretchen Smith, Mike Schomaker, Susan Will-Wolf, Don Rogers, Anne Jenkins, Lyn Thornhill, Janet Griffin, Sharon Johnson, and Charlene Walker.

Contents

Highlights from the 2002 Forest Inventory of North Carolina

Area

- Area of forest land totaled 18.3 million acres equaling 59 percent of the total land area in the State.
- There were 552,000 acres of forest in reserved status. This forest land withdrawn from timber utilization was concentrated in the Mountain region of the State.
- Timberland, the portion of forest available for timber utilization, amounted to 17.7 million acres.
- Planted pine stands occurred on 2.6 million acres, or 15 percent of the timberland.
- Hardwood types prevailed on 12.7 million acres, or 72 percent of the timberland.
- The potential for wildland-urban interfaces are increasing. North Carolina's population reached 8.0 million and increased by >1.4 million between 1990 and 2000, the sixth highest numeric change in the Nation.

Ownership

- Nonindustrial private forest (NIPF) ownership, individuals and corporate combined, accounted for 13.8 million acres or 79 percent of the timberland.
- Family forests account for about 11.4 million acres of the NIPF timberland. About 89 percent of North Carolina's total family forest ownerships are <50 acres in size.
- Forest industry controlled 1.5 million acres, or 8 percent of the timberland.
- Public lands contain 2.4 million acres, or 13 percent of all timberland. The National Forest System (NFS) manages 47 percent of the publicly owned timberland.

Volume

- Volume of all live trees totaled 33 billion cubic feet; 66 percent was hardwood volume, and 34 percent was softwood volume.
- Softwood volume totals were down 10 percent to 11.4 billion cubic feet since 1990.
- Planted pine made up 3.1 billion cubic feet, or 28 percent, of the softwood volume.
- Loblolly pine was the dominant species with 6.7 billion cubic feet, or 59 percent of softwood volume.
- Hardwood volume declined by 2 percent to 21.6 billion cubic feet since 1990.
- Yellow-poplar was the most common individual hardwood with 4.1 billion cubic feet, 19 percent of the total hardwood volume.

Growth and Removals

- Net annual growth for all live trees averaged 1.2 billion cubic feet. Softwoods made up 51 percent and hardwoods 49 percent of this growth.
- Average annual removals for all live trees totaled 1.2 billion cubic feet. Softwoods made up 59 percent and hardwoods 41 percent.
- Softwood net annual growth increased 5 percent to 623 million cubic feet from that reported in 1990.
- Planted pines accounted for 296 million cubic feet, or 47 percent, of the softwood net annual growth.
- Softwood removals increased 42 percent to 729 million cubic feet from that reported in 1990.
- Planted pines contributed 223 million cubic feet, or 31 percent, of the softwood average annual removals.
- The growth-to-removal ratio for softwoods was negative, with removals exceeding growth by 105 million cubic feet, or 17 percent.
- Hardwood net annual growth totaled 602 million cubic feet, up by 3 percent from that in 1990.
- Hardwood removals totaled 498 million cubic feet, up by 8 percent from 1990 figures.
- The growth-to-removal ratio for hardwoods was positive, with growth exceeding removals by 104 million cubic feet, or 21 percent.

Timber Products and the Economy

- Forestry, logging, and wood products manufacturing contribute $10.9 billion annually to the State's economy (U.S. Bureau of the Census 2003).
- There are about 249 sawmills, pulpwood mills, and other primary wood-processing plants across the State.
- Pulpwood remained the leading wood product at 454 million cubic feet annually, up by 2 percent since 1990.
- Saw-log output remained second, although it increased 21 percent to 400 million cubic feet annually since 1990.
- Veneer logs and composite panels were third, at 115 million cubic feet annually.

Forest Health

- Mortality averaged 426 million cubic feet annually for all species in North Carolina. Softwood mortality averaged 191 million cubic feet, and hardwood mortality averaged 235 million cubic feet.
- Pine beetles affected an average of 2.7 million acres each year from 1990 to 2002.
- Fuels accumulated at a higher rate in the Coastal Plain than in the remainder of the State as a result of hurricane impacts on coastal forests.
- Ozone injury to vegetation foliage occurred in both urban and rural areas of the State, as indicated by FIA ozone data combined with Environmental Protection Agency (EPA) monitoring station data. Plant numbers exhibiting symptoms were low, but 50 percent of sampled sites exhibited ozone damage.
- Lichen gradient model scores indicate air quality in North Carolina is slightly lower than average compared with other Southeastern States.
- Yellow pine snags are numerous and vary in diameter, providing habitat for many primary and secondary cavity-nesting wildlife species.

Family river outing. (photo by Bill Lea)

Forest Area and Land Use

Overview

North Carolina has 31.2 million acres of land (fig. 1) (U.S. Bureau of the Census 1991). The 2002 forest survey found 18.3 million acres, or 59 percent of the land, to be forested. The remaining 12.9 million nonforested acres consisted of urban and industrial developments, farmland, and inland water.

Three percent of the 18.3 million forest acres were classified as reserved. The 552,000 acres in this reserved status were mostly located in the Great Smoky Mountains National Park, national forest wilderness areas, and State parks. Another 32,000 forest acres were classed as unproductive because of adverse site conditions such as rock outcrops, cliffs, or deep water.

After deduction of the reserved and unproductive forest acres, there are 17.7 million acres of North Carolina's forests (97 percent) classified as timberland. Timberland is forest land capable of growing 20 cubic feet of wood per acre per year and not reserved from cutting. The State's timberland summary as well as related issues are the primary focus of this report. More detailed statewide forest statistics for North Carolina's timberland from the 2002 forest inventory are available in 49 tables of data published in Southern Research Station (SRS) Resource Bulletin SRS–88 titled "Forest Statistics for North Carolina, 2002" (Brown 2004). The publication and its tables can be found on the Web at www.srs.fs.fed.us/pubs.

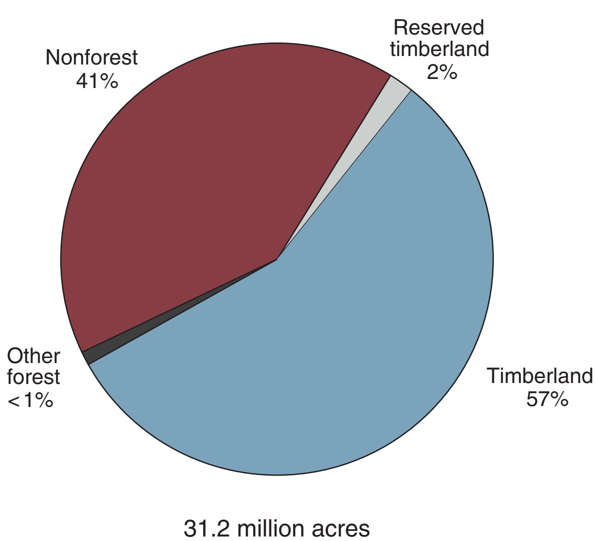

Figure 1—Classification of land area in North Carolina for the 2002 survey.

Mountain biking in the Pisgah National Forest. (photo by Bill Lea)

North Carolina is one of the most physiographically diverse States in the Eastern United States. Elevations range from sea level to 6,684 feet, the highest point east of the Rocky Mountains. North Carolina has more peaks over 6,000 feet than any State east of the Mississippi River. In contrast, it also has the most extensive system of barrier islands in the United States. Not far inland are pocosins and Carolina Bays, more concentrated here than in any other State. Areas of deep swamps are common in the eastern third of the State as well. North Carolina has three distinct physiographic regions recognized as the Coastal Plain, the Piedmont Plateau, and the Appalachian Mountains (fig. 2). Not only are there topographic differences between these regions, but also varying between them are land use, ownership, demographics, and tree species occurrence. Primary forest management issues differ between the regions as well. In the Coastal Plain, loss of longleaf pine is a concern. In the Piedmont, the loss of shortleaf pine is a concern. In the Mountains, oak regeneration and retention is a concern, along with the amount of older, overmature stands.

The Coastal Plain is 57 percent forested and contains almost 48 percent of the State's timberland. In addition, sizable areas exist in agricultural production. Metropolitan areas are widely dispersed. Most of the State's softwood forest types, 65 percent, are found in this region as well. Forest management practices such as site preparation and planting are applied to more acres in the Coastal Plain than in the State's remaining physiographic regions combined. The Coastal Plain accounts for most, 74 percent, of the State's pine plantations. In fact, the majority of forest industry holdings in the State, 90 percent, are found in this region. Because the Coastal Plain contains the State's lowest elevations as well

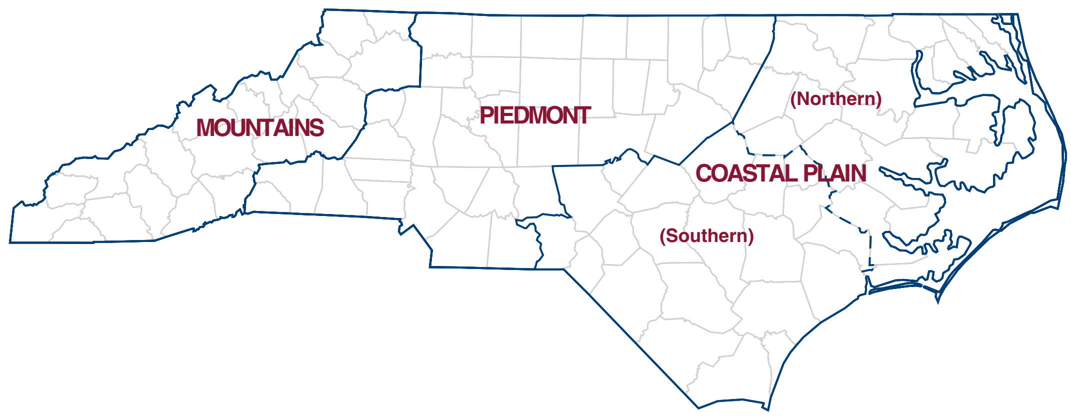

Figure 2—Physiographic regions of North Carolina based upon survey unit boundaries (data collected in the Coastal Plain units is cumulative throughout this publication).

as the smallest gradients in elevation, it contains most of North Carolina's swamps and pocosins. Riverine systems are slower, more meandering, and typically of blackwater type if originating within the region. As a result of these features, most of the State's bottomland hardwoods and cypress (a combined 88 percent) are found in the Coastal Plain. Loblolly pine is the most prevalent softwood type in the region. Nearly all of the State's longleaf pine and pond pine are found there. Once common, their stocks have declined considerably, but longleaf pine restoration has been promoted recently. Unique to this region of the State, Atlantic white cedar once covered large expanses but is now confined to small areas. Detailed forest statistics for the Coastal Plain have been published and are available in two reports titled "Forest Statistics for the Southern Coastal Plain of North Carolina, 1999" (Conner and Sheffield 2001) and "Forest Statistics for the Northern Coastal Plain of North Carolina, 2000" (Conner 2003). These reports are Resource Bulletins SRS–59 and SRS–83, respectively, and can be found on the Web at www.srs.fs.fed.us/pubs.

The Piedmont Plateau has the least proportion of forest, 52 percent. Only 30 percent of the State's timberland is found here. The Piedmont region contains the State's largest metropolitan areas and the highest concentrations of people, urban development, and nonforested areas (fig. 3). The Piedmont also has extensive areas in agriculture, and several of the State's large reservoirs were impounded in the region. NIPF owners control a higher proportion of the timberland, 93 percent, than in the other two regions of the State. The terrain in the Piedmont is much more varied than that of the Coastal Plain region, and includes a wide range

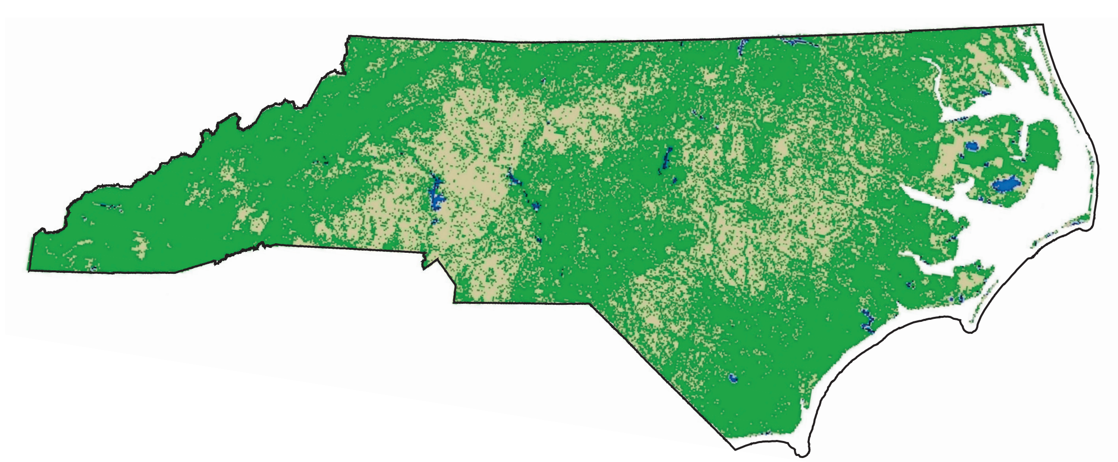

Figure 3—The green areas show the distribution of forest cover in North Carolina. The tan areas represent nonforest urban and/or agriculture area.

of tree species. Hardwoods predominate, but mixed stands are common, with loblolly pine the most abundant softwood type and Virginia pine type second. After mixed hardwood types, the yellow-poplar-oak followed by the sweetgum-yellow-poplar are the most common hardwood types. Riverine systems encounter more gradient and because of the less organic soils, are of red river bottom type. Detailed forest statistics for the Piedmont have been published and are available in a report titled "Forest Statistics for the Piedmont of North Carolina, 2002" (Brown and Sheffield 2003). This report is Resource Bulletin SRS–86 and can be found on the Web at www.srs.fs.fed.us/pubs.

The Appalachian Mountain unit is 74 percent forested, highest of all the regions. It contains most of the State's reserved timberland, primarily in the Great Smoky Mountains National Park. The Mountain region has the highest proportion of publicly owned timberland in the State, mainly because it includes the Pisgah and Nantahala National Forests. The Mountains have fewer large cities and urban development than the State's other regions. The Mountains contain the State's highest elevations and most rugged terrain. Because of its topography, the Mountains are the headwaters of many streams. Waters here are often white water in nature, and most are classed as freestone streams. The Mountains are dominated by upland hardwoods, which account for 80 percent of the region's timberland. Mixed hardwood stands dominate, followed by yellow-poplar-oak types and then chestnut oak type in abundance. The highest elevations of the Mountains also contain tree species typically occurring at more northern latitudes, such as spruce, fir, and yellow birch. White pine is the most common softwood type in the Mountains, whereas Virginia pine type is the most common yellow pine type present. Detailed forest statistics for the Mountains are available in a report titled "Forest Statistics for the Mountains of North Carolina, 2002" (Brown 2003). This report is Resource Bulletin SRS–87 and can be found on the Web at www.srs.fs.fed.us/pubs.

Historical Trends

The 2002 inventory was the seventh forest survey of North Carolina. The first one was completed in 1938 (Cruikshank 1944). They were repeated in 1956 (Larson 1957), 1964 (Knight and McClure 1966), 1974 (Knight and McClure 1975), 1984 (Sheffield and Knight 1986), and 1990 (Brown 1993). The 1938 survey recorded 18.1 million acres of timberland (fig. 4). This was a time of widespread family farms and the Great Depression era. Most of the agricultural land was in subsistence farming.

The next survey, in 1956, recorded 19.3 million acres of timberland. The 1.2 million-acre increase largely occurred from the reversion of many old fields to forest as a result of industrial expansion after World War II. During this time, much of America's population left farming for work in factories, for which many relocated to urban areas (Healy 1985).

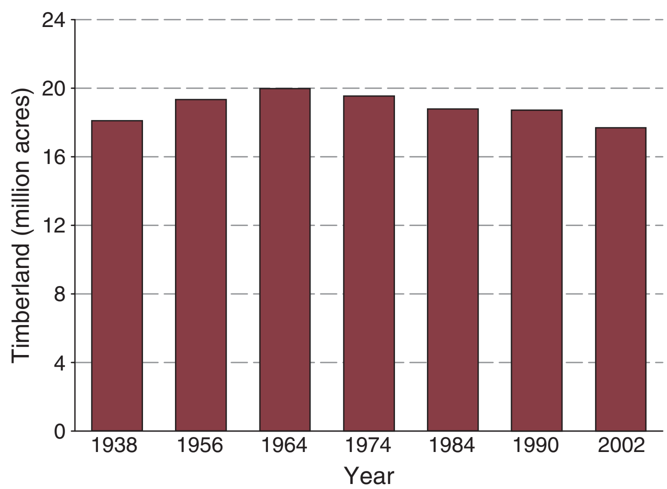

Figure 4—Trends in area of timberland in North Carolina for surveys completed in 1938, 1956, 1964, 1974, 1984, 1990, and 2002.

The trend of old fields reverting to forest continued into the 1964 survey, when timberland totaled nearly 20.0 million acres. This was the largest area of timberland recorded in any of the State's seven surveys. The 700,000-acre increase since the previous survey was also augmented by government programs and incentives for the planting of pine on many of the old fields (U.S. Department of Agriculture Soil Bank Act 1956).

By 1974, however, the increases in timberland measured by the forest survey had ended. The 1974 survey recorded 19.5 million acres of timberland in the State. The nearly 500,000-acre decline was largely driven by increased agricultural activity and the beginning of corporate farming. Much of this activity occurred in the Coastal Plain region of the State because of the flat terrain and high organic soils.

By the 1984 survey, another 800,000 acres more of timberland were removed from the State's forests, leaving 18.8 million acres in timberland. In this decade, about one-half of the loss went to agriculture and one-half to urban development. Most of the loss to urban development took place in the Piedmont region where populations and cities were beginning to grow.

In the 1990 survey, timberland totaled 18.7 million acres, a decline of $<100,000$ acres. However, this was the shortest interval between all seven surveys to date. Again, one-half the loss resulted from urban development and one-half from agricultural uses.

In 2002, area of timberland had fallen to 17.7 million acres, the smallest amount in North Carolina since the surveys began. This was the fourth consecutive survey to record a decrease in area of timberland. The decline was 1.0 million acres, a 5-percent decrease from the previous survey. Timberland accounted for 97 percent of North Carolina's forests in 2002.

The loss of timberland was the net result of changes in timberland between the last two survey periods as defined by survey plot locations either reverting, diverting, or remaining in a forest land use. These changes caused additions or gains in timberland as well as diversions or losses of timberland. These additions and diversions occurred simultaneously between surveys, and ultimately one component outweighed the other, resulting in a net gain or loss of timberland. Additions typically result from reversion or planting of old agricultural fields or pasture. Diversions typically go to urban and related land uses or clearing for cropland or pasture, but sometimes they include new lakes or other impoundments.

Between 1990 and 2002, urban and other related land uses accounted for most of the diversions of timberland (table 1). Agricultural uses, a major cause of such forest diversions in past decades, were a distant second in losses in this latest survey period. Population increases, primarily resulting from immigration to the State, were responsible for most of the increase in urbanization. The associated increases in urban infrastructure (e.g., transportation and power line rights-of-way, office and industrial parks, shopping centers and malls, schools, subdivisions, etc.) cumulatively consumed sizable areas formerly classed as timberland. Although timberland declined in all physiographic regions of the State, the Piedmont suffered the highest percentage loss, despite already being the least forested region. Timberland declined 7 percent in the Piedmont, 5 percent across the Coastal Plain, and 4 percent in the Mountain region. This is understandable since the Piedmont contains more miles of interstate and more cities with populations >100,000 than the other regions (fig. 5).

Altogether, between 1990 and 2002 in North Carolina, diversions totaled 1.6 million acres and outpaced total additions of 0.6 million acres for a net loss of 1.0 million acres. Urban and related uses accounted for 63 percent of these diversions. Agricultural uses accounted for 35 percent of the diverted acreage. New water impoundments accounted for 1 percent, and timberland transferred to a reserved status made up the final 1 percent.

Wildland-Urban Interface Issues

Plot records may indicate urban and related uses are capturing much of North Carolina's timberland, but other sources also suggest this is a growing concern for the State.

Between 1990 and 2000, North Carolina was among the fastest growing States in the country, with the sixth highest numeric population change. According to the 1990 and 2000 Federal censuses, North Carolina's population grew by >1.4 million people during this time span. The State's population increased some 21 percent from 6.6 to 8.0 million people (North Carolina Office of State Budget and Management 2001). Roughly 70 percent of this growth, almost 1 million people, was the result of net migration into

Table 1—Changes in area of North Carolina's timberland between 1990 and 2002, by region

	Area of timberland			Changes							
					Additions from			Diversions to			
Region	1990	2002	Net change	Total gain	Nonforest	Other forest land	Total loss	Other forest land	Agri-culture	Urban and other	Water
					thousand acres						
Coastal Plain	9,004,240	8,547,299	-456,941	215,012	215,012	—	671,953	15,106	249,694	396,216	10,937
Piedmont	5,751,123	5,361,185	-389,938	319,548	319,548	—	709,485	1,513	205,637	495,100	7,235
Mountains	3,955,018	3,775,932	-179,086	84,431	84,431	—	263,517	4,170	112,323	147,024	—
State	18,710,381	17,684,416	-1,025,965	618,991	618,991	—	1,644,955	20,789	567,654	1,038,340	18,172

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— = no sample for the cell.

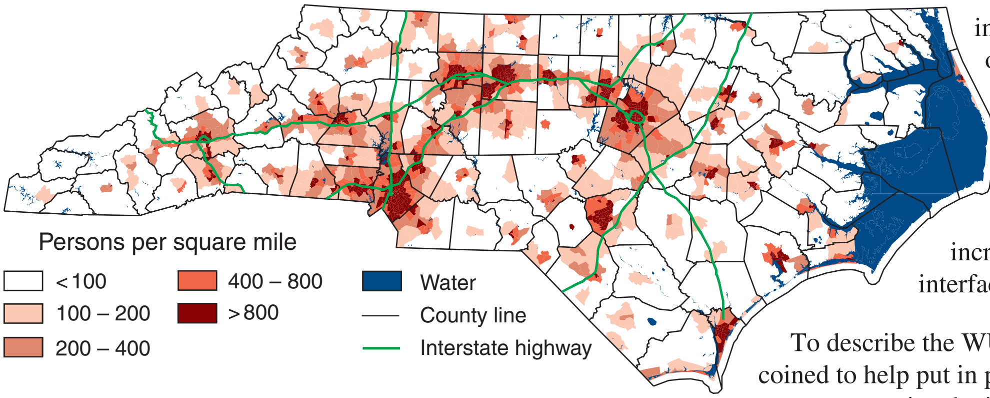


Figure 5—Population of North Carolina, 2000.

the State. The fastest growing county was Johnston with 50 percent growth. Next were Wake, Hoke, and Union Counties with 47 percent growth each. Brunswick County had nearly 44 percent and Pender County 42 percent. Three of these were Piedmont counties, and one bordered the Piedmont, and each was adjacent to major metropolitan or resort areas, which helps corroborate high timberland loss in the Piedmont. Two of these counties were along the coast where retirement and tourism interests could be driving the population influx. Some of these counties with population gains did not lose timberland. Population density may only loosely correlate with housing density, where affluent suburban society and its connected marketing/shopping/services infrastructure may consume more of the landscape than just high-density populated areas (fig. 6).

By 2030, North Carolina's population is expected to increase 50 percent from the 2000 census, adding 4 million people to reach more than 12 million in the State. Over 60 percent of this growth is expected to be from net migration into the State (North Carolina Office of State Budget and Management 2005). Much of this population growth and corresponding development is expected to impact even greater proportions of North Carolina's timberland and increase the State's wildland-urban interface (WUI) area.

To describe the WUI situation, new terms have been coined to help put in perspective the potential risks/concerns associated with population increases and urban sprawl and their impact on the landscape. Direct risks would involve wildland fire, and concerns could involve biodiversity declines, habitat degradation, introduction of nonnative and exotic species, and fragmentation of wood supply sources for area wood-using mills. In describing the WUI, Radeloff and others (2005) adopted a definition published in the Federal Register: "The wildland-urban interface is the area where houses meet or intermingle with undeveloped wildland vegetation." In their assessment of WUI extent and conditions across the coterminous United States, they separate the collective WUI into two components, intermix and interface. The interface involves homes that border against forest land (fig. 7). The intermix involves homes that are intermingled with forest land. The WUI is the combination of interface and intermix.

North Carolina ranks first nationally in both the area of land classified as intermix (11,823,478 acres) and in the area of land in the collective WUI category (12,772,756 acres) (Stewart and others 2003). This translates to 38 percent of North Carolina's land base classed as intermix and 41 percent classed as WUI (fig. 8). An intermix of homes within and among forest land is widely dispersed throughout

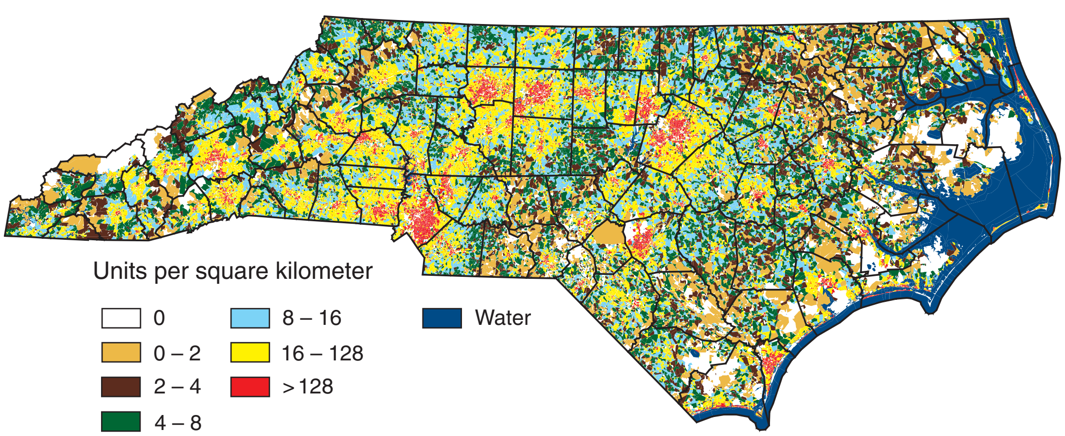


Figure 6—North Carolina housing density, 2000.

Figure 7—Wildland-urban interfaces in North Carolina's Piedmont. (photo courtesy of North Carolina Division of Forest Resources)

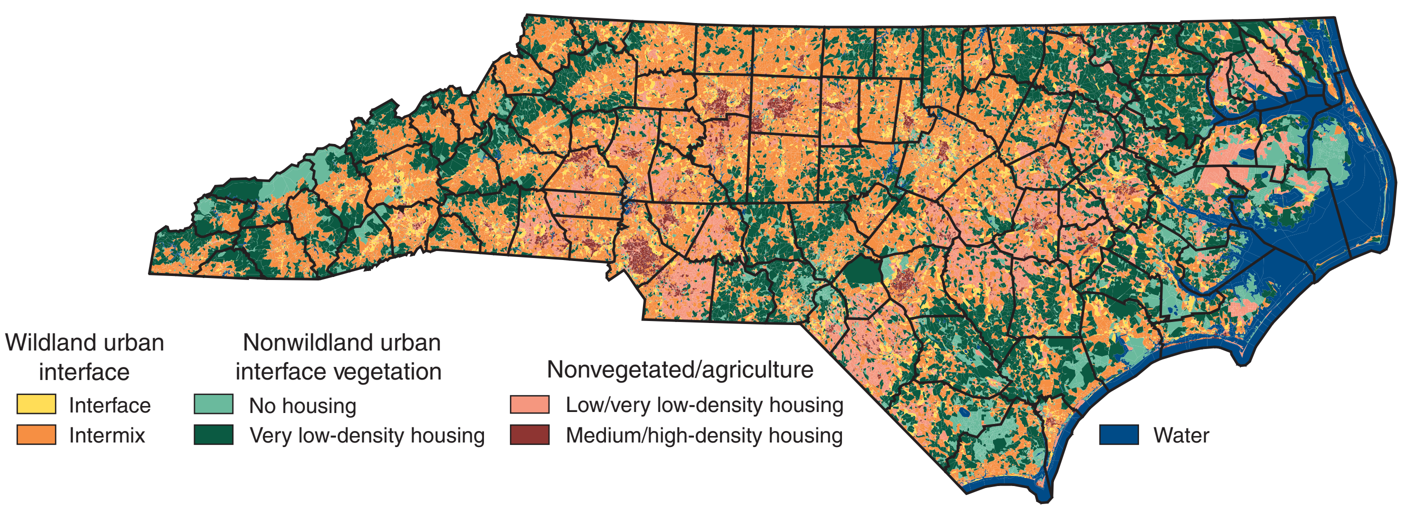


Figure 8—North Carolina wildland-urban interface, 2000.

North Carolina's Piedmont, correlating with extensive urbanization and fragmentation of forest lands (Wear and Greis 2002). Both the mountains and coastal areas also contain significant areas classified as intermix. Wear and Greis eds. (2002) identified three subregions of concern in the Southern United States where population growth and land use changes are forecasted to increase substantially over the next 20 to 40 years. All three of these subregions—Southern Appalachians, Piedmont, and Lower Atlantic and Gulf Coast Plains—occur in North Carolina.

North Carolina ranks third nationally for number of homes located in the intermix. There are 1.45 million homes intermingled with forest land in the State. North Carolina also ranks fifth nationally for number of homes in the combined WUI. There are 1.78 million homes intermingled with and bordering forest land.

Based on these figures, the State has >1,400 communities at risk from wildfire. Fire statistics from 2001 show 5,964 structures were threatened and saved, and 562 structures burned, 69 of which were homes. Structures were threatened in >70 percent of all wildfires. Between 1995 and 2004, wildfires in North Carolina destroyed 544 homes and other structures valued at >17 million dollars. During that same time period, 42,695 homes and other structures valued at >5.5 billion dollars were threatened and saved due to fire-fighting efforts.[1]

Ownership

Timberland owned by nonindustrial private individuals totaled 11.4 million acres and accounted for 65 percent of all timberland in the State (fig. 9). Timberland owned by private nonindustrial corporations totaled 2.4 million acres and accounted for 14 percent of all timberland. Together, these individual and corporate timberlands comprise the NIPF landowner category. NIPF timberland totaled 13.8 million acres, or about 78 percent of the State's timberland. Overall, the NIPF category declined 5 percent in timberland acreage since 1990. However, hidden within this change were diametrically opposed changes for the groups comprising the category. The 11.4 million acres in the private individual group declined by 9 percent since 1990 (fig. 10A) and has been declining for several decades. In contrast, the 2.4 million acres in the private corporate group increased by 22 percent since 1990 (fig. 10B) and has been increasing for decades. This signifies either a real change in ownership from private individuals to entities like timber investment management organizations (TIMO's), or a trend toward incorporation by private landowners, or both. NIPF ownership varied between regions of the State. The proportion of a region's timberland under NIPF ownership was highest in the Piedmont; NIPF owners controlled 93 percent of the timberland in that region. The proportion under NIPF ownership was 72 percent across the Coastal Plain and 71 percent in the Mountains.

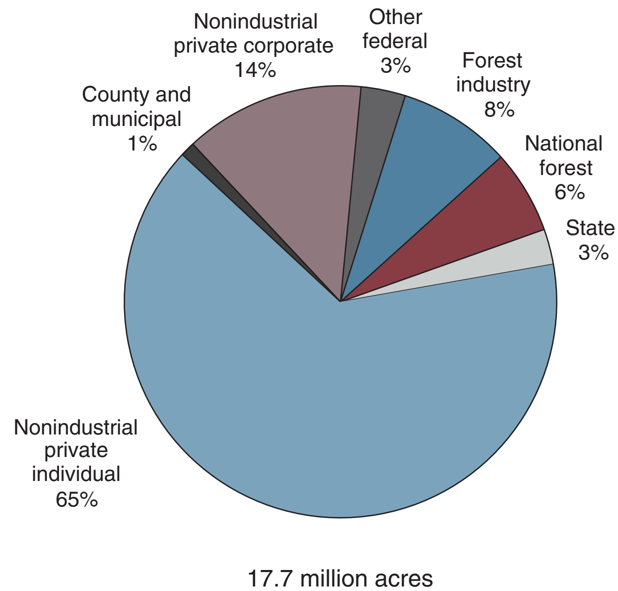


Figure 9—Area of timberland by ownership in North Carolina for the 2002 survey.

Timberland owned by forest industry totaled 1.5 million acres and accounted for 8 percent of all timberland in the State. Since 1990, forest industry ownership of timberland has decreased by 33 percent (fig. 10C). Forest industry holdings in the State have been declining since the 1980s, when they peaked at 2.3 million acres. In 2002, forest industry ownership was concentrated in the Coastal Plain. Forest industry ownership accounted for 16 percent of the Coastal Plain timberland. Forest industry owned only 2 percent of the Piedmont timberland and just 1 percent of the timberland in the Mountains.

Timberland owned by all public agencies totaled nearly 2.4 million acres and accounted for 13 percent of all timberland in the State. Public ownership of timberland has continued to increase (fig. 10D), by about 20 percent since 1990. National forest system (NFS) lands comprised almost one-half (47 percent) of the State's publicly owned timberland (fig. 11) with 1.1 million acres. Miscellaneous Federal lands,

[1] North Carolina Division of Forest Resources. Annual fire reports, 1995 to 2004. Unpublished data. On file with: North Carolina Department of Environment and Natural Resources, 1616 Mail Service Center, Raleigh, NC 27699-1616.

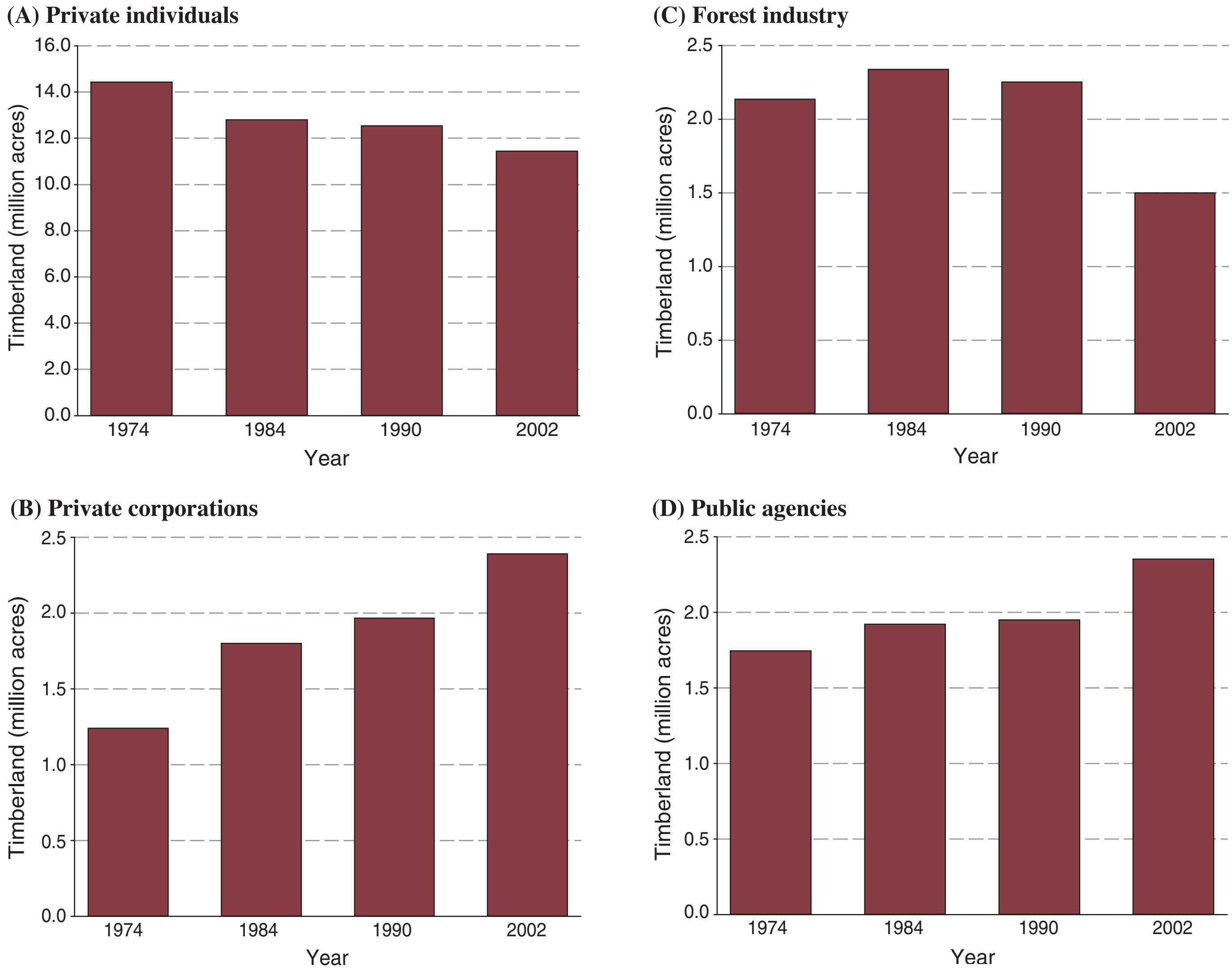


Figure 10—Trends in timberland in North Carolina by ownership for surveys completed in 1974, 1984, 1990, and 2002 (A) Private individuals, (B) Private corporations, (C) Forest industry, and (D) Public agencies.

primarily military lands, accounted for 586,000 acres, equal to one-fourth of the total public timberland. State ownership of timberland accounted for 469,000 acres or about one-fifth of all public timberland. Local governments made up the remaining 192,000 acres of public timberland. The area of NFS lands has remained somewhat stable for decades, with 85 percent of it located in the Mountains. However, each of the other categories of public timberland has continued to increase during this time. Publicly owned timberland was not equally distributed among the regions. Public ownership was highest in the Mountains—28 percent of the timberland—largely due to NFS holdings. Public ownership accounted for 12 percent of the Coastal Plain timberland, largely a combination of military, national forest, and State forest holdings. The lowest proportion and the fewest acres were found in the Piedmont, where just 5 percent of the timberland was under public ownership.

The National Woodland Ownership Survey (NWOS) (Butler and others 2005) conducted by the Forest Service is a nationwide effort to identify landowner opinions, goals, management styles, and concerns involving forest land in the NIPF category. Similar efforts were conducted in 1994 about the private forest landowners of the United States (Birch 1996) and for the Southern United States as well (Birch 1997). In the recent ownership survey, mail-out questionnaires and telephone surveys were conducted on a subset of the forest inventory sampled ownerships. The

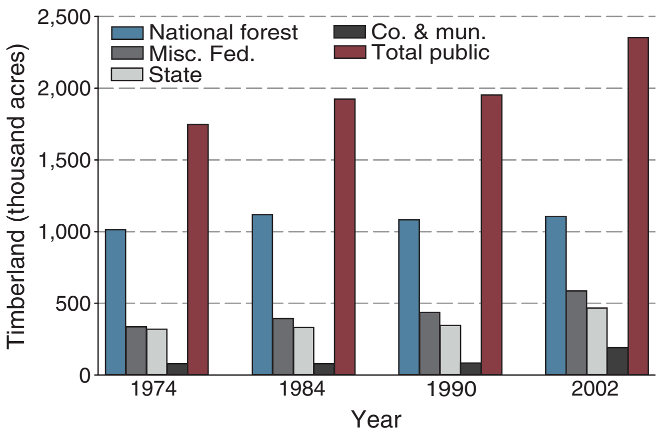


Figure 11—Detailed trends in timberland owned by public agencies in North Carolina for surveys completed in 1974, 1984, 1990, and 2002.

objectives were to better understand what is important to the owners of family forests (i.e., private individual ownership) in the United States. North Carolina was sampled to a lesser degree than some of the Nation's other States, and the responses were compiled and summarized in aggregate to protect privacy.

The NWOS sampled 313 family forest owners in North Carolina between 2002 and 2004. Summarized responses were developed from the return of 221 questionnaires and completion of 92 telephone surveys. Statistically, family forests accounted for 11.4 million acres or 63 percent of the 18.3 million acres of forest land (i.e., timberland plus reserved and other forest land) in the State (table 2). North Carolina's percentage of forest land under family forest ownership ranked higher than the southern average of 59 percent or the northern average of 55 percent and the western average of 17 percent. Findings indicated that there were 479,000 family forest owners comprising the

Hiking in the Uwharrie National Forest. (Photo by Bill Lea)

11.4 million acres in the category. However, only 213,000 of these owners have tracts 10 acres or larger (table 3). These owners controlled 91 percent or 10.4 million acres of family forest land. The number of family forest owners drops significantly again when considering tracts 50 acres and larger, which accounted for 62 percent or 7.1 million acres of total family forest land. By age, 58 percent of the State's family forest owners are at least 55 years old (table 4). This group controlled 69 percent or 7.9 million acres of the family forest land. About one-half of the family forest owners have some college background (table 5),

Table 2—Forest land area in North Carolina by ownership type, 2004

All	Public				Private		
ownerships	Total[a]	Federal[a]	State[a]	Local[a]	Total[a]	Family	Business[b]
				thousand acres			
18,269	2,932	2,157	582	192	15,337	11,443	3,894
(180)	(72)	(43)	(32)	(18)	(165)	(142)	(83)

Data may not add to totals because of rounding.

Numbers in parentheses are standard errors.

[a] Source: *Forest Resources of the United States, 2002* (Smith and others 2004).

[b] Includes corporations, nonfamily partnerships, tribal lands, nongovernmental organizations, clubs, and other nonfamily groups.

Table 3—Area and number of family-owned forests in North Carolina by size of forested landholdings, 2004

Size of forested landholdings	Area: Acres	Area: Standard error	Area: Percent	Ownerships: Number	Ownerships: Standard error	Ownerships: Percent	Count
acres	- - - *thousand* - - -			- - - - *thousand* - - - -			
1 – 9	1,060	236	9.3	266	58	55.5	29
10 – 19	1,097	238	9.6	85	15	17.7	30
20 – 49	2,230	293	19.5	75	9	15.7	61
50 – 99	1,938	282	16.9	30	4	6.3	53
100 – 499	3,363	328	29.4	21	2	4.4	92
500 – 999	695	210	6.1	1	<1	0.2	19
1,000 – 4,999	987	231	8.6	1	<1	0.1	27
5,000 +	73	151	0.6	<1	<1	<0.1	2
Total	11,443	142	100.0	479	58	100.0	313

Table 4—Area and number of family-owned forests in North Carolina by age of owner, 2004

Age	Area: Acres	Area: Standard error	Area: Percent	Ownerships: Number	Ownerships: Standard error	Ownerships: Percent	Count
years	- - - *thousand* - - -			- - - - *thousand* - - - -			
< 35	243	179	2.1	57	49	11.9	5
35 – 44	536	213	4.7	14	6	2.9	11
45 – 54	1,802	307	15.7	98	32	20.5	37
55 – 64	2,630	345	23.0	126	35	26.3	54
65 – 74	2,922	356	25.5	93	18	19.4	60
75 +	2,337	333	20.4	58	11	12.1	48
No answer	974	253	8.5	33	11	6.9	20

Table 5—Area and number of family-owned forests in North Carolina by highest level of formal education, 2004

Highest level of educational attainment	Area: Acres	Area: Standard error	Area: Percent	Ownerships: Number	Ownerships: Standard error	Ownerships: Percent	Count
	- - - *thousand* - - -			- - - - *thousand* - - - -			
12th grade or lower	1,206	245	10.5	68	19	14.2	33
High school or equivalent	2,632	308	23.0	129	26	26.9	72
Some college	1,901	280	16.6	88	21	18.4	52
Associate degree	951	228	8.3	28	9	5.8	26
Bachelor degree	2,413	300	21.1	76	39	15.9	66
Graduate degree	1,462	259	12.8	62	27	12.9	40
No answer	877	223	7.7	30	11	6.3	24

and they are predominantly white (table 6). From a list of eleven reasons for owning forest land, nontimber forest products ranked first in area of forest land controlled (table 7). Owning forest land for land investment purposes and for aesthetics ranked second and third, respectively. The purposes of firewood production and timber production ranked the two lowest in importance to North Carolina's family forest owners. However, based upon reported most recent forestry activities, timber harvest and tree planting ranked third and fourth after posting of land and private recreation (table 8). Written management plans existed on just 23 percent of the family forest land (table 9). Only 39 percent of the family forest land received management advice. State forestry agencies followed by consultants led the sources of management advice. Chief concerns of family forest owners (table 10) were fire, family legacy, and insects or diseases. Behind these top three were storm damage, property taxes, and trespassing. Ironically, compared with area ranking of reasons for owning forest land, the harvest of saw logs or pulpwood was first in area based on near future plans for the forest land (table 11).

Table 6—Area and number of family-owned forests in North Carolina by ethnicity and race, 2004

	Area			Ownerships			
Ethnicity and race	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - thousand - - -			*- - - - thousand - - - -*			
Ethnicity							
Hispanic or Latino	49	150	0.4	0	0	0.0	1
Non-Hispanic/Latino	9,885	293	86.4	435	67	90.8	203
No answer	1,510	290	13.2	43	13	9.0	31
Race[a]							
White	10,372	260	90.6	439	68	91.6	213
Black or African-American	146	165	1.3	9	5	1.9	3
American Indian or Alaska Native	195	172	1.7	9	5	1.9	4
Asian	49	150	0.4	0	0	0.0	1
Native Hawaiian or other Pacific Islander	146	165	1.3	7	5	1.5	3
Other	0	0	0.0	0	0	0.0	0
No answer	828	240	7.2	25	10	5.2	17

[a] Categories are not exclusive.

Firewood harvest. (SRS photo)

Table 7—Area and number of family-owned forests in North Carolina by reason for owning forest land, 2004

	Area			Ownerships			
Reason[a]	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - thousand - - -			*- - - - thousand - - - -*			
Aesthetics	6,288	352	55.0	312	55	65.1	172
Nature protection	5,411	353	47.3	212	35	44.3	148
Land investment	6,471	351	56.5	254	49	53.0	177
Part of farm, home, or cabin[b]	3,802	337	33.2	186	33	38.8	104
Privacy	5,591	413	48.9	152	36	31.7	107
Family legacy	5,228	353	45.7	271	50	56.6	143
Nontimber forest products	7,495	339	65.5	307	49	64.1	205
Firewood production	1,316	251	11.5	51	18	10.6	36
Timber production	1,206	245	10.5	27	7	5.6	33
Hunting or fishing	4,204	343	36.7	66	15	13.8	115
Other recreation	3,656	334	31.9	85	15	17.7	100
No answer	2,486	303	21.7	125	41	26.1	68

Numbers include landowners who ranked each objective as very important (1) or important (2) on a seven-point Likert scale.

[a] Categories are not exclusive.

[b] Includes primary and secondary residences.

Table 8—Area and number of family-owned forests in North Carolina by recent (past 5 years) forestry activity, 2004

	Area			Ownerships			
Activity[a]	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - thousand - - -			*- - - - thousand - - - -*			
Timber harvest	3,798	380	33.2	61	14	12.7	78
Collection of NTFPs[b]	633	222	5.5	23	16	4.8	13
Site preparation	1,938	282	16.9	44	22	9.2	53
Tree planting	3,071	320	26.8	73	24	15.2	84
Fire hazard reduction	1,609	266	14.1	29	9	6.1	44
Application of chemicals	1,097	238	9.6	22	9	4.6	30
Road/trail maintenance	3,034	319	26.5	48	11	10.0	83
Wildlife habitat improvement	1,536	263	13.4	29	14	6.1	42
Posting land	4,912	409	42.9	113	26	23.6	94
Private recreation	4,441	404	38.8	98	21	20.5	85
Public recreation	784	242	6.9	19	10	4.0	15
Cost share	2,011	285	17.6	22	12	4.6	55
Conservation easement[c]	292	102	2.6	1	1	0.2	8
Green certification[c]	329	179	2.9	1	0	0.2	9

[a] Categories are not exclusive.

[b] NTFPs = nontimber forest products.

[c] Not limited to past 5 years.

Table 9—Area and number of family-owned forests in North Carolina by management plan and advice sought, 2004

Management plan and advice sought	Area			Ownerships			
	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - thousand - - -			*- - - - thousand - - - -*			
Written management plan							
Yes	2,632	308	23.0	18	4	3.8	72
No	7,897	332	69.0	417	57	87.1	216
No answer	914	226	8.0	44	14	9.2	25
Sought advice							
Yes	4,460	346	39.0	63	14	13.2	122
No	6,581	350	57.5	394	57	82.3	180
No answer	402	186	3.5	22	11	4.6	11
Advice source[a]							
State forestry agency	2,705	310	23.6	41	13	8.6	74
Extension	731	213	6.4	7	2	1.5	20
Other state agency	73	151	0.6	0	0	0.0	2
Federal agency	658	207	5.8	4	2	0.8	18
Private consultant	2,047	286	17.9	13	4	2.7	56
Forest industry forester	841	221	7.3	5	2	1.0	23
Logger	695	210	6.1	7	3	1.5	19
Other landowner	548	198	4.8	5	3	1.0	15

Data may not add to totals because of rounding.

[a] Categories are not exclusive.

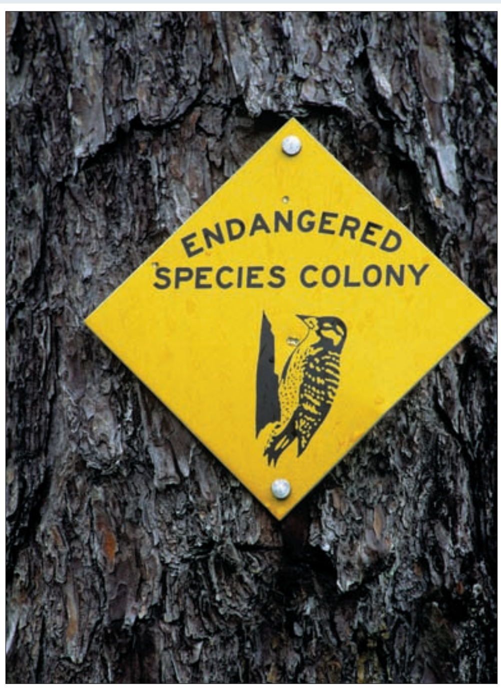
Management considerations in a loblolly pine plantation. (SRS photo)

Table 10—Area and number of family-owned forests in North Carolina by landowners' concerns, 2004

Concern[a]	Area			Ownerships			
	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - *thousand* - - -			- - - - *thousand* - - - -			
Endangered species	3,263	366	28.5	116	51	24.2	67
Property taxes	6,184	399	54.0	228	41	47.6	127
Family legacy	6,671	395	58.3	211	34	44.1	137
Lawsuits	2,630	345	23.0	155	57	32.4	54
Harvesting regulations	3,896	382	34.0	164	56	34.2	80
Land development	3,019	359	26.4	80	15	16.7	62
Noise pollution	2,337	333	20.4	79	21	16.5	48
Trespassing	5,405	400	47.2	222	58	46.3	111
Timber theft	2,581	343	22.6	114	33	23.8	53
Dumping	5,162	398	45.1	215	40	44.9	106
Air or water pollution	4,334	390	37.9	152	25	31.7	89
Exotic plant species	2,435	338	21.3	76	15	15.9	50
Domestic animals	730	232	6.4	22	9	4.6	15
Wild animals	1,656	299	14.5	58	14	12.1	34
Fire	6,817	394	59.6	195	34	40.7	140
Insects/diseases	6,525	397	57.0	163	25	34.0	134
Regeneration	2,240	329	19.6	47	10	9.8	46
Storms	6,233	399	54.5	181	32	37.8	128

Numbers include landowners who ranked each issue as a very important (1) or important (2) concern on a seven-point Likert scale.

[a] Categories are not exclusive.



Red-cockaded woodpecker colony location sign. (SRS photo)

Table 11—Area and number of family-owned forests in North Carolina by landowners' future (5-year) plans for their forest land, 2004

	Area			Ownerships			
Future plans[a]	Acres	Standard error	Percent	Number	Standard error	Percent	Count
	- - - *thousand* - - -			- - - - *thousand* - - - -			
No activity	2,523	304	22.0	121	27	25.3	69
Minimal activity	2,596	306	22.7	52	13	10.9	71
Harvest firewood	1,499	261	13.1	32	7	6.7	41
Harvest saw logs or pulpwood	2,669	309	23.3	25	6	5.2	73
Collect NTFPs[b]	390	197	3.4	3	1	0.6	8
Sell all or part of land	731	213	6.4	11	5	2.3	20
Transfer all or part of land to heirs	1,718	272	15.0	42	10	8.8	47
Subdivide all or part of land	146	160	1.3	3	2	0.6	4
Buy more forestland	1,133	240	9.9	75	43	15.7	31
Land use conversion (forest to other)	292	175	2.6	10	6	2.1	8
Land use conversion (other to forest)	475	192	4.2	5	2	1.0	13
No current plans	1,609	266	14.1	53	13	11.1	44
No answer	73	151	0.6	2	1	0.4	2

[a] Categories are not exclusive.

[b] NTFPs = nontimber forest products.

Forest-Type Groups

Due to the numerous and diverse forest types across the State, groupings were used to portray the make-up of forests and the recent trends in their area (fig. 12). Oak-hickory types were clearly the predominant forest-type group in the State, covering some 7.3 million acres. This type group increased in area by 5 percent since 1990 and accounted for 41 percent of the State's timberland in 2002.

The loblolly-shortleaf pine type group was second in abundance and covered 4.5 million acres. This group included Virginia pine and pond pine types as well. The loblolly-shortleaf group decreased in area by 19 percent since 1990 and accounted for 25 percent of all timberland in 2002. Some of the reduction in the area of loblolly-shortleaf group certainly resulted from heavy impact by pine beetles since the previous survey. Planted stands accounted for 44 percent of the loblolly-shortleaf group (fig. 12), or nearly 2.0 million acres. The acres of the planted loblolly-shortleaf group rose only slightly, but their proportion of the type group increased as a result of the overall total acreage decline.

Young longleaf pine stand. (SRS photo)

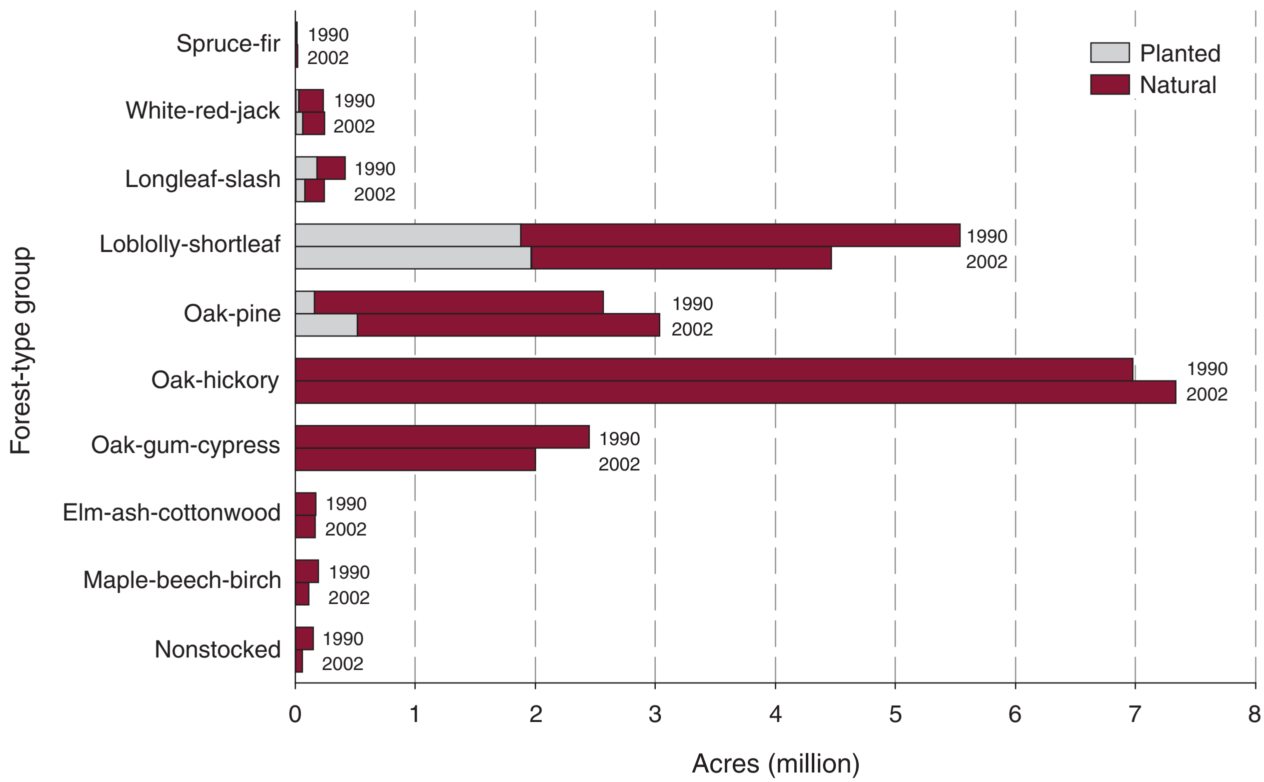


Figure 12—Area of timberland by forest-type group, stand origin, and year of survey, North Carolina.

Area of oak-pine type group increased 18 percent to 3.0 million acres. The area of planted oak-pine more than tripled. In the 2002 survey, 17 percent of the oak-pine stands had evidence of planting. Planted oak-pine stands have usually resulted from significant hardwood competition and stocking ratios that precluded classification as a pine type. Many of these stands originated as pine plantations. Over time and due to natural succession, hardwoods invaded and thrived, and the distribution of species changed to a mixed stand. Planting without site preparation or lack of other stand treatments would expedite the change in type.

The area of the oak-gum-cypress type group decreased 18 percent to 2.0 million acres. The forces behind this change are unclear. Possibly reclassification to oak-hickory or oak-pine types captured some of these acres. Slight changes in stocking, particularly for samples located in transition zones, can alter type classification. Another possible explanation may reside in the change of sample designs between surveys. This change in design is explained in the Inventory Methods section of this report.

The longleaf-slash pine type group dropped from 230,000 to 156,000 acres. In fact, all the yellow pine types within these groupings decreased in acreage. Only the white pine type increased in area, although minimal, as evidenced by the white-red-jack pine group increase.

All regions were dominated by hardwood types. However, their dominance differed by region. Hardwood types accounted for 90 percent of the Mountain timberland, 74 percent of the Piedmont, and 62 percent of the Coastal Plain. As one might expect, hardwood types were mostly upland in the Mountains and lowland in the Coastal Plain.

Cove hardwood forest. (photo by Bill Lea)

Forest-Management Types

Timberland in the preceding ten forest-type groups was consolidated into fewer categories, namely six forest-management types, based on a combination of stocking and stand origin. The six management types are pine plantation, natural pine, oak-pine, upland hardwood, lowland hardwood, and nonstocked. This was done to simplify the State's timber resource and facilitate an easier portrayal of the resource revolving around these types.

Statewide, the area classified as pine plantation increased only slightly (fig. 13). With 2.1 million acres, pine plantations accounted for 12 percent of the State's timberland. However, this was not evenly distributed across the State. Seventy-four percent of all pine plantations in the State occurred in the Coastal Plain, where 18 percent of the timberland was in pine plantations. Pine plantations made up 9 percent of the Piedmont timberland and just 2 percent of the Mountain timberland. Although North Carolina had a 17-percent increase in area exhibiting some form of planting evidence (2.6 million acres), pine plantations were not the driving force. The increase largely came from within the additional 0.5 million acres planted but classified as oak-pine types because of stocking ratios. FIA does not classify stands as a pine type unless pines constitute a plurality of the stocking. It was the increase in planted oak-pine stands that contributed to the overall increase in stands with planting evidence. Oak-pine type, which increased, as mentioned in the previous section of this report, totaled 3.0 million acres. Oak-pine accounted for 17 percent of all timberland in the State in 2002. Some of the overall increase in the oak-pine type resulted from pine mortality in former pine types, which caused reclassification to oak-pine based on new stocking ratios. Probable causes include death from insects, disease, or weather. For instance,

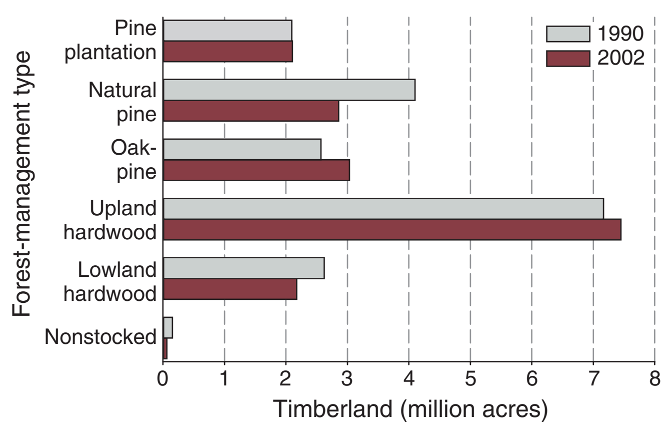


Figure 13—Area of timberland by forest-management type in North Carolina for surveys completed in 1990 and 2002.

a pine type formerly stocked with 85 percent pine and 15 percent hardwood that was decimated by beetles, and where the surviving stocking percentage is 40 percent pine and 60 percent hardwood, now would be classified as an oak-pine type.

Most notably, the area of natural pine stands decreased 30 percent, to 2.9 million acres. Natural pine stands made up 16 percent of all timberland in 2002, compared with 22 percent in 1990. The decline in area of natural pine stands continued a decades-long trend.

Area of upland hardwood types increased 4 percent to 7.4 million acres. Upland hardwood stands accounted for 42 percent of the State's timberland. The area classified in lowland hardwood types decreased 17 percent to 2.2 million acres. Lowland hardwood stands comprised 12 percent of timberland in the State.

Stands from these six forest-management types were classified and distributed among 10-year age classes based on ages of representative trees from the manageable stands present on sample plots. There were notable age structure differences between the forest-management type categories. There were also notable differences over time in the age distribution within some of the forest-management types.

For stands classified as pine plantations (fig. 14A), it was clear that most pine plantations in the State were <30 years old. Very few pine plantations in the State were >40 years old. This suggested that most pine plantations are harvested beginning around 30 years old or change composition through succession. Another indication was that few plantations were established before the 1970s. Since 1990, the reduction in plantations <10 years old and the increase in plantations >30 years old, could indicate fewer or less successful establishment of plantations in the 1990s compared with the 1980s.

For stands classified as natural pine, the age structure was quite different from that for pine plantations (fig. 14B). It was clear that most older pine stands in North Carolina were natural pine stands. The natural pine age structure was also more evenly distributed across the age classes than pine plantations were. Perhaps most notable were sizable reductions that occurred in natural pine stands between 30 and 60 years old. Possibly these reductions were reflected in the decline of shortleaf pine, pond pine, and Virginia pine within the State in lieu of loblolly pine. However, this is also an effect of the impact of pine beetles on all yellow pine types in the State.

The oak-pine age distribution (fig. 14C) somewhat resembled the pine plantation structure for the youngest age classes. For the older age classes, oak-pine more closely emulated the natural pine age structure. Since 1990, some of the oak-pine increase in the 0- to 10-year age class may be correlated to the decrease in pine plantations in the 0- to 10-year age class that failed to achieve plurality of pine stocking. Oak-pine type increased in all age classes through 40 years.

Upland hardwood types (fig. 14D) were dominated by stands >40 years old. However, the area of younger stands increased. Lowland hardwood types (fig. 14E) differ in age distribution from the upland types and appeared more evenly distributed across the age classes. This was particularly evident after declines in age classes >40 years old since 1990. The declines in older lowland hardwood stands could have resulted from mortality after flooding or storm damage. Another possibility is greater interest in lowland hardwoods as a wood source because of and coinciding with declines in area of natural pine.

Cypress in lowland hardwood stand. (SRS photo)

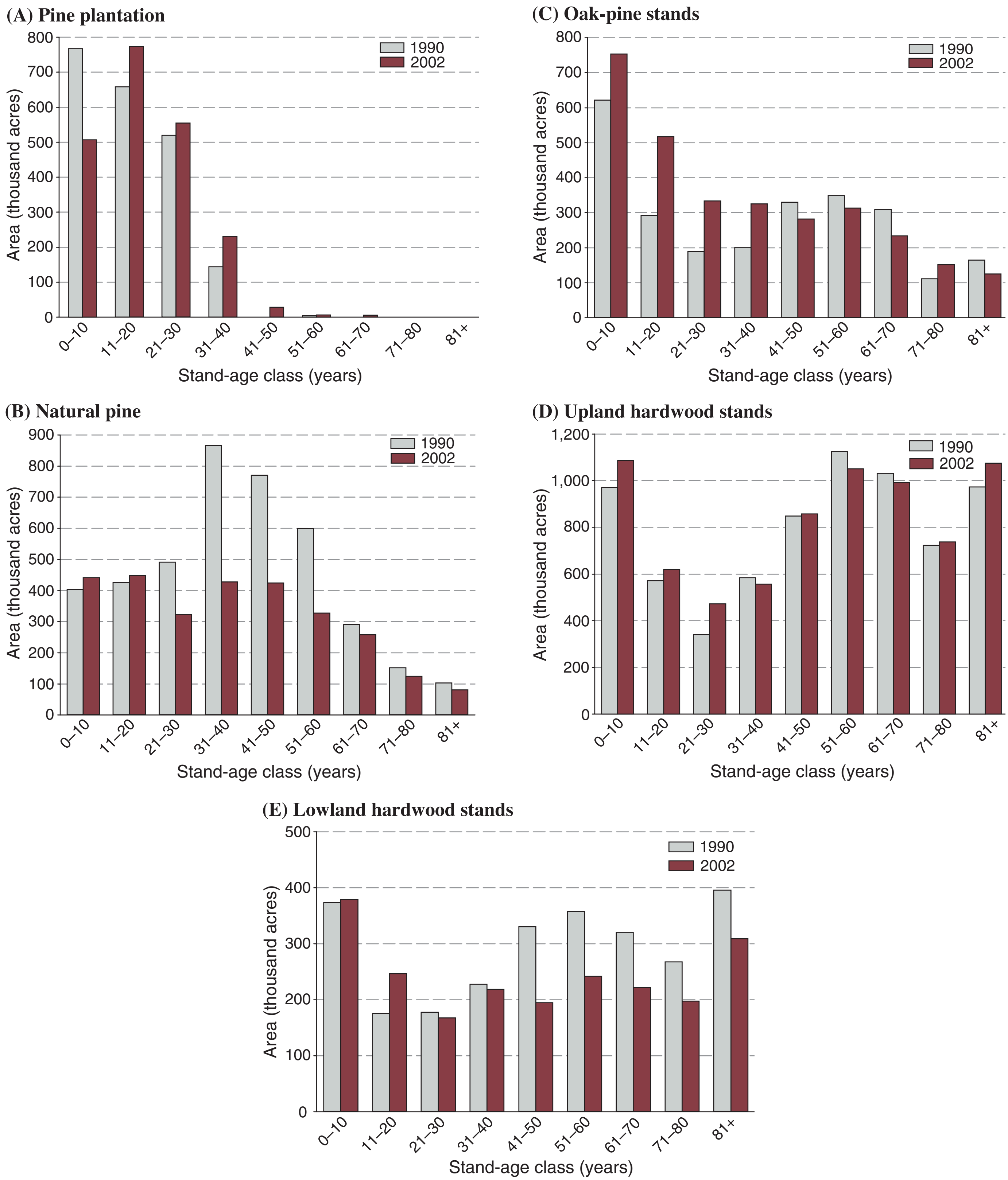


Figure 14—Changes in area of timberland by forest management and stand-age class in North Carolina for surveys completed in 1990 and 2002 (A) Pine plantation, (B) Natural pine, (C) Oak-pine stands, (D) Upland hardwood stands, and (E) Lowland hardwood stands.

Prescribed burn in longleaf pine stand. (SRS photo)

Invasive Exotic Species

Nonnative species and exotic invasions in North Carolina's forests are a particular concern. Limited information exists, however, about their impact. The perceived threat to forested areas from invasive plants arises from nonnative species directly damaging forest resources, occupying areas that might otherwise contain a more diverse native flora, and transforming ecological processes that impact wildlife habitat and other values. Earlier surveys of the State contained a few easily recognized nonnative invasive species as part of an understory vegetation survey. Among the species noted was Japanese honeysuckle. Probability-of-occurrence maps produced from the 1990 survey (largely based on samples of interior forests) indicate Japanese honeysuckle distributed at lower frequencies in the Coastal Plain and Mountains, and at higher frequencies elsewhere (fig. 15). Speculation about its apparent distribution is that Japanese honeysuckle persists in the formerly highly disturbed and comparatively fertile soils of the Southern mixed forest province (Rudis and others, in press).

Miller (2003) provides information on selected invasive plant species of concern across the South. Inventories documenting the occurrence and areal cover of most of these species were incorporated in North Carolina beginning in late 2002. Observations are ongoing, but too few samples were processed as of this writing to provide area estimates or to test associations with other forest attributes by species.

Comparative sample frequencies based on one-fifth of systematically located samples throughout the State serve as a guide to what one might expect once the full survey is completed. Of the 711 forest locations surveyed between December 2002 and January 2004, 47 percent of the locations were infested, with Japanese honeysuckle, privet, and

Japanese honeysuckle. (SRS photo)

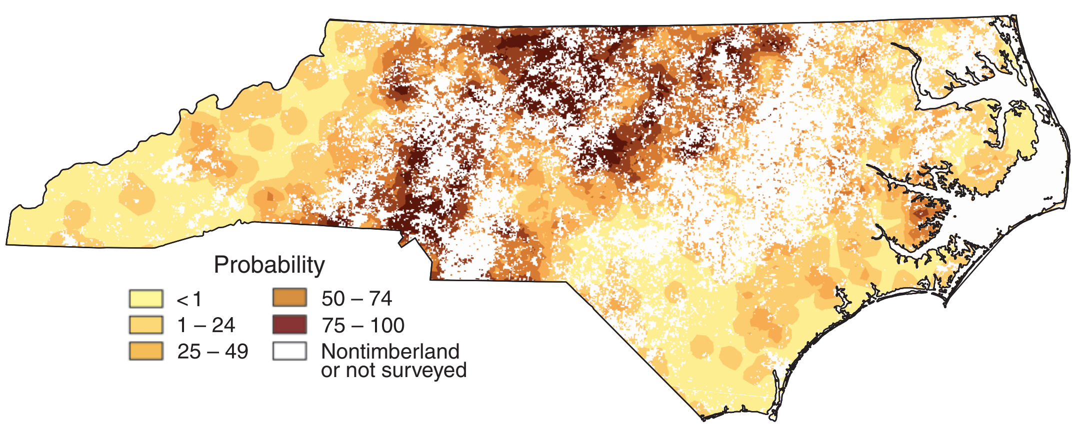


Figure 15—Probability of Japanese honeysuckle occurrence on timberland, North Carolina, 1990.

Kudzu. (photo by Rod Kindlund)

exotic roses heading the list (table 12). As elsewhere in the South (Rudis and others, in press), kudzu ranks low on this list, as it is found more commonly at the forest edge than the forest interior. In general, the data suggest bird-dispersed and shade-tolerant species are more widespread within forests.

Insects, Diseases, and Weather

Natural disturbances to forests are continuously occurring factors affecting tree growth and survival. However, sometimes these disturbance cycles spike and impact large areas of forest. Between 1990 and 2002, a variety of insects, pathogens, and weather-related events took their toll on North Carolina's forests. The resultant mortality can be sizable. In fact, between 1990 and 2001, mortality from all sources averaged 426 million cubic feet of wood per year across the State.

Pine beetles had the greatest overall impact on the State's forests. This was largely due to their persistence as a pest

Southern pine beetle infestation. (SRS photo)

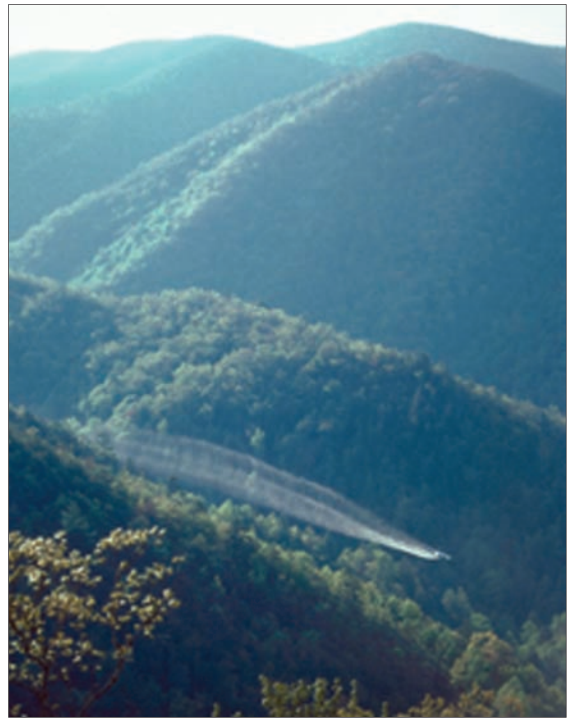
Table 12—Relative frequency of selected invasive plant taxa inventoried by forested subplot, North Carolina, December 2002 to January 2004

Taxa	Relative frequency
	percent
Japanese honeysuckle	58.5
Privet spp.	20.5
Exotic roses	9.3
Chinese lespedeza	3.5
Autumn olive	1.9
Bush honeysuckles	1.9
Exotic bamboos	1.2
Tree-of-heaven	1.1
Mimosa	1.0
Nepalese browntop	1.0
Shrubby lespedeza	0.8
Royal paulownia	0.7
Chinese/Japanese wisteria	0.4
Chinese tallowtree	0.3
Oriential/Asian bittersweet	0.3
Exotic climbing yams	0.3
Kudzu	0.3
Tall fescue	0.3
Vinca	0.3
Winged burning bush	0.2
Wintercreeper	0.2
Chinaberry	0.1
Chinese silvergrass	0.1
Garlic mustard	0.1
All taxa above	100.0
Number of subplot infestations by taxa for all taxa[a]	1,049.0

[a] Taxa selected for the survey included the following trees: *Ailanthus altissima* (Mill.) Swingle, *Albizia julibrissin* Durazz, *Paulownia tomentosa* (Thunb.) Sieb. & Zucc. ex Steud., *Melia azedarach* L., *Triadica sebifera* (L.) Small, *Elaeagnus angustifolia* L.; shrubs: *E. pungens* Thunb., *E. umbellata* Thunb., *Ligustrum sinense*, Lour., *L. vulgare* L., *L. japonicum* Thunb., *L. lucidum* Ait.f., *Lonicera* spp., *Nandina domestica* Thunb., *Rosa* spp.; vines: *Celastrus orbiculatus* Thunb., *Dioscorea bulbifera* L., *D. oppositifolia* L., *Euonymus fortunei* (Turcz.) Hand.-Maz., *Lonicera japonica* Thunb., *Pueraria montana* (Lour.) Merr., *Vinca* spp., *Wisteria* spp.; grasses: *Arundo donax* L., *Lolium arundinaceum* (Schreb.) S.J. Darbyshire, *Imperata cylindrica* (L.) Beauv., *Microstegium vimineum* (Trin.) A. Camus, *Miscanthus sinensis* Anderss., nonnative bamboo; ferns: *Lygodium japonicum* (Thunb. ex Murr.) Sw.; and forbs: *Alliaria petiolata* (Bieb.) Cavara & Grande, *Lespedeza bicolor* Turcz., *L. cuneata* (Dum.-Cours.) G. Don, *Solanum viarum* Dunal. (U.S. Department of Agriculture Natural Resources Conservation Service 2006)

year after year. In terms of area affected, between 1990 and 2002 the biggest spikes came in 1995, 1998, and again in 2002 (table 13). Outbreaks were largely confined to the Piedmont and Coastal Plain regions of the State in the early 1990s. From 1999 to 2002, the outbreaks were concentrated in the Mountains and Western Piedmont areas of the State.

Other insects of concern include the gypsy moth and hemlock wooly adelgid. The gypsy moth is advancing toward North Carolina, with the front of the infestation located in Virginia along the North Carolina border. The USDA Forest Service (along with affected States) "Slow the Spread" program has held it there for several years. Treatment has been confined to spot infestations. Some slight defoliation has caused mortality in the Dare, Currituck, and Camden County area. The hemlock wooly adelgid has been confirmed (2005 survey) generally infesting hemlocks (Eastern and Carolina) throughout the range of hemlocks in the State (Mountains and Western Piedmont). Some mortality is beginning to show in older trees.



Mountain view of aerial gypsy moth spray, Nantahala National Forest, Clay County, NC. (photo by Donald F. Rogers, North Carolina Division of Forest Resources, www.forestryimages.org)

Table 13—Mortality correlations for North Carolina

Event	Year	Area affected	Mortality			Value	Area affected
		acres	*cords*	*mbf*[a]	*ccf*[b]	*dollar*	
Pine beetle	1990	1,476,000	4,153	520	4,414	54,000	Piedmont
Pine beetle	1991	761,000	718	5,356	7,609	796,000	Piedmont
Pine beetle	1992	1,442,000	37,406	31,998	75,263	5,168,000	Piedmont, Northern Coastal Plain
Pine beetle	1993	2,149,000	20,009	25,881	51,653	4,671,000	Piedmont, Northern Mountains, Southern Coastal Plain
Pine beetle	1994	1,528,000	24,528	8,882	33,622	2,014,000	Piedmont, Northern and Southern Coastal Plain
Pine beetle	1995	3,999,000	86,169	780,155	1,091,754	20,456,000	Piedmont, Northern and Southern Coastal Plain
Pine beetle	1996	2,595,000	12,540	17,043	33,442	4,029,000	Piedmont, Northern and Southern Coastal Plain
Pine beetle	1997	2,387,000	1,352	3,650	5,962	890,000	Central Mountains, Piedmont, Southern Coastal Plain
Pine beetle	1998	6,451,000	1,379	1,311	2,945	324,000	Piedmont, Northern and Southern Coastal Plain
Pine beetle	1999	1,817,000	19,235	15,724	37,753	3,947,000	Mountains, Western Piedmont
Pine beetle	2000	1,526,000	77,272	48,150	132,140	12,372,000	Mountains, Western Piedmont
Pine beetle	2001	1,567,000	55,588	64,428	133,786	15,104,000	Mountains, Western Piedmont
Pine beetle	2002	6,845,000	57,494	53,388	121,149	13,620,000	Mountains, Western Piedmont
Total		34,543,000	397,843	1,056,486	1,731,491	83,445,000	
Hurricane Fran	1996	8,257,000	14,540,000	8,694,183	24,388,438	1,295,652,000	Piedmont, Southern Coastal Plain
Hurricane Floyd[c]	1999	—	—	—	1,512,000	89,400,000	Northern and Southern Coastal Plain
Winter storm	2000	578,000	2,242,000	1,001,202	3,319,363	264,511,000	Sandhills; 6 counties
Ice storm	2002	2,008,805	4,116,000	2,307,316	4,300,911	481,373,000	Piedmont
Hurricane Isabel	2003	822,511	3,893,000	2,349,256	6,557,733	562,937,000	Northern Coastal Plain

— = data unavailable.

[a] *mbf* = Scribner rule.

[b] *ccf* = hundred cubic feet.

[c] Estimated *ccf* blow down and killed by flooding per Federal Emergency Management Agency.

Dogwood anthracnose was first discovered in western North Carolina in 1987. The North Carolina Division of Forest Resources (NCDFR) has monitored a series of impact plots scattered throughout western North Carolina since its discovery. In 2004, results show that 83 percent of all dogwoods at elevations >2,000 feet have died. About 60 percent of these deaths were attributed to dogwood anthracnose. The remainder died from assorted causes including weather and even cutting. The NCDFR has estimated that dogwood anthracnose is responsible for killing 300 million dogwood trees across 2.5 million acres in western North Carolina.

Hurricanes primarily pounded the Coastal Plain region in 1996, 1999, and 2003. Hurricane damage was not limited to wind damage, as one brought large-scale flooding of lowland forests. Winter storms affected the Piedmont as well.

Dogwood anthracnose. (photo by Bob Anderson)

Volume

Softwood Volume

Volume of softwood species made up 34 percent of the State's wood volume in 2002 (fig. 16). Volume of softwood trees decreased 10 percent since 1990 to 11.4 billion cubic feet. Planted softwoods accounted for 28 percent, or 3.1 billion cubic feet of the total softwood volume. This was a 17-percent increase from the 2.2 billion cubic feet it accounted for in 1990. Loblolly pine remains the predominant softwood species (fig. 17). In addition, loblolly pine also accounted for the most volume of any single species in

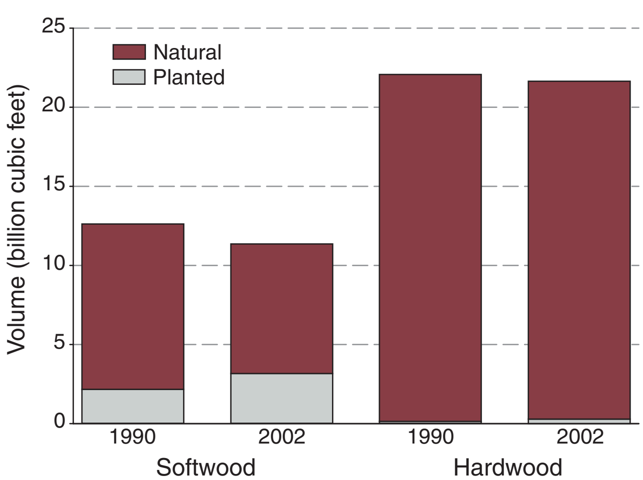


Figure 16—Volume of live trees on timberland by species group and stand origin in North Carolina for surveys completed in 1990 and 2002.

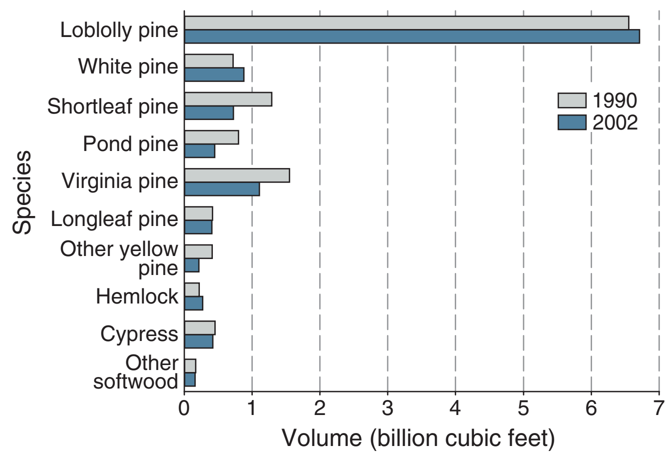


Figure 17—Volume of live softwood trees by species in North Carolina for surveys completed in 1990 and 2002.

Planted pine. (SRS photo)

North Carolina, whether softwood or hardwood—6.7 billion cubic feet, or 59 percent of all softwood volume. However, loblolly pine was the only yellow pine that increased in volume. Shortleaf and Virginia pine volume decreased significantly. Pine beetles affected Virginia and shortleaf pines, whereas removals and conversion to loblolly probably affected the pond pine more. White pine volume increased, as did hemlock. However, hemlock is in danger of infestation by the hemlock wooly adelgid across its range. Most softwood volume was in the 8-, 10-, and 12-inch diameter classes (fig. 18). Softwood volume peaked in the 10-inch diameter class. Softwood volume declined notably in the 6-, 8-, and 10-inch diameter classes since 1990. Beyond the 12-inch diameter class, as diameters increase, softwood volume dropped appreciably, except that volume increased in the >20-inch diameter class.

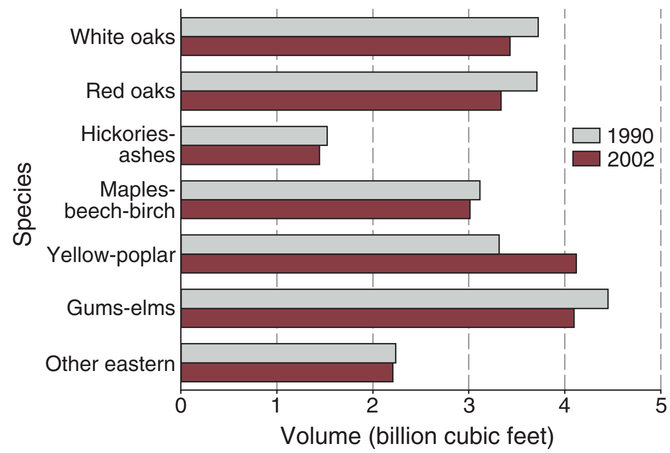


Figure 19—Volume of live hardwood trees by species in North Carolina for surveys completed in 1990 and 2002.

Hardwood Volume

Volume of hardwood species made up 66 percent of the State's wood volume in 2002 compared with 64 percent in 1990 (fig. 16). This occurred despite a 2-percent reduction in volume to 21.6 billion cubic feet. Hardwoods increased their proportion of the State's wood volume as a result of greater declines in the softwood volume. As expected, only 1 percent of hardwood volume came from planted stands; however, this was double that of 1990. Yellow-poplar was the predominant hardwood species (fig. 19). Yellow-poplar was also second only to loblolly pine in volume of all species in the State. Yellow-poplar increased by 24 percent to 4.1 billion cubic feet. Soft maple and sweetgum were second and third in hardwood species volume. Soft maple had 2.5 billion cubic feet, while sweetgum increased almost 2 percent to 2.1 billion cubic feet. Collectively, the white oaks and the red oaks declined in volume, as did blackgum and tupelo. By diameter class (fig. 20), hardwood volume was fairly evenly distributed compared with that of softwoods. Hardwood volume was highest in the14-inch diameter class. Hardwood volume declined in all diameter classes <18 inches since the previous inventory.

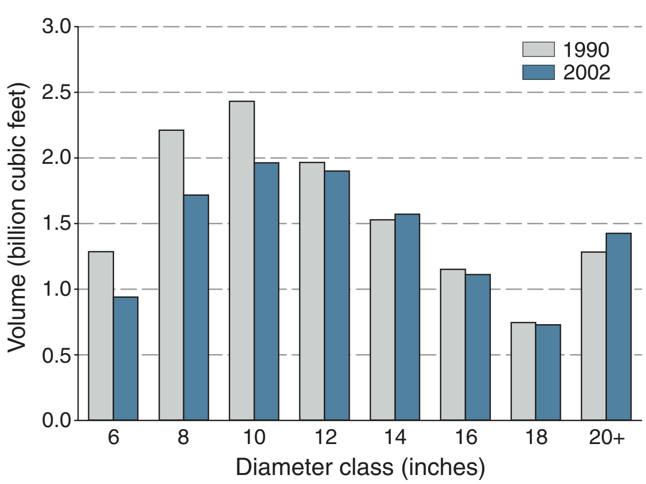


Figure 18—Volume of live softwood trees by diameter class in North Carolina for surveys completed in 1990 and 2002.

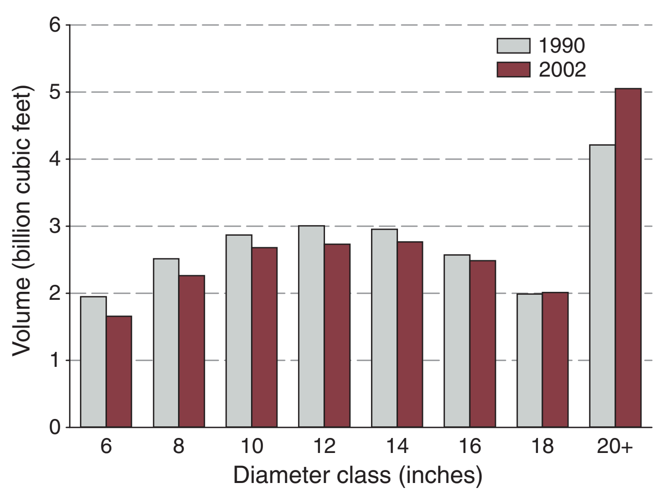


Figure 20—Volume of live hardwood trees by diameter class in North Carolina for surveys completed in 1990 and 2002.

Softwood Growth, Removals, and Change

The following two sections involve components of change surrounding the State's softwood and hardwood resources. Each begins with a computed average total for growth during the remeasurement period referred to as gross growth. Gross growth includes growth on trees that survived since the previous survey, growth on new ingrowth or ongrowth trees, growth on mortality trees up until the time they died during the period, and growth on removal trees up until the time they were removed. It should be noted here that removals for FIA purposes include not only harvested trees but trees removed from timberland for other reasons such as land clearing, conversion to urban uses, and transfer to reserved status. In addition to gross growth, the other components of change are mortality and removals. Mortality reduces gross growth to net annual growth, and removals reduce net annual growth for net change.

Softwoods provided 51 percent of the State's total net annual growth. From 1990 to 2001, softwood growth averaged 623 million cubic feet annually (fig. 21) and increased 5 percent from the 1984 to 1989 period. Planted softwoods made up 47 percent, or 296 million cubic feet of the softwood net annual growth during the 1990 to 2001 period. This was a notable increase from 35 percent, or 209 million cubic feet in the 1984 to 1989 period.

Softwoods made up 59 percent of the State's total annual removals. During the 1990 to 2001 period, softwood removals averaged 729 million cubic feet annually (fig. 21) and rose 42 percent from that in the 1984 to 1989 period.

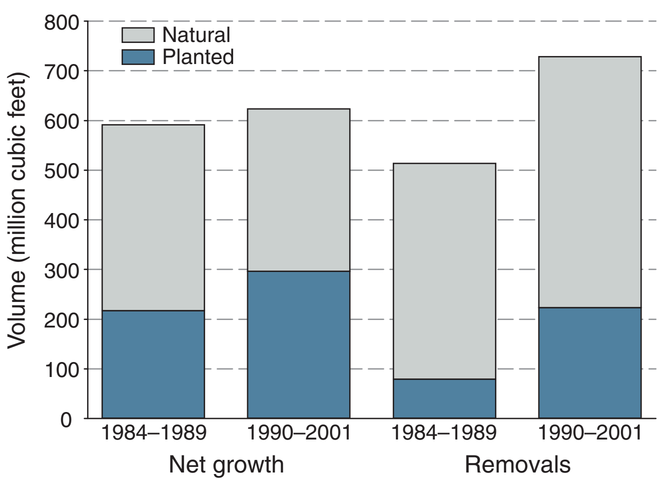


Figure 21—Average net annual growth and removals of softwood live trees by stand origin in North Carolina for survey periods 1984–1989 and 1990–2001.

Planted softwoods provided 31 percent, or 223 million cubic feet of the State's average annual softwood removals during the 1990 to 2001 period. This was a substantial increase from that in the 1984 to 1989 period, when planted softwoods accounted for just 15 percent or 79 million cubic feet of total softwood removals.

Between 1990 and 2001, annual softwood removals exceeded net annual softwood growth by 17 percent, or by 105 million cubic feet. The growth and removals figures above reflect the changes that took place in the softwood resource from 1990 to 2001. A more complete look leading to net change observations in the softwood resource includes the impact of varying mortality rates and the ratio of growth to removals. Figure 22 portrays how gross growth is reduced by mortality to yield net growth. Then net growth is reduced by removals to yield net change. The impact of mortality on net change is often overlooked. Mortality is virtually uncontrollable in most cases, and largely unpredictable. Most significant mortality resulted from weather (drought, flooding, ice storms, tornados, and hurricanes), fires, and insect outbreaks. Mortality can even be species specific. From 1990 to 2001, the State's softwood resource accumulated 709 million cubic feet of gross growth per year. However, softwood mortality averaged 191 million cubic feet annually during the same timeframe. Thus, mortality reduced gross growth to 623 million cubic feet of net growth. Then the net growth was reduced by removals of 729 million cubic feet, which yielded an average net change in the softwood resource of minus 105 million cubic feet per year. This happened despite increased softwood gross growth since the 1984 to 1989 period because mortality increased as well. Although the resultant net growth was still higher than in the 1984 to 1989 period, the large increase in removals exceeded the net growth and led to a negative change in the softwood resource. This situation is in direct contrast to that measured in the 1990 survey for the 1984 to 1989 period. Efforts to control pine beetle outbreaks during the 1990 to 2001 period could have boosted removal rates for softwoods.

Hardwood Growth, Removals, and Change

Hardwoods contributed 49 percent of the State's total net annual growth. From 1990 to 2001, hardwood growth averaged 602 million cubic feet annually (fig. 23) and increased 3 percent over that in the 1984 to 1989 period. Planted stands provided <3 percent of hardwood growth during the 1990 to 2001 period; however, this was an increase from that in the 1984 to 1989 period.

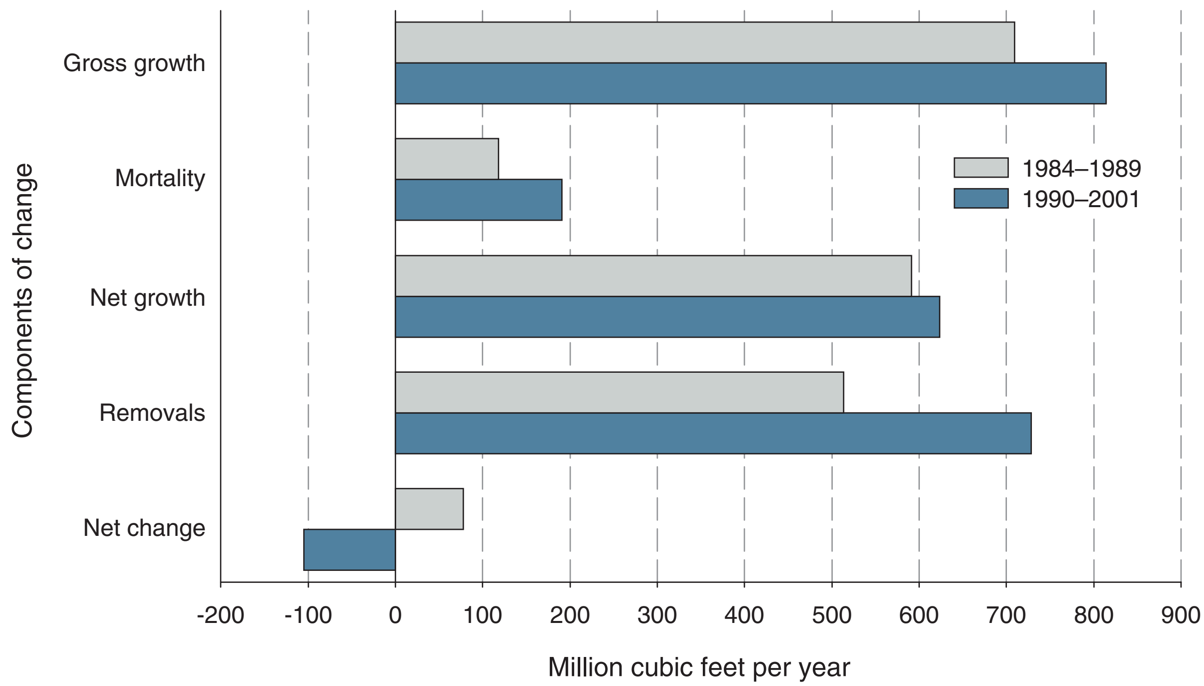


Figure 22—Components of change for softwoods in North Carolina for survey periods 1984–1989 and 1990–2001.

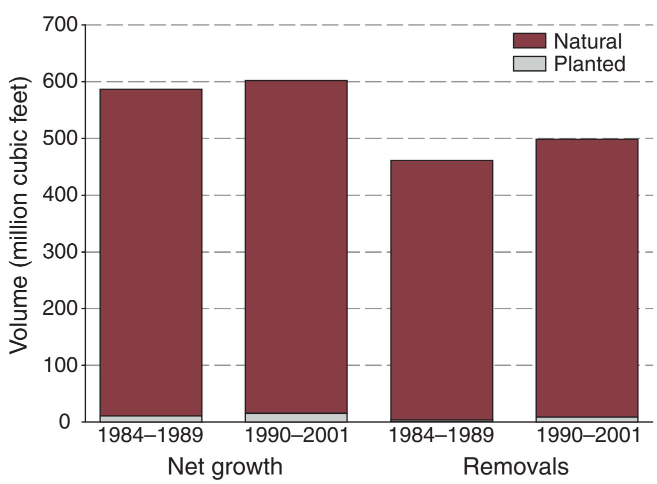


Figure 23—Average net annual growth and removals of hardwood live trees by stand origin in North Carolina for survey periods 1984–1989 and 1990–2001.

Hardwoods made up 41 percent of the State's total annual removals. During the 1990 to 2001 period, hardwood removals averaged 498 million cubic feet annually (fig. 23), an 8-percent increase from that in the 1984 to 1989 period. Planted sources contributed <2 percent of hardwood removals during the 1990 to 2001 period. Even as low as this was, it represented an increase since the 1984 to 1989 period.

The growth-to-removal ratio for hardwoods was in contrast to the situation for softwoods. From 1990 to 2001, net annual hardwood growth exceeded annual hardwood removals by 21 percent, or 104 million cubic feet. Gross growth of hardwoods averaged 837 million cubic feet annually (fig. 24). Average annual hardwood mortality of 235 million cubic feet reduced their gross growth to 602 million cubic feet of net annual growth. Because hardwood removals of 498 million cubic annually were less than the net annual growth, a positive change of 104 million cubic feet annually occurred in the hardwood resource. This change follows another positive change in hardwoods recorded in the 1984 to 1989 period as well.

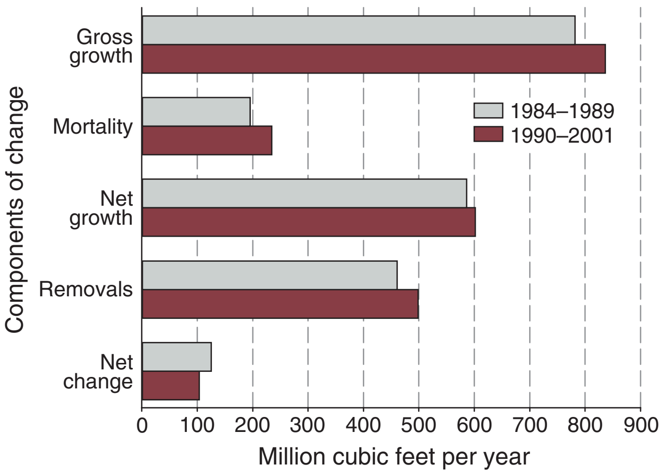


Figure 24—Components of change for hardwoods in North Carolina for survey periods 1984–1989 and 1990–2001.

Timber Products and the Economy

North Carolina's forest products industry is an important component of the State's economy. According to the IMPLAN (IMpact Analysis for PLANning) model (Abt and others 2002) generated by the Forest Service, the total economic importance of North Carolina's forests is calculated to be nearly $25 billion. The $25 billion includes all activities associated with the forest products industry—direct, indirect, and induced effects resulting from the industry operation.

Forestry, logging, and wood products manufacturing contributes $10.9 billion annually to the State's economy (U.S. Bureau of the Census 2003). In 2000, about 249 sawmills, pulpwood mills, and other primary wood-processing plants distributed across the State (fig. 25) directly employed >56,000 individuals, with an annual payroll of $1.8 billion. With the addition of the furniture sector, the wood products industry employs nearly 136,000 individuals, or 18 percent of the State's manufacturing workers (North Carolina Cooperative Extension Service 2002). With an annual payroll of $3.8 billion, the wood products industry ranks second only to the textile mill products and apparel industries. Nontimber benefits of the forest such as specialty forest products, recreation, water, wildlife habitat, and aesthetic values also contribute greatly to the State's economy and the well-being of the general population.

Timber Product Output and Removals

This section presents estimates of average annual roundwood product output and timber removals for the period 1990 through 2001. Estimates of timber product output (TPO) and plant residues were obtained from canvasses (questionnaires) sent to all primary wood-using mills in the State. The canvasses are used to determine the types and amount of roundwood (i.e., saw logs, pulpwood, poles, etc.) received by each mill, the county of origin of the wood, the species used, and how the mills dispose of the bark and wood residues produced. The canvasses are conducted every 2 years by personnel from the North Carolina Department of Environment and Natural Resources, Division of Forest Resources, and the SRS. These data are used to augment FIA's annual inventory of timber removals by providing the product proportions for that segment of removals that is used for products. Individual studies are necessary to track trends and changes in product output levels. Total product

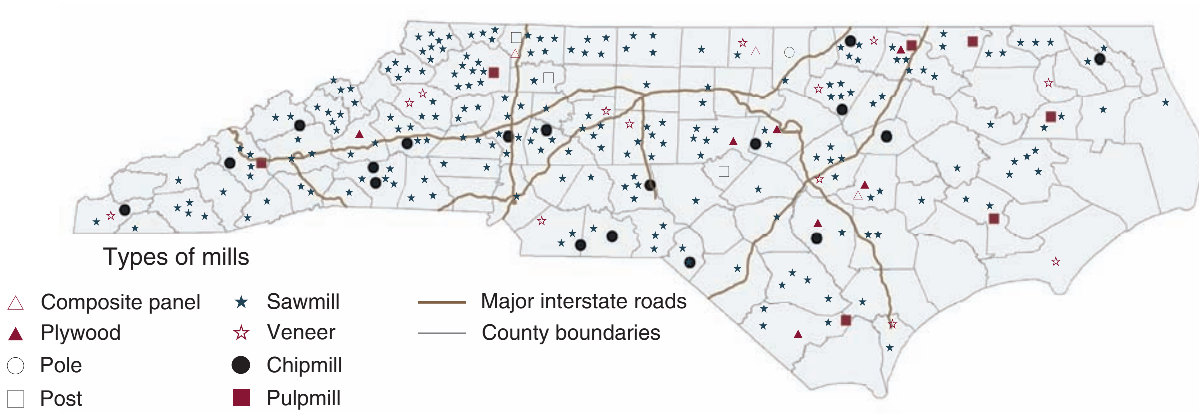


Figure 25—Primary wood-producing mills in North Carolina by county and mill type, 2001. Mills are randomly placed within the county in which they fall.

output, averaged over the survey period, is the sum of the volume of roundwood products from all sources (growing stock and other sources) and the volume of plant byproducts or the mill residues.

Total output of timber products, which includes domestic fuelwood and plant byproducts, averaged more than 1.1 billion cubic feet per year between 1990 and 2001, a 7-percent increase from the previous period between 1984 and 1989 (table 14). Eighty-three percent of the total output was from roundwood products, while the remainder was from plant byproducts. At 688 million cubic feet, softwood species provided 62 percent of the total product output volume. Hardwoods provided the remaining 38 percent, or 420 million cubic feet of total output.

With only minor fluctuations, the distribution of total volume among products has remained relatively constant over the past four survey periods. Pulpwood has been and remains the primary wood product produced by North Carolina's mills. Pulpwood production increased nearly 2 percent between the last two survey periods (1984 to 1989 and 1990 to 2001). Pulpwood production averaged 446 million cubic feet during the period 1984 to 1989 and increased to 454 million cubic feet during the period 1990 to 2001. Pulpwood accounted for 41 percent of the total TPO volume in the 1990 to 2001 period, compared with 43 percent for the period of 1984 to 1989, 44 percent from 1974 to 1983, 45 percent from 1965 to 1973, and 32 percent from 1955 to 1964 (fig. 26). Saw-log volume, used mainly for dimension lumber, increased from 331 million cubic feet in 1989 to 400 million cubic feet. Saw-log output increased 21 percent and accounted for 36 percent of the total output volume, about the same proportion as the past three survey periods. Veneer logs and composite panels combined ranked third in product output at 115 million cubic feet and accounted for another 10 percent of total TPO volume.

Average annual output of roundwood products (including fuelwood) increased 54 million cubic feet from 871 million cubic feet in the previous survey period, to an average of 925 million cubic feet between 1990 and 2001. Ninety-six percent of the roundwood products volume came from growing-stock trees, split between sawtimber (73 percent)

Logging operation. (SRS photo)

Table 14—Average annual output of timber products by product, species group, and type of material, North Carolina, 1990 to 2001

Product and species group	Total output	Roundwood products	Plant byproducts
		million cubic feet	
Saw logs			
Softwood	286.0	282.0	4.0
Hardwood	113.7	113.2	0.6
Total	399.7	395.2	4.6
Veneer logs			
Softwood	44.2	44.2	—
Hardwood	19.7	19.7	—
Total	63.9	63.9	—
Pulpwood[a]			
Softwood	273.9	194.6	79.3
Hardwood	180.0	148.0	32.1
Total	454.0	342.6	111.3
Composite panels			
Softwood	34.0	20.4	13.6
Hardwood	17.5	14.4	3.2
Total	51.5	34.8	16.7
Other industrial[b]			
Softwood	38.1	2.5	35.6
Hardwood	12.3	0.0	12.2
Total	50.4	2.6	47.8
Total industrial products			
Softwood	676.2	543.8	132.4
Hardwood	343.3	295.2	48.0
Total	1,019.5	839.0	180.4
Fuelwood[c]			
Softwood	11.3	10.8	0.5
Hardwood	77.0	75.0	2.0
Total	88.3	85.9	2.5
All products			
Softwood	687.5	554.6	132.9
Hardwood	420.3	370.3	50.0
Total	1,107.8	924.9	182.9

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

— = no sample for the cell; 0.0 = a value of >0.0 but <0.05 for the cell.

[a] Roundwood figures include an estimated 11.6 million cubic feet of roundwood chipped at other primary wood-using plants.

[b] Includes liter, mulch, particleboard, charcoal, and other specialty products.

[c] Excludes about 70.6 million cubic feet of wood residues and 47.3 million cubic feet of bark used for industrial fuel.

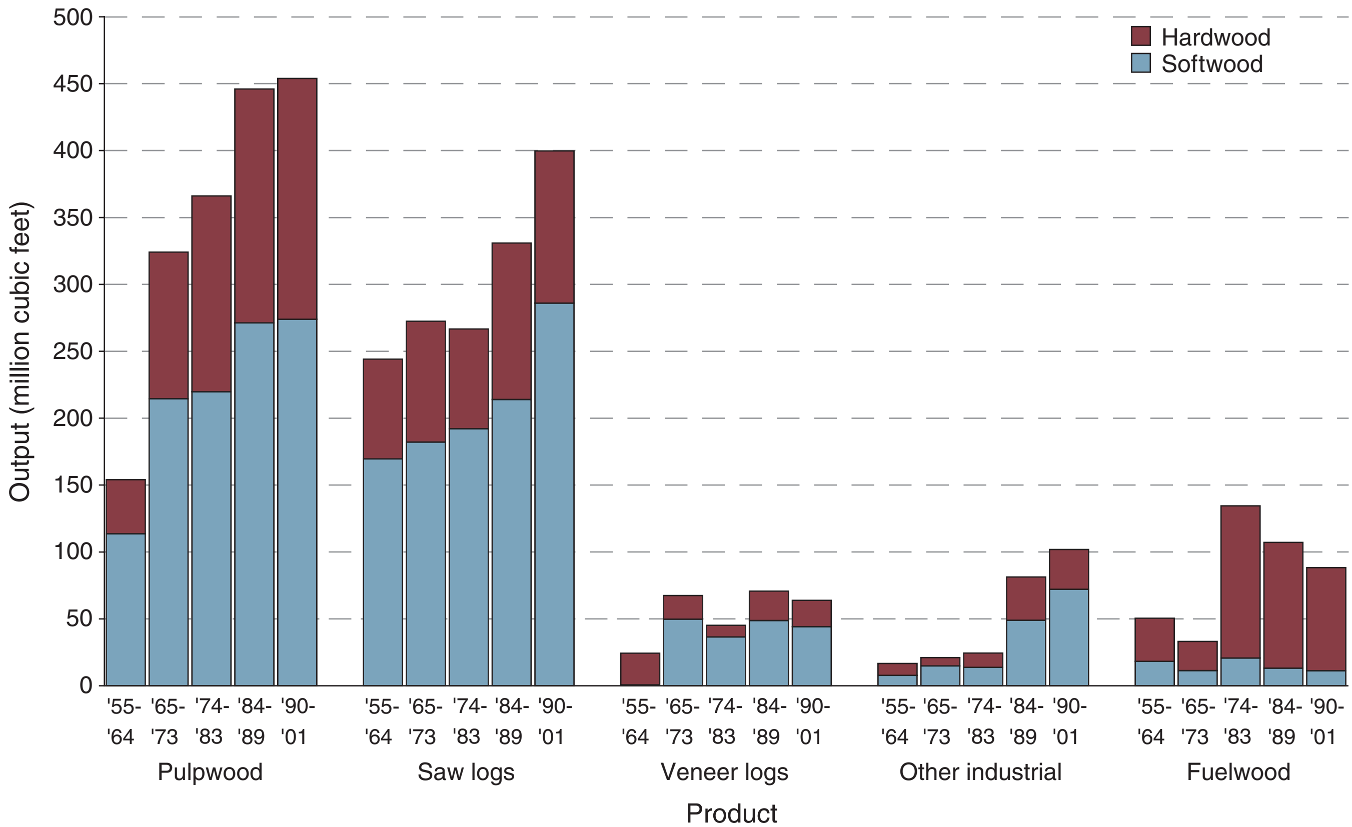


Figure 26—Average annual output of timber products by survey period, product, and species group, North Carolina.

and poletimber (27 percent) trees (table 15). Other sources, which include cull trees, salvable dead, and stumps and tops of harvested trees, dropped from 85 million cubic feet reported in the previous survey period to 39 million cubic feet.

Total timber removals, averaged over the time period, are the sum of the volume of roundwood products, logging residues (unused portions of trees left in the woods), and other removals (removals attributed to land clearing or land use changes) from growing-stock and nongrowing-stock sources. Removals from all sources, for both softwoods and hardwoods combined, totaled 1.3 billion cubic feet (table 16). Softwoods accounted for 56 percent of total removals. Volume used for roundwood products totaled 925 million cubic feet, or 70 percent, of total removals. Logging residues and other removals amounted to 246 million cubic feet (19 percent) and 145 million cubic feet (11 percent), respectively.

Preliminary results for the most recent timber product assessment for North Carolina indicate a decline in product output for both softwoods and hardwoods with a resulting decline in total removals.

Specialty Forest Products

Specialty forest products or nontimber forest products (NTFP) have been harvested from North Carolina's forests for many years. Although these products contribute a much smaller percentage to the overall economy than traditional forest products do, they remain very important and provide millions of dollars to many local rural economies each year. Many of these products are collected with very little forest disturbance and range from edible products (fruits, nuts, mushrooms, and ramps) to medicinal products (ginseng and bloodroot) to ornamental products (galax, pine tips for garlands, pine straw, and grapevines) and specialty woods (burl and crotch wood for fine crafts).

Table 15—Average annual output of roundwood products by product, species group, and source of material, North Carolina, 1990 to 2001

Product and species group	All sources	Growing-stock trees[a] Total	Sawtimber	Poletimber	Other sources[b]
	million cubic feet				
Saw logs					
Softwood	282.0	277.8	271.3	6.5	4.2
Hardwood	113.2	112.0	108.6	3.4	1.2
Total	395.2	389.7	379.9	9.8	5.4
Veneer logs					
Softwood	44.2	43.3	42.0	1.3	0.8
Hardwood	19.7	19.5	19.5	—	0.2
Total	63.9	62.8	61.5	1.3	1.1
Pulpwood					
Softwood	194.6	186.1	82.8	103.3	8.5
Hardwood	148.0	142.3	49.7	92.6	5.7
Total	342.6	328.4	132.5	195.9	14.2
Composite panels					
Softwood	20.4	20.1	8.1	12.0	0.3
Hardwood	14.4	13.8	8.1	5.7	0.6
Total	34.8	33.9	16.1	17.7	0.9
Other industrial					
Softwood	2.5	2.1	1.1	1.0	0.4
Hardwood	0.0	0.0	0.0	0.0	—
Total	2.6	2.1	1.1	1.0	0.4
Total industrial products					
Softwood	543.8	529.4	405.3	124.1	14.4
Hardwood	295.2	287.6	185.9	101.6	7.7
Total	839.0	817.0	591.2	225.7	22.0
Fuelwood					
Softwood	10.8	9.6	7.8	1.8	1.2
Hardwood	75.0	59.5	47.0	12.6	15.5
Total	85.9	69.1	54.8	14.3	16.7
All products					
Softwood	554.6	539.0	413.1	125.9	15.6
Hardwood	370.3	347.1	232.9	114.2	23.2
Total	924.9	886.1	646.0	240.1	38.8

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

— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

[a] On timberland.

[b] Includes trees < 5.0 inches in diameter, tree tops and limbs from timberland, or material from other forest land or nonforest land such as fencerows or suburban areas.

Table 16—Volume of timber removals by removals class, species group, and source, North Carolina, 1990 to 2000

Removals class and species group	All sources	Source: Growing stock	Source: Nongrowing stock
	million cubic feet		
Roundwood products			
Softwood	554.6	539.0	15.6
Hardwood	370.3	347.1	23.2
Total	924.9	886.1	38.8
Logging residues			
Softwood	116.6	46.8	69.8
Hardwood	128.9	53.0	75.9
Total	245.6	99.8	145.7
Other removals			
Softwood	69.7	61.8	8.0
Hardwood	75.8	65.1	10.7
Total	145.5	126.9	18.6
Total removals			
Softwood	741.0	647.6	93.4
Hardwood	575.0	465.2	109.8
Total	1,316.0	1,112.8	203.1

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

According to a survey of county extension agents, as of April 2003, North Carolina had a total of 6,357 NTFP enterprises (Chamberlain 2004). North Carolina is by far the leading State in the South for firms that specialize in floral and decorative and landscape products. Fifty-two percent or 3,283 of the NTFP enterprises in the State fell into the floral and decorative products category. The landscape products category had 1,326, or 21 percent, of the NTFP enterprises, while medicinal products comprised 770, or 12 percent, of the firms. Firms that specialized in edible products and specialty wood products numbered 526 and 452, respectively, and accounted for another 8 and 7 percent of the NTFP enterprises. North Carolina ranked first in total number of NTFP enterprises in the Southern region, accounting for 25 percent of the total NTFP firms.


Forest products. (SRS photo)

Forest Health Monitoring in North Carolina

Introduction

With the development of the Healthy Forest Initiative and the Forest Service Chief's identification of Four Threats to American Forests in the 21st Century, forest health has become a topic of great interest to the scientific and lay community (U.S. Department of Agriculture Forest Service 2005). The Forest Service currently monitors forest health by measuring a combination of indicators much like a doctor would monitor a patient through a combination of discrete measurements like temperature, blood pressure, and weight (McCune 2000). Forest health indicators measured by the FIA program include crown structure, down woody material (DWM), soil characteristics, vegetation structure and diversity, lichen communities, and ozone damage. Through analysis of each of these variables at State, regional, and national levels, scientists are able to identify potential problems and pinpoint areas of concern for intensified research programs. Additionally, trends may be detected and changes tracked over time.

The forest health variables presented here for North Carolina reflect monitoring conducted by two programs that were merged in 2000: Forest Health Monitoring (FHM) and FIA. The FHM program initially developed and implemented procedures for collecting data related to forest health. After the merger with FIA, data collection has been implemented in every State, resulting in the development of the FIA phase 3 (Forest Health) subset of FIA data collection plots (Stolte 2001). In North Carolina, 2001 forest health data collection included variables related to crown structure, DWM, lichen communities, and ozone damage. Samples for soil and vegetation were limited, and those indicators were omitted from this report.

Characteristics of North Carolina's Forest Health Plots

In North Carolina, 243 forest health plots were established between 1998 and 2001. Of those, 165 were classified as accessible forested plots. One hundred and one species were detected on forest health plots during data collection. Twenty-six percent of all trees detected that were ≥5.0 inches diameter at breast height (d.b.h.) were loblolly pines. Red maple (8.1 percent), sweetgum (6.8 percent), Virginia pine (6.2 percent), and yellow-poplar (5.1 percent) were the next most abundant species tallied (fig. 27), although red maple occurred in more plots (fig. 28). Sixteen percent of all saplings (1.0 to 4.9 inches d.b.h.)

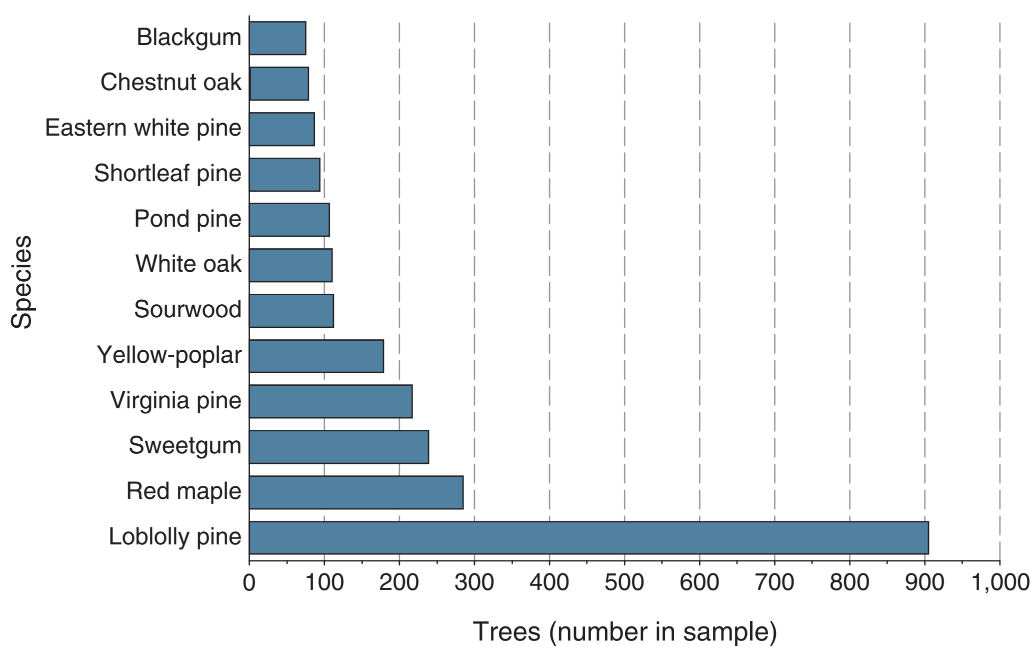


Figure 27—Number of most abundant trees ≥5.0 inches d.b.h. in entire sample on forest health plots, North Carolina, 2002.

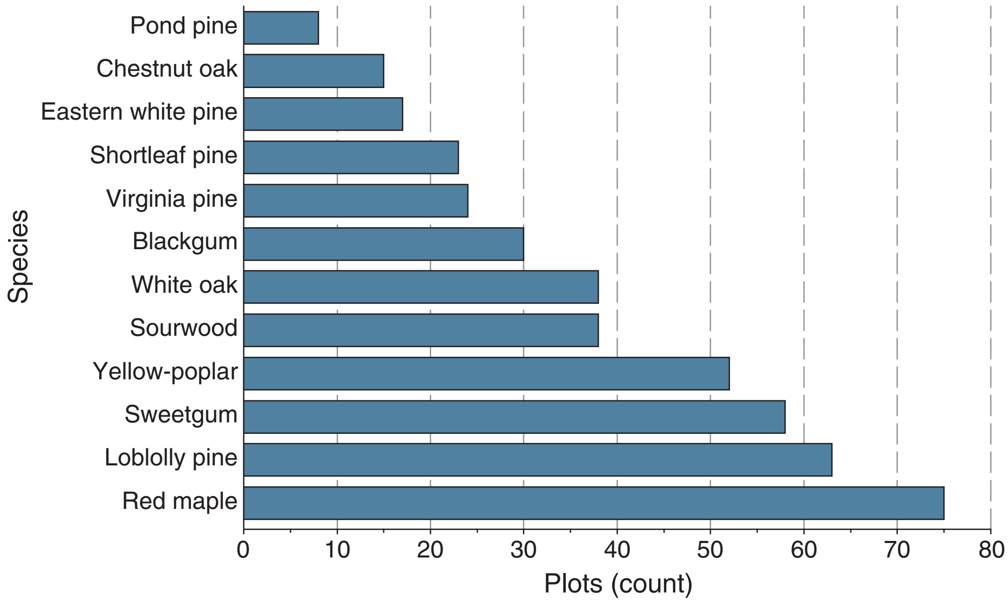


Figure 28—Frequency of abundant trees ≥5.0 inches d.b.h. on forest health plots, North Carolina, 2002.

were red maple, followed by sweetgum (12.4 percent) and loblolly pine (10.0 percent). The most abundant seedlings (<1.0 inch d.b.h.) recorded were sweetgum (20.8 percent), followed by black locust (11.1 percent), chestnut (9.7 percent), and yellow-poplar (6.9 percent). These findings are comparable to those from forest inventory plots as a whole.

Tree Crown Structure and Health

Tree health is governed by a multitude of factors, including genetics, climate, site productivity, stand structure, forest dynamics, and other external stressors like disease, pest infestation, and pollution (Millers and others 1992). Tree stress is often reflected in visible attributes like growth form and crown characteristics. Additionally, the condition of a tree's crown affects the ability of the tree to perform photosynthesis, influencing the productivity and vigor of a particular tree (Schomaker and others, in press). FIA collects information on crown density, transparency, and dieback to aid in describing the health of the Nation's forests. In a broad sense, high amounts of crown dieback and foliage transparency and low crown densities indicate poor vigor, while low amounts of dieback, little foliage transparency, and high crown densities indicate good health.

Crown dieback, foliage transparency, and crown density information was collected on 124 of the accessible forested plots. Statistics for crown health were computed on species containing at least 25 individuals with a d.b.h. ≥5.0 inches on these 124 plots (Schomaker and others, in press). Most of the trees exhibited good crown condition with little or no dieback (fig. 29), and forest health plots, on average, contained about 3 percent total crown dieback. Similarly, most trees had low foliage transparency values (fig. 30), and plot-level averages were also low at 21 percent. In contrast, crown densities were >30 percent for most trees (fig. 31), and the average crown density on a plot was about 48 percent. Although these indicators are species specific and complicated by variations in stand density, these survey data suggest that trees in North Carolina are primarily healthy and productive. A small number of trees exhibit crown conditions typical of trees undergoing stress, but this is not unexpected given the statewide scale of the survey and is no cause for alarm.

North Carolina's Deadwood

Downed and standing deadwood are important components of forested systems. Dead forest material contributes to the quality and types of habitat available to plant and animal species, affects soil nutrient content, influences global carbon stores, and affects forest fire behavior. The ecological benefits of DWM have been identified along with recognition of the potential threat of fuel accumulation in our Nation's forests. Establishing a balance between the deadwood necessary to sustain a healthy, productive forest,

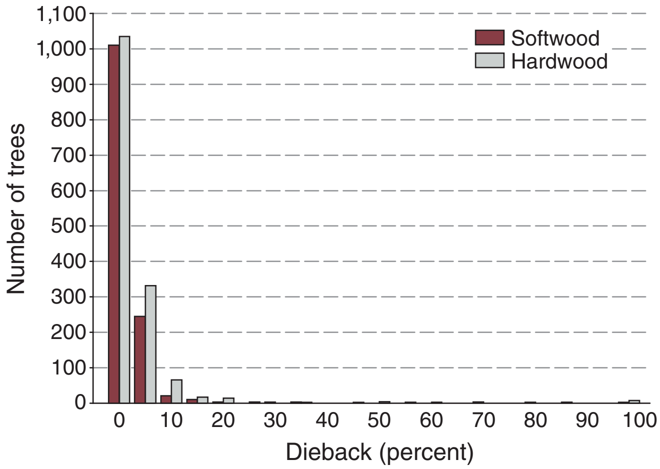


Figure 29—Crown dieback on forest health plots, North Carolina, 2002.

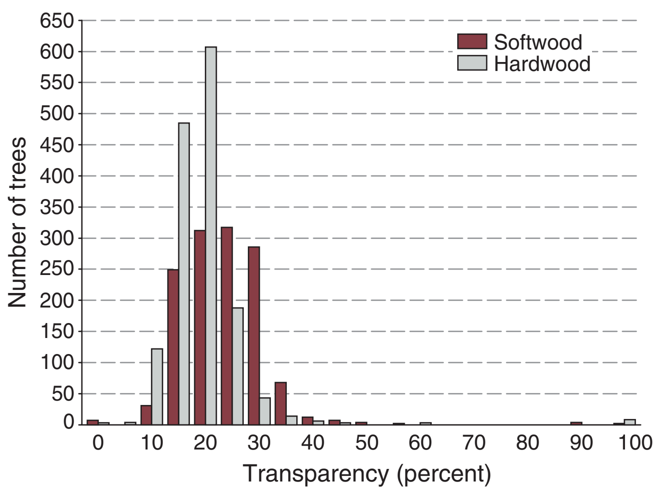


Figure 30—Foliage transparency on forest health plots, North Carolina, 2002.

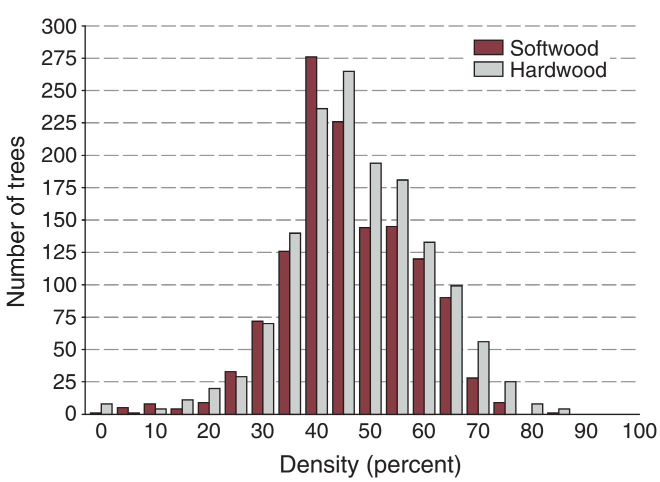


Figure 31—Crown density on forest health plots, North Carolina, 2002.

while addressing growing concerns over fuel loading in our Nation's forests, is an incredibly complicated process that first requires an understanding of the spatial distribution of the resource on the ground. The FIA program collects data on the extent and distribution of standing deadwood (snags) and DWM on all forest health plots across the Nation.

Deadwood as habitat—Snags, hollow logs, and brush piles provide important habitat for vertebrate communities, while decaying material, litter, and duff provide important habitat for micro- and macroinvertebrates. Many types of vegetation rely on decaying plant material as a growth substrate. Deadwood is not distributed evenly across the landscape, nor is it equally important for wildlife in every forest. For example, live deciduous trees in Eastern forests often contain cavities that provide habitat for cavity-nesting animals, decreasing the number of standing dead trees necessary to provide quality nest sites (Mannan and others 1996). In contrast, cavity-nesting animals living in the coniferous forests of the Southeastern United States may be more dependent on standing dead trees as appropriate habitat, increasing the number necessary to provide optimum habitat (Mannan and others 1996). The size and stage of decay of a snag also influence the types and numbers of animals that can use the tree. Generally, trees >14 inches d.b.h. are preferred for nesting, though snags of any size or decay class can provide food resources for multiple animals (Mannan and others 1996). The optimal number of snags to retain for wildlife on each acre of forest land depends on multiple conditions, including the management goals for the forest, the wildlife species present or desired, and the size, age, and species of trees present.

FIA collects data on snags on all phase 2 sample plots statewide. There are about 349 million standing dead trees on North Carolina's forest land today. Softwoods, particularly yellow pine, provide the largest number of snags on North Carolina's forests (fig. 32). Small snags (5.0 to 13.9 inches d.b.h.) outnumber large snags (>14 inches d.b.h.) by 9 to 1. There is an average of 19 snags per acre of forest land in North Carolina, and the number of snags per acre is similar for each region in the State (fig. 33).

Hollow logs and other types of coarse woody material also provide shelter or food for many species during at least some portion of their life-history cycle. Information on coarse woody debris was collected on 56 forest health plots across the State of North Carolina from 2001 to 2002. Measurements of the size and decay class of individual pieces of debris provide information regarding the suitability of logs for use by wildlife and about the recruitment of new dead material onto the forest floor. Most of the coarse debris sampled in 2001 to 2002 was moderately decayed (classes

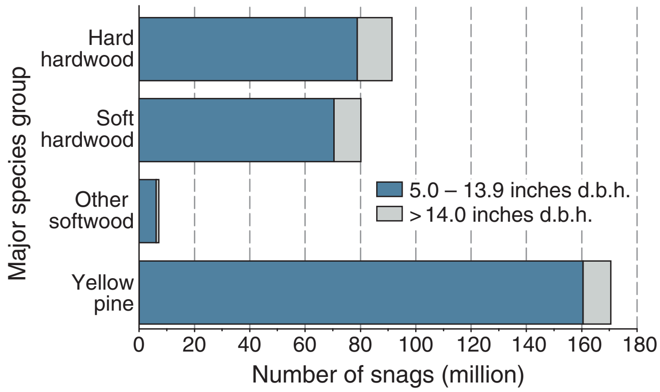


Figure 32—Total number of snags on all forest land by species group and diameter class, North Carolina, 2002.

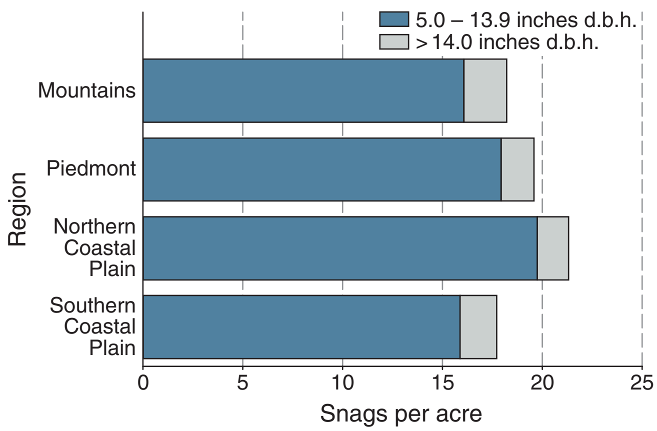


Figure 33—Number of snags per acre on all forest land by region, North Carolina, 2002.

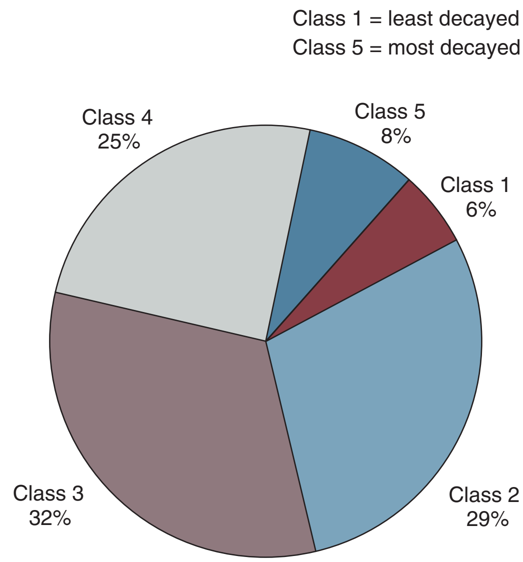


Figure 34—Proportion of coarse woody debris sampled in each decay class, North Carolina, 2001 to 2002.

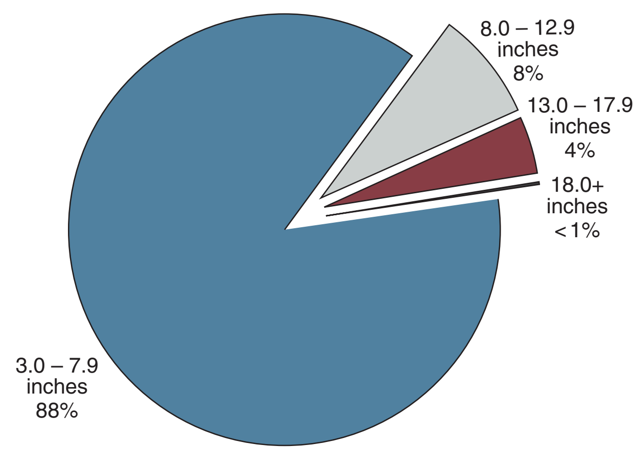


Figure 35—Proportion of coarse woody debris sampled in each diameter class, North Carolina, 2001 to 2002.

2, 3, and 4) (fig. 34) and fell into the smaller diameter classes (fig. 35). The disparity in the proportion of woody debris occupying the moderately to heavily decayed classes compared with the class containing freshly fallen wood indicates that much of the coarse debris is older. Estimates and geospatial interpolation of coarse woody debris tonnage indicate that the largest amounts occur in the Mountains and the Northern Coastal Plain (fig. 36).

Deadwood as fuel—Fire plays an important role in sculpting landscapes. As a natural event and a silvicultural tool, fire influences every aspect of forest ecology, including soil chemistry, wildlife habitat, biomass storage, and plant composition (Barnes and others 1998). Some tree species are dependent on forest fires to complete portions of their life cycles. For example, some conifers have evolved serotinous (closed) cones that require heat from fire to open. Other species have developed thick leaves and bark that

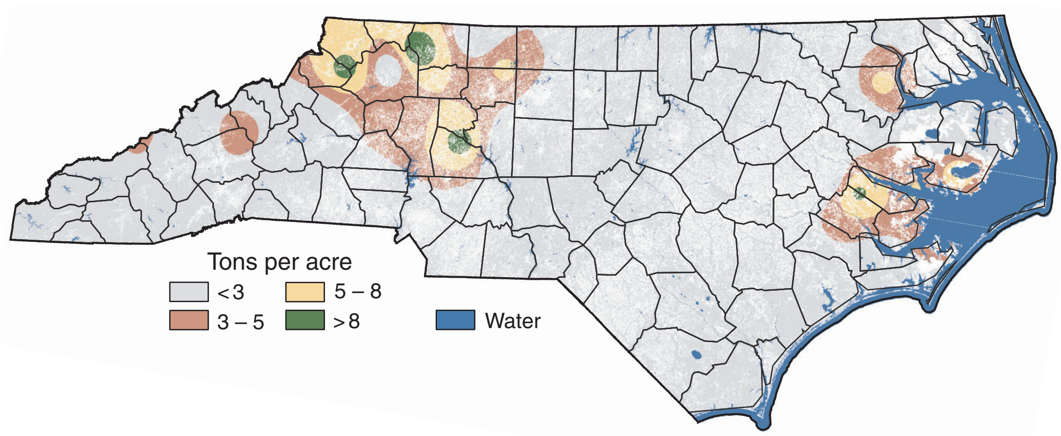


Figure 36—Prediction of coarse woody debris for North Carolina, based on inverse distance weighted interpolation of 56 2001 to 2002 down woody material plots with nonforest areas removed.

resist fire damage, or seeds that require heat for germination (Barnes and others 1998). Many wildlife species also favor conditions established by forest fires. The stimulation of plant growth resulting from forest fires benefits small and large game in Southern forests. Fires also promote the development of live-tree cavities suitable for black bears (Mannan and others 1996).

Forest fires are not always beneficial, however. Federal spending on wildfire suppression and prevention reaches as much as $500 million a year (Butry and others 2001), and the NCDFR spends an estimated 40 percent of State-appropriated dollars on wildland fire activities, annually.[2] Economic impacts beyond suppression and prevention costs include timber loss and disaster relief. Beyond economic losses, catastrophic fires increase air pollution through the emission of carbon monoxide, hydrocarbons, and volatile organic compounds (VOCS) (McMahon 1983). Additionally, intense wildfires can increase the rate of erosion on steep sites when soils are exposed (Barnes and others 1998).

In order to ignite and burn, a fire requires three primary ingredients: an ignition source, oxygen, and fuel. Surface fuels include the duff (partially decomposed organic matter) and litter (leaves, twigs, and other small pieces of organic matter) layers of the forest floor, fine woody debris and slash piles, and finally, coarse woody debris (McMahon 1983). The accumulation of large amounts of surface fuels, particularly fine woody debris and slash, increases the

Fuel accumulation. (photo by Christopher Woodall)

[2] Personal communication. 2005. R. Trickel, Forest Health Monitoring Coordinator, North Carolina Division of Forest Resources, Griffith's Forestry Center, 2411 Old U.S. 70 West, Clayton, NC 27520.

potential risk of catastrophic wildfire, given the appropriate weather conditions and an ignition source. Small (1-hour and 10-hour) fuels tend to dry out rapidly and ignite quickly, while large (100-hour and coarse debris) fuels tend to retain moisture and smolder rather than ignite. North Carolina averaged 0.2 tons per acre of 1-hour, 0.7 tons per acre of 10-hour, and 1.5 tons per acre of 100-hour fine woody fuels (Woodall 2003) on forest land in 2001 to 2002 (fig. 37). Estimates of fine woody debris distribution across the State of North Carolina suggest that fuel levels are particularly high in the Mountains and in some areas along the coast (fig. 38). The relatively high rates in the mountainous areas could be due partially to slower decomposition rates associated with hardwoods as opposed to some softwoods, or to temperature and moisture differences. Fuel accumulation along North Carolina's coast is most likely a result of the large number of hurricanes that made landfall along the eastern section of the State in the 1990s, including Hurricanes Emily in 1993, Fran in 1996, Bonnie in 1998, and Floyd in 1999 (Jarrell and others 2001). Fuel buildup may also be common near residential areas where prescribed burning and other management activities are less frequently used to reduce accumulation.

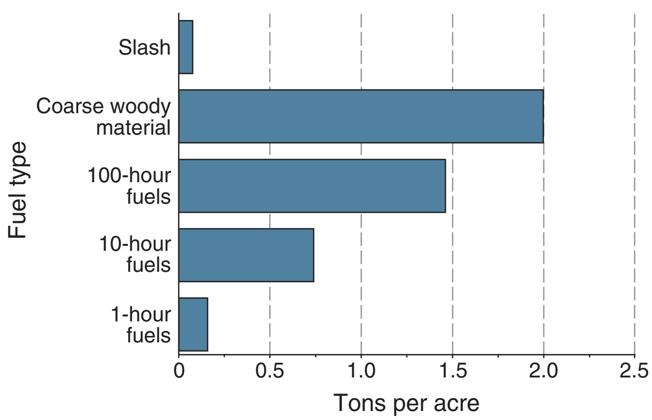


Figure 37—Average tons per acre of surface fuel on forest land by fuel type (n = 56), North Carolina, 2001 to 2002.

Although the 2001 to 2002 dataset is small, the data suggest that the Mountains and Coast of North Carolina are accumulating more fuels than other regions within the State. This could present a forest fire risk, given the appropriate weather conditions, particularly in the heavily forested Mountains.

Ozone and North Carolina's Forests

Ozone (O_3) is a chemical compound that occurs naturally in the Earth's atmosphere. In the upper atmosphere, ozone is essential for protecting the Earth's surface from intense ultraviolet rays coming from the Sun. In the troposphere (lower atmosphere), however, ozone becomes a secondary pollutant, contributing to permanent damage to human respiratory systems. Tropospheric ozone also affects the growth and development of forest vegetation (Skelly 2000).

Nitrogen oxides (NOX) are byproducts of organic fuel combustion and may be particularly high near industrial areas. Volatile organic compounds (VOCs) are emitted from many natural sources such as trees. These two chemical compounds combine in the presence of sunlight to form

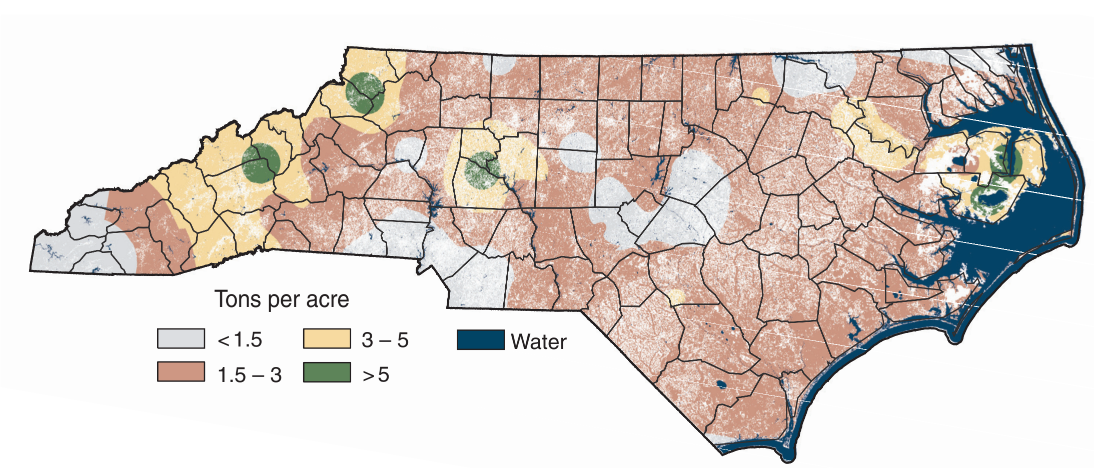


Figure 38—Prediction of 1-hour, 10-hour, and 100-hour fine woody fuels for North Carolina, based on inverse distance weighted interpolation of 56 2001 to 2002 down woody material plots with nonforest areas removed.

tropospheric ozone. Tropospheric ozone concentrations fluctuate naturally in response to weather events and changes in the chemistry of the air. Hot, cloudless summer days produce perfect weather conditions for the chemical reactions that combine NOXs and VOCs into ozone levels high enough to be harmful.

Pollution due to high concentrations of tropospheric ozone may affect forest vegetation growth and directly injures the foliage of sensitive species (Lefohn and others 1997, Coulston and others 2003). Forests in the Eastern United States may be particularly susceptible because of lingering high-pressure systems common in the region. This, combined with concentrated areas of urbanization and industrialization that generate the precursors to ozone, may be injurious (Skelly 2000). The resulting ozone travels downwind from these population centers, often reaching peak concentrations in remote areas.

High amounts of ozone in the troposphere may result in visible damage to forest vegetation. Some species are known to be particularly sensitive to ozone and exhibit this sensitivity through changes in leaf pigmentation, leaf senescence, or other species-specific symptoms (fig. 39). These sensitive species are used as bioindicators of ozone presence and are particularly useful in areas where ozone monitoring stations may not be present, such as remote forest locations (Skelly 2000). In North Carolina, species used as bioindicators include black cherry, sassafras, and yellow-poplar, among others (table 17).

Ozone data were collected on 6,218 plants of 6 species from the bioindicator list in North Carolina on 87 sites from 1999 through 2001. Fifty-six percent of all evaluated biosites contained at least some ozone-related damage. About 10 percent of the plants sampled exhibited signs of ozone-related damage (table 18). The majority of injured plants exhibited <25 percent ozone-related damage.

Figure 39—Ozone damage to a yellow-poplar leaf. (photo by Robert L. Anderson, USDA Forest Service, www.forestryimages.org)

Table 17—List of bioindicators by common and scientific name in North Carolina, 1999

Common name	Scientific name
Spreading dogbane	*Apocynum androsaemifolium* L.
Milkweed	*Asclepias* spp.
Bigleaf aster	*Eurybia macrophylla*
White ash	*Fraxinus americana*
Sweetgum	*Liquidambar styraciflua* L.
Yellow-poplar	*Liriodendron tulipifera* L.
Pin cherry	*Prunus pensylvanica* L. f.
Black cherry	*P. serotina* Ehrh.
Blackberry	*Rubus* spp.
Sassafras	*Sassafras albidum* (Nutt.) Nees

The Environmental Protection Agency (EPA) has developed Air Quality Standards (AQS) for the United States. In North Carolina, the national AQS for ozone is currently 0.08 parts per million, averaged over an 8-hour period. Data from EPA combined with FIA data suggest that not only are ozone levels reaching unacceptable (nonattainment) levels in population centers but in remote forest locations, as well. Figure 40 illustrates the predicted biosite index across the State of North Carolina, as interpolated from combined 1999 to 2001 sampling measurements, along with the locations of EPA air quality monitoring stations for the same time period. Monitoring stations exceeding the AQS for North Carolina in 2001 are flagged as nonattainment. Future FIA ozone measurements will be used in combination with other variables to help biologists determine where ozone concentrations are highest in remote forested locations. Where ozone values are high, additional studies may be conducted to help determine the long-term effects of ozone uptake on forest vegetation in terms of increased susceptibility to insect infestation or disease, tree growth, and aesthetics (Skelly 2000).

Lichen Diversity as a Measure of Forest Health

Lichens are life forms based on mutually beneficial relationships formed between fungi and algae, in which the fungus provides structure and absorbs water and nutrients, and the algae provides energy in the form of photosynthesis. Epiphytic lichens grow on tree trunks, snags, and branches, and obtain nutrients from the atmosphere, making them especially sensitive to changes in air quality (McCune

Table 18—Summary of biosite data for ozone injury, North Carolina, 1999 to 2001

	Biomonitoring program			
Parameter	1999	2000	2001	Total
Number of biosites evaluated	17	28	42	87
Number of biosites with injury	7	24	18	49
Number of plants evaluated	840	1,989	3,389	6,218
Number of plants injured	76	286	272	634
Average biosite injury score[a]	12	8	6	8
Percent sample plants by injury severity category				
0 = no injury	91	86	92	90
1 = 1 to 6 percent	0	1	1	1
2 = 7 to 25 percent	2	12	5	7
3 = 26 to 50 percent	7	2	2	3
4 = 51 to 75 percent	0	0	0	0
5 = >75 percent	0	0	0	0
Number of plants evaluated by species[b]				
Sweetgum (77)	163	547	720	1,430
Yellow-poplar (42)	216	361	810	1,387
Milkweed (0)	0	34	30	64
Black cherry (36)	160	279	528	967
Blackberry (479)	286	611	1,042	1,939
Sassafras (0)	15	157	259	431

[a] The biosite index is based on the average injury score (amount ∗ severity) for each species averaged across all species on the biosite multiplied by 1,000.
[b] Total number of injured plants given in parenthesis.

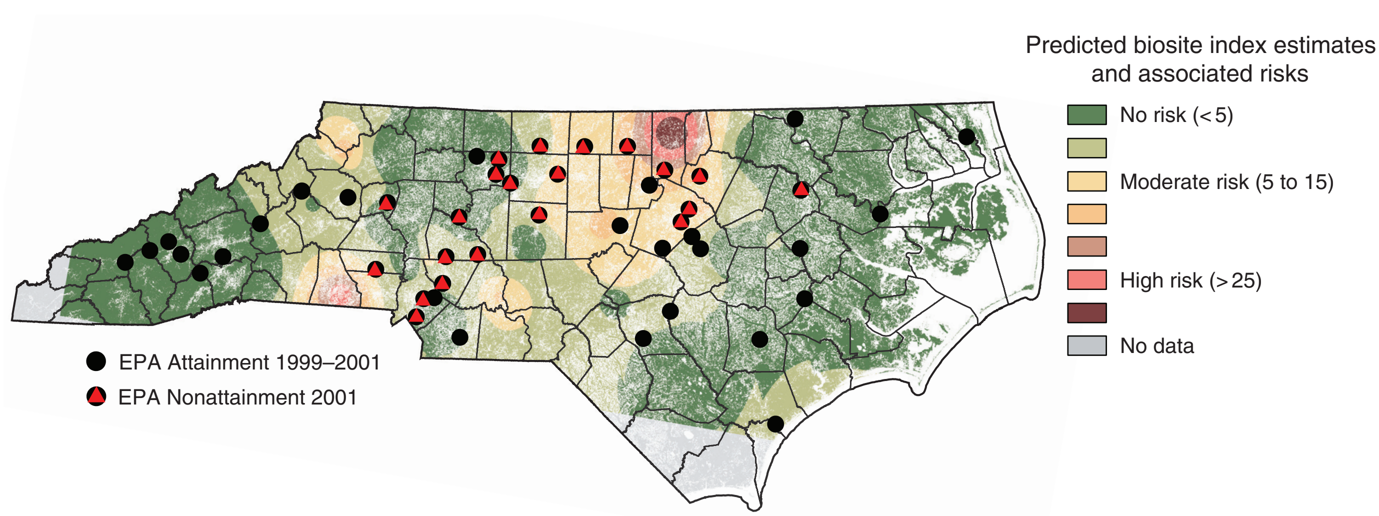


Figure 40—Predicted ozone risk in North Carolina using inverse distance weighted interpolations of USDA Forest Service measured ozone biosite index means, 1999–2001. Nonforest areas are shown in white.

2000). Studies of the numbers and species of lichens present in a forest community can help forest managers, scientists, and others better understand the effects of atmospheric pollution on forest health.

Ecological measurements of lichen species diversity are used to help gauge the productivity and health of a particular forest. The diversity measurements used include species richness or counts and diversity measures that incorporate richness and equitability. The diversity measures are often termed alpha, beta, and gamma diversity and refer to the number of species present in individual sample units (alpha), the total number of species observed in a collection of sample units (gamma), and the variability in diversity over the entire sample area (beta), calculated by dividing gamma by alpha. Per-plot species richness (alpha diversity) corresponds with air quality and climatic gradients in the Southeast (McCune and others 1997). Areas with poor air quality tend to house fewer lichen species. Likewise, areas with good air quality tend to support higher species richness. Along a climatic gradient, warmer climates (coastal or more southern) in the Southeast support fewer species than areas with cooler climates (more mountainous or more northern).

Lichen Species Richness

A total of 39 plots were sampled for lichens in North Carolina in 1999. These plots were compared with regional summaries of lichen samples collected across the Southeastern Lichen Gradient Region (Alabama, Georgia, North Carolina, South Carolina, and Virginia) during the same year (McCune and others 1997). Species richness ranged from 2 species in a plot to 33 species in a plot across the State of North Carolina, which was similar to the Southeastern Lichen Gradient Region as a whole (table 19). Plots contained an average of 12 species, also comparable to regionwide estimates. In general, plots that fell in the Mountain region of North Carolina had higher lichen species richness scores, with an average of 19 species per plot, while plots that fell in the Coastal Plain region had the lowest species richness scores, with an average of 8 species per plot (fig. 41). Overall, North Carolina had a high proportion of the species known to occur in the region. This indicates that the State as a whole has a fairly rich lichen assemblage, which may be due to the wide range of climates and habitats available for colonization.

Table 19—Lichen community indicator of species richness in North Carolina as compared to the Southeastern Lichen Gradient Region, 1999

Parameter	Gradient region[a]	North Carolina
Number of plots surveyed	77	38
Number of plots by species richness score category[b c]		
0 – 6 species	43	10
7 – 15 species	111	19
16 – 25 species	21	7
> 25 species	2	2
Median of species richness scores per plot	—	10
Range of species richness scores per plot (low to high)	0 – 33	2 – 33
Average species richness score per plot (alpha diversity)	10.33	11.67
Standard deviation of species richness scores per plot	6.27	6.87
Species turnover rate (beta diversity)[d]	14.95	8.57
Total number of species per area (gamma diversity)	154	100

— = no sample for the cell.

[a] Southeast region data (Conner and others 2004).

[b] Categories are based on a cumulative distribution function of plot species richness scores for the Southeastern Lichen Gradient Region model.

[c] Plots with no lichens are included.

[d] Beta diversity is calculated as gamma diversity divided by alpha diversity.

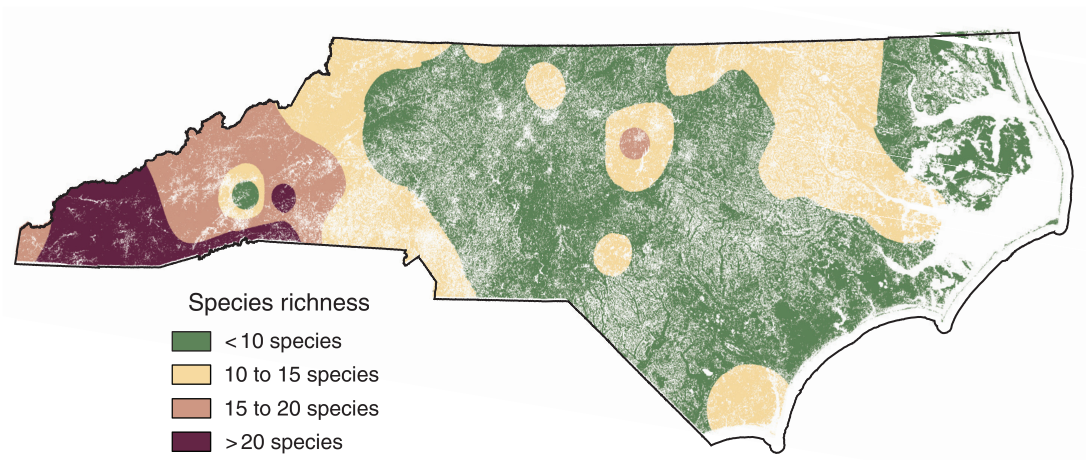


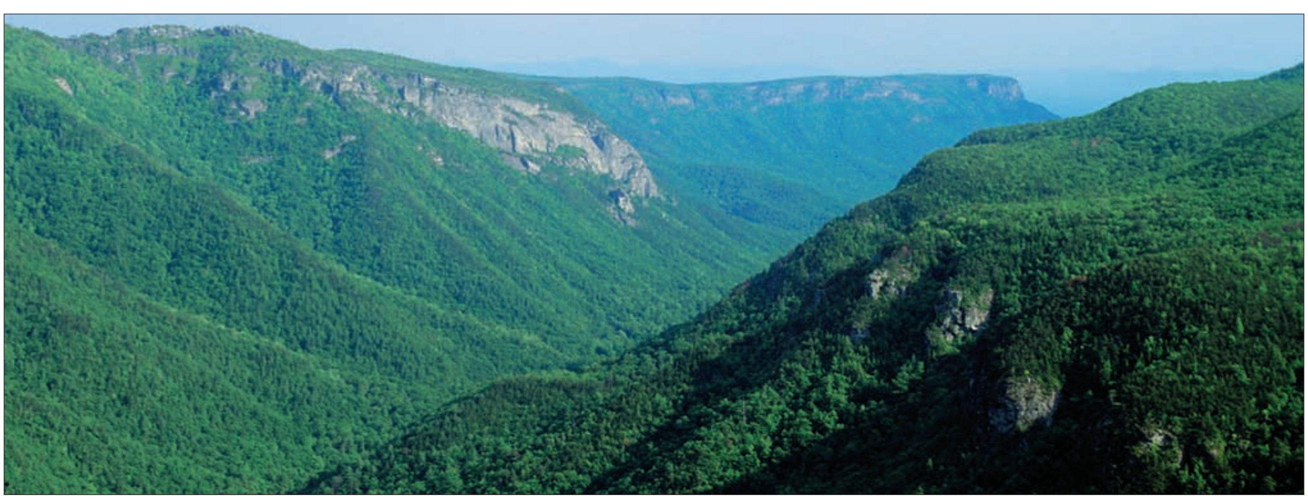
Figure 41—Predictions of lichen species richness on forest land across the State of North Carolina based on inverse distance weighted interpretation of 39 USDA Forest Service lichen survey plots.

Climate and Air Quality

Lichen data collected on 38 of 39 plots in North Carolina were fitted to a multivariate gradient model for the Southeast developed by McCune and others (1997) to derive scores pertaining to the climate and air quality of the State. In general, low scores on the climate index reflect a warm, moist climate typical of coastal regions, while high scores reflect cooler temperatures typical of mountainous areas. On the air quality index, low scores reflect poor air quality, while high scores reflect good air quality. Average scores on each index provide a means for some comparison with regionwide data.

In North Carolina, the largest number of plots sampled fell into the cool range of the climate index (table 20). The climate index scores for North Carolina reflect the topographic change across the State from the Coastal Plain to the Mountains, with the largest number of warm plots falling in the Piedmont (fig. 42). The average score on the climate index for North Carolina was similar to the overall index for the Southeast.

Fifty-five percent of plots in North Carolina fell in the intermediate air quality range, while 40 percent fell in the poor range of the index, and only 5 percent fell in the best air quality range (table 21). The overall average score on the air quality index was slightly lower in North Carolina compared with the overall Southeast. Lichen scores combined with ozone data suggest that North Carolina's overall air quality may be slightly poor compared with the gradient region as a whole.



Linville Gorge as seen from Wiseman's view overlook. (photo by Bill Lea)

Table 20—Lichen community indicator of climate in North Carolina as compared with the Southeastern Lichen Gradient Region, 1999

Parameter	Gradient region[a]	North Carolina
Number of plots surveyed	177	38
Number of plots by climate index category[b]		
Coastal/warmest: index value <25	28	9
Warm: index value 25 – 50	53	2
Cool: index value 50 – 75	65	19
Mountainous/coolest: index value >75	27	8
Median score on climate index	—	61
Climate index extremes	-8.56 – 114.99	-6.47 – 104.21
Average score on climate index	50.43	52.52
Standard deviation of mean climate index scores	26.08	28.74

— = no sample for the cell.

[a] Southeast regional data (Conner and others 2004).

[b] Categories are based on a cumulative distribution function of plot climate index scores for the Southeastern Lichen Region gradient model. Plots with no lichens are excluded, as are plots that have no species in common with the gradient model.

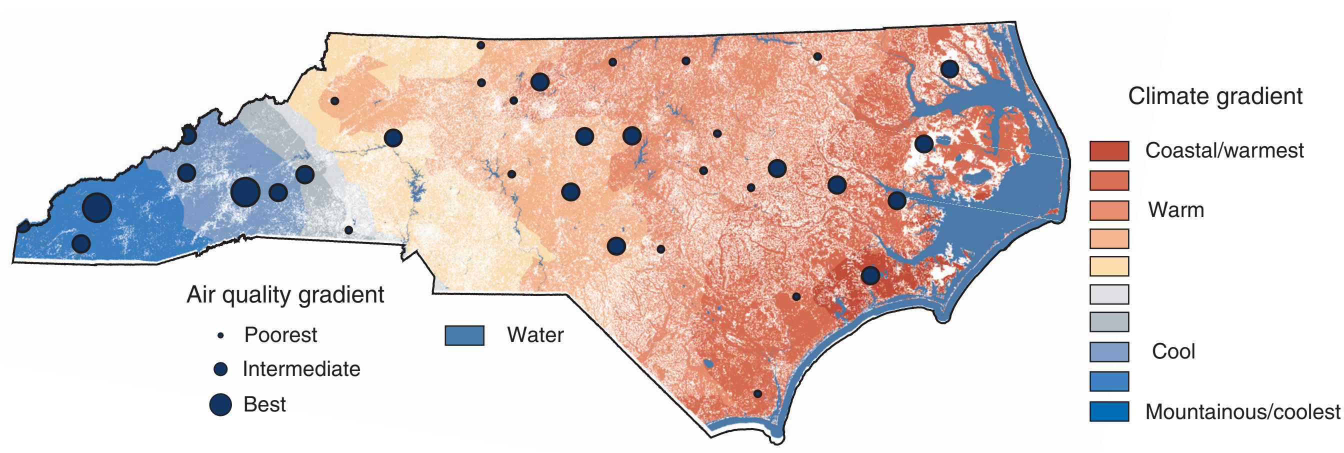


Figure 42—Predictions of climatic gradient for North Carolina based on kriged interpretation of 39 USDA Forest Service lichen survey plots, with overlay of air quality gradient scores.

Table 21—Lichen community indicator of air quality in North Carolina as compared to the Southeastern Regional Gradient Region, 1999

Parameter	Gradient region[a]	North Carolina
Number of plots surveyed	177	38
Number of plots by air quality index category[b]		
Lowest (poorest) air quality: index value <40	46	15
Intermediate air quality: index value 40 – 80	103	21
Highest (best) air quality: index value >80	24	2
Median of species air quality index scores	—	52
Range of species air quality index scores (low to high)	2.01 – 119.47	2.39 – 100.12
Average score on air quality index	52.72	46.91
Standard deviation of mean air quality index scores	23.39	19.64

— = no sample for the cell.

[a] Southeast regional data (Conner and others 2004).

[b] Categories are based on a cumulative distribution function of plot air quality index scores for the Southeastern Lichen Gradient Region model. Plots with no lichens are excluded, as are plots that have no species in common with the gradient model.

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Upper Creek Falls. (SRS photo)

Appendix

Inventory Methods

The inventory design and methodology used to collect and process the information needed to derive the current forest resource estimates for the 2002 survey of North Carolina have undergone substantial change since the previous survey conducted in 1990. These changes necessitate the use of caution when making rigorous comparisons between forest resource assessments.

The current inventory is a three-phase, fixed-plot design conducted on an annual basis. Phase 1 provides the area estimates for the inventory. Phase 2 involves on-the-ground measurements of sample plots by field personnel. Phase 3 is a subset of the phase 2 plot system where additional measurements are made by field personnel to assess forest health indicators.

Survey Sample Overview: 1990 Periodic vs. 2002 Periodic

The current survey's sample design and intensity has changed from that used in the previous inventory of North Carolina. The 2002 survey sample intensity was reduced to one plot per 6,000 acres for national consistency among surveys in all States. The 1990 survey had a sample of one plot per 2,800 acres in the Coastal Plain, one plot per 3,600 acres in the Piedmont, and one plot per 4,500 acres in the Mountains. The 2002 survey design switched to a fixed radius-plot sample. The 1990 survey design used a variable radius plot. Both of these changes, alone or in combination, weaken comparisons between surveys. When a design changes, the only way to quantify the true impact of such a change on trend analysis would be to conduct the survey using both plot designs simultaneously and compare the results of these two independent surveys. Neither the time nor money was available to do this.

Sample Phases

2002 Phase 1—The three phases of the current sampling method are based on a hexagonal grid design (fig. A.1), with successive phases being sampled with less intensity. There are 16 phase 2 hexagons for every phase 3 hexagon. Phase 2 and 3 hexagons represent about 6,000 acres and 96,000 acres, respectively.

Phase 1 involves the forest area estimation procedures. For the 2002 inventory of North Carolina, the phase 1 area estimate was based upon the count of a grid of 25 dots that was laid over each phase 2 sample plot location on an aerial photo. Each dot represented about 225 acres. A photo interpreter classified each dot as either forest or nonforest, and a percentage for each class was derived for each county in the State. The forest area for each county was then determined by multiplying the percentage of forested dots by the Census Bureau's estimate of all land for each county (U.S. Bureau

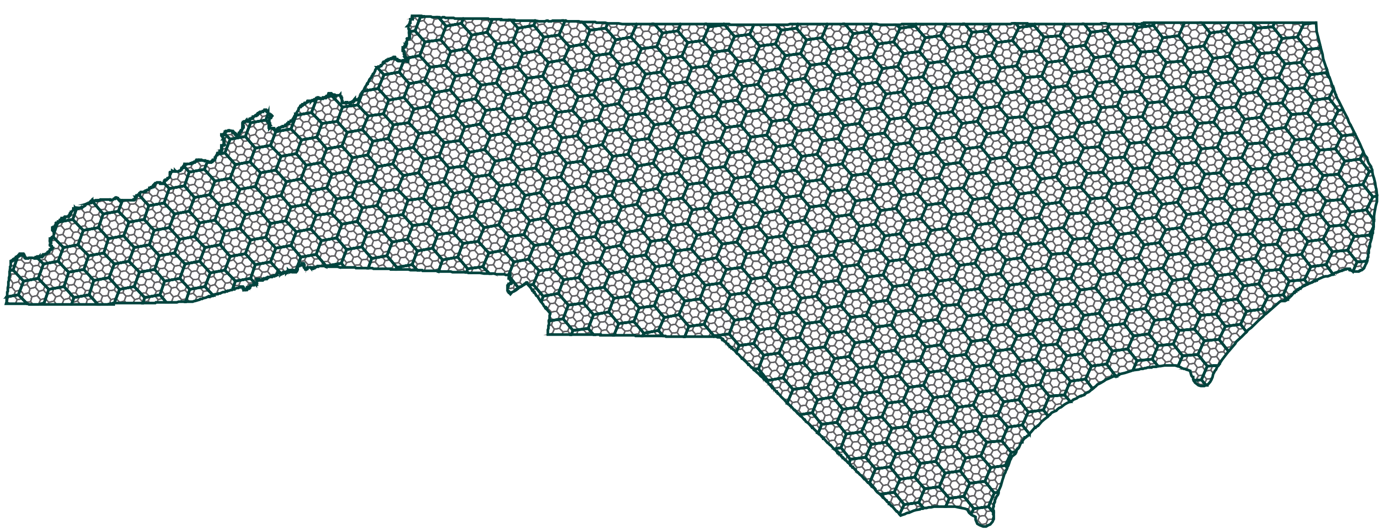

Figure A.1—Phase 2 and phase 3 hexagonal grid, North Carolina, 2002.

Scenic mountains. (SRS photo)

of the Census 1991). Ground truths were done at each phase 2 sample location and one additional location by field personnel. Any missed classifications were used to adjust the percent forest derived from the original phase 1 dot count estimate. These correction factors adjust for possible misinterpretation of aerial photos and for real changes on the ground that may have occurred since the date of the aerial photography. Plot-level expansion factors were determined by dividing the number of forested plots into the total forest land.

In the establishment of the new hex-grid layout, the intent was for only one phase 2 plot to be located in each hex cell. The purpose of this was to ensure that all of the FIA regions had the same sampling intensity across the United States. In switching from the previous design system to the hex grid, as many existing plot locations as possible were retained. However, hexagons containing no prior survey plots had a new plot located and established within a certain random oriented distance from hexagon center. If two or more plots from a prior survey existed within the same hexagon, then those additional plots were dropped from the inventory. If a plot from a prior inventory existed in a phase 2 hexagon, then that same location was retained.

1990 Phase 1—The significant difference between the 1990 and 2002 phase 1 estimation procedures was that in 1990, many more dots were counted to estimate forest area. This was because a grid of 25 clusters of 16 points each was laid over each photo. Therefore, in 1990 about 2,053,152 dots were counted vs. 144,350 dots counted in 2002. The higher number of classification points in 1990 was a result of both more dots being counted for each phase 2 plot and a higher number of phase 2 plots measured than in 2002. The end result is the potential for the 2002 survey area estimates to have a higher sampling error.

Change in Ownership Collection

2002 Ownership—In the 2002 North Carolina survey, only national forest and reserved forest land were enumerated from known sources of these records, such as public agency reports and other public domain documents at the State and county levels. The number of samples on national forest lands was divided into this known forest area for each county in the State to develop expansion factors. The known area of national forest ownership was then subtracted from the timberland area derived for the county, and the remaining forested plots were divided into this area to derive the expansion factors for the remaining forest industry and NIPF ownerships. Thus, the area for the remaining ownership categories was determined by the probability of selection of phase 2 plot locations. As a result, known forest land area compared to area derived by means of probability of selection for some ownerships will not always agree. For example, the acreage of State-owned forest land, found in State forestry organization documents and records, will not agree exactly with the statistical estimation of State-owned forest land derived by FIA. These numbers could be substantially different as the areas become smaller in size, such as at the county level.

1990 Ownership—In the 1990 North Carolina survey, all public forest lands (national forest, military, national parks, wildlife refuges, miscellaneous Federal, State, county, and municipal) plus any forest industry holdings in a county were enumerated from courthouse records, publications, and other public domain documents. The number of sample locations that were established on each enumerated ownership class was divided into the respective known forest area in each county to derive expansion factors. The enumerated forest areas were subtracted from the total forest area derived for the county from phase 1, and the remaining forested plots were divided into this area to derive expansion factors for the nonenumerated NIPF ownerships. In addition, supplemental plots were installed to account for the many small parcels of enumerated land where a FIA plot did not fall.

Sample Design Changes

2002 Phase 2—The current plot design employed a fixed-plot composed of four subplots spaced 120 feet apart (fig. A.2). The sample area of these four subplots was 1/6 of an acre, while the footprint of the cluster was about one acre. Trees ≥5.0 inches d.b.h. were measured on each subplot (1/24 of an acre; 24-foot radius). Trees 1.0 to 4.9 inches d.b.h. and seedlings (<1.0 inch d.b.h.) were measured on a microplot (1/300 of an acre; 6 foot 8-inch radius) on each of the four subplots.

A unique feature of this plot design was in the mapping of different land-use and forest conditions that are encountered on the plot cluster. Since the plots were placed on the ground without bias i.e., systematically but at a scale large enough to be considered random, there was a probability that the plot cluster might straddle more than one type of land use or forest condition. There were two steps in the mapping process. The first step involved identifying forest and nonforest areas on the plot and establishing a boundary line on the plot if both were present. The

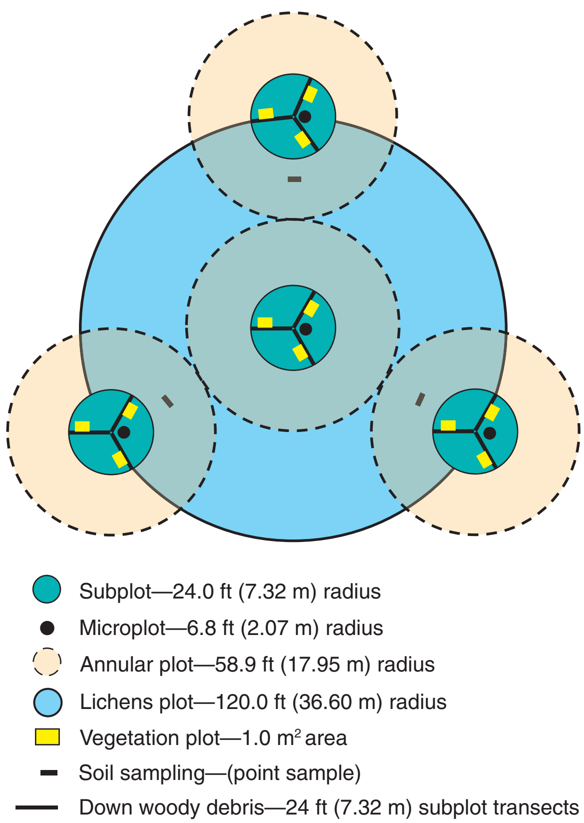

Figure A.2—Layout of fixed-radius plot used in 2002 North Carolina survey.

second step involved identifying differing conditions in the forested portion of the plot based on six factors: forest type, stand size, ownership, stand density, regeneration status, and reserved status. These, too, were mapped into separate entities.

1990 Phase 2—In the previous inventory, FIA utilized a prism sampling technique. At each forested location, a sample plot cluster consisting of five satellite points was installed (in some instances involving irregularly shaped forest areas, as few as three satellite points were installed). The cluster covered about one-half acre (fig. A.3). At each forested sample plot, trees ≥5.0 inches d.b.h. were selected with a 37.5 basal-area-factor prism at each of the five satellite points. Trees <5.0 but >1.0 inch d.b.h. and seedlings (<1.0 inch d.b.h.) were tallied on a 1/300-acre circular fixed plot centered on the five satellite points.

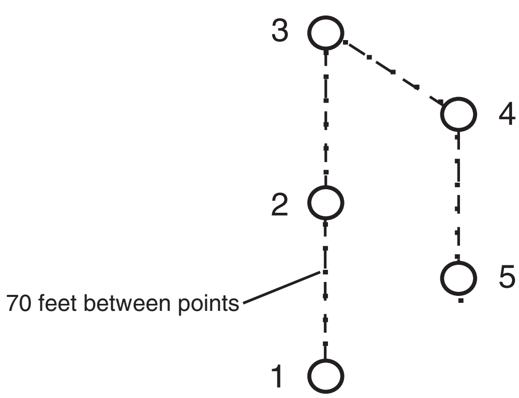

Figure A.3—Pattern of five-point prism plot used in 1990 North Carolina survey.

There was no plot mapping done on the prism five-point cluster. Point 1 was used to identify the land-use for the entire plot, either as forest or nonforest. If point 1 fell in forest, the entire plot was classified as forest; if point 1 fell in a nonforest area, the entire plot was classed as nonforest. In situations where point 1 was forested but the plot cluster straddled a forest-nonforest area, points that fell in the nonforest area were rotated into the forest condition. If all five points were located on forest but straddled different forest conditions, points were systematically moved into one common forest condition, which was determined by point 1.

2002 Phase 3 (not collected in 1990)—Forest health variables (phase 3) are collected on about one-sixteenth of the phase 2 sample plots. Phase 3 data are coarse descriptions and are meant to be used as general indicators of overall forest health over large geographic areas.

Phase 3 data collection includes variables pertaining to tree crown health, down woody material, foliar ozone injury, lichen diversity, and soil composition. Tree crown health, down woody material, and soil composition measurements are collected using the same plot design as in phase 2 data collection, while lichen data are collected within a 120-foot radius circle centered on subplot 1 of each FIA phase 3 field plot (fig. A.2).

Biomonitoring sites for ozone data collection are based on specific criteria and are located independently of the FIA grid. Sites must be one-acre fields or similar open areas adjacent to or surrounded by forest land and must contain a minimum number of plants of at least two identified bioindicator species (Smith and others, in press). Plants are evaluated for ozone injury, and voucher specimens are submitted to a regional expert for verification of ozone-induced foliar injury.

Volume Estimation

2002—Tree volumes in North Carolina were computed using the simple linear regression model:

$$Volume = Diameter^2 * Height$$

This equation estimated gross cubic foot volume from a 1-foot stump to a 4-inch upper diameter for each sample tree. Separate equation coefficients for 77 species or species groupings were utilized. The volume in forks in the central bole and the volume in limbs outside of the main bole were excluded. Net cubic foot volume was derived by subtracting the estimate of rotten or missing wood for each sample tree. Volume of the saw-log portion (expressed in International 1/4-inch board feet) of sample trees was derived by using board foot to cubic foot ratio equations. All equations and coefficients were developed from standing and felled tree volume studies conducted across several Southern States (Cost 1978).

1990—The methods for estimating tree volumes in the previous inventory of North Carolina were essentially the same as those described above, with one main exception. Previous estimates of live merchantable volume included forks in the central stem. Analysis of average volume per tree by species group and diameter class for the two inventories indicates that this change did not have a significant impact on individual tree and statewide volume estimates. However, users should be aware of possible impacts on volume comparisons due to the sample design change.

Growth, Removals, and Mortality Estimation

Estimates of the components of change (growth, removals, and mortality) were determined from the remeasurement of 3,183 sample plots from the 1990 inventory. This was accomplished by remeasuring trees on the original prism plot points. However, a full remeasurement of the prism plot was not performed.

Remeasurements and assessments of growth, removals, and mortality were made only on trees that were tallied in 1990. The only new trees on the prism points tallied were those that were previously missed. Trees that were <5.0 inches d.b.h. were remeasured on the microplot, but only on points 1, 2, and 3. New tally on the microplots at points 1, 2, and 3 included through-growth trees (trees that went from <1.0 inch d.b.h to ≥5.0 inches d.b.h. between surveys). In the 1990 survey the microplot was measured on all five points.

The remeasurement information was then used in the calculation of seven components of change: survivor growth, ingrowth, growth on ingrowth, growth on mortality, mortality, growth on removals, and removals. The Beers and Miller (1964) estimator technique was used to determine gross growth, net growth, removals, mortality, and net change of the inventory. This methodology required personnel to only account for previously tallied trees. Another change in the survey effecting growth, removals, and mortality trends was the decrease in the number of plots. The number of plots used in the calculations went from 5,429 in 1990 to 3,183 in 2002. This may impact growth, removals, and mortality estimates, especially when comparing certain post-defined categories such as ownership, forest type, and stand size.

Changes in variable assessments—The methods used to assess various attributes have changed in some cases, and this may impact trend analysis. Three of the more important ones include forest type, stand size, and stand age. Forest type was assessed by field personnel in both the 1990 and 2002 surveys. Field personnel were instructed to use the plot tally, where possible, to define the forest type. The biggest difference between the 1990 and 2002 forest-type assessments would be in the sample design change. In 1990, field personnel were instructed to describe the stand size of the sample plot without reference to any stand-level attributes. In 2002, field personnel were instructed to describe stand size based upon the predominant portion of the stand, e.g., the predominant stand layer. In 1990, field personnel recorded the stand age of the manageable portion of the stand, e.g., that portion of the stand that forest managers would carry through to harvest. In 2002, stand age was assigned to the predominant portion of the stand (as with stand size, above). Adding to the complexity of the comparisons over time is the complication of mapping by conditions across the plot. This changes the size and homogeneity of the assessment areas.

Summary

Users wishing to make rigorous comparisons of data between surveys should be aware of the significant differences in plot designs and variable assessments. Assuming there is no bias in plot selection or maintenance of plot integrity, the most valuable and powerful trend information comes from the same plots being revisited from one survey to the next and measured in the same way. This is also the only method that yields reliable components of change estimation (growth, removals, and mortality). This approach reduces the noise that is present in natural forest stands and lends a higher level of confidence in assessing trends. However, if sample designs change, there can never be a high level of certainty that the trends in the data are real or due to procedural changes. Even though both designs may be judged statistically valid, the naturally occurring noise in the data hinders confident and rigorous assessments of trend over time. Comparing different sample designs may have different degrees of strength in trend, depending on what is being compared. Defining the confidence and strength of trend over time is difficult (if not impossible) to discern when sample methodology differs.

Statistical Reliability of the Data

A relative standard of accuracy has been incorporated into the forest survey. This standard satisfies user demands, minimizes human and instrumental sources of error, and keeps costs within prescribed limits. The two primary types of error are measurement error and sampling error.

There are three elements of measurement error: (1) biased error, caused by instruments not properly calibrated; (2) compensating error, caused by instruments of moderate precision; and (3) accidental error, caused by human error in measuring and compiling. All of these are held to a minimum by a system that incorporates training, check plots, and editing and checking for consistency. Editing checks in the office screen out logical and data entry errors for all plots. It is not possible to determine measurement error statistically, only to hold it to a minimum.

Sampling error is associated with the natural and expected deviation of the sample from the true population mean. This deviation is susceptible to a mathematical evaluation of the probability of error. Sampling errors for State totals are based on one standard error. That is, the chances are two out of three that, if the results of a 100-percent census were known, the sample results would be 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 table.

Estimates smaller than State totals will have proportionately larger sampling errors. The smaller the area examined, the larger the sampling error. In addition, as area or volume totals are stratified by forest type, species, diameter class, ownership, or other subunits, the sampling error increases and is greatest for the smallest divisions. The magnitude of

Item	Sample estimate and confidence interval	Sampling error
		percent
Timberland (1,000 acres)	17,684.4 ± 60.6	0.34
All live (million cubic feet)		
Inventory	33,011.9 ± 544.7	1.65
Net annual growth	1,225.4 ± 28.7	2.34
Annual removals	1,227.0 ± 45.2	3.68
Annual mortality	425.8 ± 15.2	3.56
Growing stock (million cubic feet)		
Inventory	30,324.9 ± 515.5	1.70
Net annual growth	1,180.9 ± 27.9	2.36
Annual removals	1,191.4 ± 44.2	3.71
Annual mortality	367.8 ± 14.3	3.89
Sawtimber (million board feet)		
Inventory	106,078.9 ± 2,280.7	2.15
Net annual growth	4,913.7 ± 123.3	2.51
Annual removals	4,225.9 ± 178.8	4.23
Annual mortality	1,160.6 ± 57.7	4.97

this increase can be calculated using the following formula. Sampling errors obtained from 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 NIPF timberland is computed as:

$$SE_s = 1.65 \frac{\sqrt{33{,}011.9}}{\sqrt{8{,}326.3}} = 3.29.$$

Thus, the sampling error is 3.29 percent, and the resulting confidence interval (two times out of three) for softwood live-tree inventory on NIPF timberland is 8,326.3 ± 273.9 million cubic feet.

Longleaf pine. (photo by Bill Lea)

Species List[a]

Common name	Scientific name[b]
Softwoods	
Fraser fir	*Abies fraseri* (Pursh) Poir.
Atlantic white-cedar	*Chamaecyparis thyoides* (L.) B.S.P.
Southern redcedar	*Juniperus silicicola* (Small) Bailey
Eastern redcedar	*J. virginiana* L.
Red spruce	*Picea rubens* Sarg.
Shortleaf pine	*Pinus echinata* Mill.
Longleaf pine	*P. palustris* Mill.
Table Mt. pine	*P. pungens* Lamb.
Pitch pine	*P. rigida* Mill.
Pond pine	*P. serotina* Michx.
Eastern white pine	*P. strobus* L.
Loblolly pine	*P. taeda* L.
Virginia pine	*P. virginiana* Mill.
Baldcypress	*Taxodium distichum* (L.) Rich.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Hardwoods	
Florida maple	*Acer barbatum* Michx.
Boxelder	*A. negundo* L.
Red maple	*A. rubrum* L.
Silver maple	*A. saccharinum* L.
Sugar maple	*A. saccharum* Marsh.
Buckeye	*Aesculus* spp. L.
Yellow buckeye	*A. octandra* Marsh.
Ailanthus	*Ailanthus altissima* (Mill.) Swingle
Serviceberry	*Amelanchier* spp. Medic.
Yellow birch	*Betula alleghaniensis* Britt.
River birch	*B. nigra* L.
American hornbeam	*Carpinus caroliniana* Walt.
Hickory	*Carya* spp. Nutt.
Water hickory	*C. aquatica* (Michx. f.) Nutt.
Bitternut hickory	*C. cordiformis* (Wangenh.) K. Koch
Pignut hickory	*C. glabra* (Mill.) Sweet
Pecan	*C. illinoensis* (Wangenh.) K. Koch
Shellbark hickory	*C. laciniosa* (Michx. f.) Loud.
Shagbark hickory	*C. ovata* (Mill.) K. Koch
Mockernut hickory	*C. tomentosa* (Poir.) Nutt.
American chestnut	*Castanea dentata* (Marsh.) Borkh.
Allegheny chinkapin	*C. pumila* Mill.
Chinkapin	*Castanopsis* (D. Don) Spach
Catalpa	*Catalpa* spp. Scop.
Sugarberry	*Celtis laevigata* Willd.
Hackberry	*C. occidentalis* L.
Eastern redbud	*Cercis canadensis* L.
Flowering dogwood	*Cornus florida* L.
Hawthorn	*Crataegus* spp. L.
Common persimmon	*Diospyros virginiana* L.
American beech	*Fagus grandifolia* Ehrh.
White ash	*Fraxinus americana* L.
Carolina ash	*F. caroliniana* Mill.
Green ash	*F. pennsylvanica* Marsh.
Pumpkin ash	*F. profunda* (Bush) Bush
Waterlocust	*Gleditsia aquatica* Marsh.
Honeylocust	*G. triacanthos* L.
Hardwoods (continued)	
Kentucky coffeetree	*Gymnocladus dioicus* (L.) K. Koch
Carolina silverbell	*Halesia carolina* L.
American holly	*Ilex opaca* Ait.
Black walnut	*Juglans nigra* L.
Sweetgum	*Liquidambar styraciflua* L.
Yellow-poplar	*Liriodendron tulipifera* L.
Cucumbertree	*Magnolia acuminata* L.
Fraser magnolia	*M. fraseri* Walt.
Southern magnolia	*M. grandiflora* L.
Bigleaf magnolia	*M. macrophylla* Michx.
Sweetbay	*M. virginiana* L.
Apple	*Malus* spp. Mill.
Chinaberry	*Melia azedarach* L.
White mulberry	*Morus alba* L.
Red mulberry	*M. rubra* L.
Water tupelo	*Nyssa aquatica* L.
Blackgum	*N. sylvatica* Marsh.
Swamp tupelo	*N. sylvatica* var. *biflora* (Walt.) Sarg.
Eastern hophornbeam	*Ostrya virginiana* (Mill.) K. Koch
Sourwood	*Oxydendrum arboreum* (L.) DC.
Redbay	*Persea borbonia* (L.) Spreng.
American sycamore	*Platanus occidentalis* L.
Bigtooth aspen	*Populus grandidentata* Michx.
Cottonwood	*P.* spp. L.
Pin cherry	*Prunus pensylvanica* L.f.
Black cherry	*Prunus serotina* Ehrh.
White oak	*Quercus* alba L.
Scarlet oak	*Q. coccinea* Muenchh.
Southern red oak	*Q. falcata* Michx.
Cherrybark oak	*Q. falcata* var. *pagodifolia* Ell.
Bluejack oak	*Q. incana* Bartr.
Turkey oak	*Q. laevis* Walt.
Laurel oak	*Q. laurifolia* Michx.
Overcup oak	*Q. lyrata* Walt.
Swamp chestnut oak	*Q. michauxii* Nutt.
Chinkapin oak	*Q. muehlenbergii* Engelm.
Water oak	*Q. nigra* L.
Pin oak	*Q. palustris* Muenchh.
Willow oak	*Q. phellos* L.
Chestnut oak	*Q. prinus* L.
Northern red oak	*Q. rubra* L.
Shumard oak	*Q. shumardii* Buckl.
Post oak	*Q. stellata* Wangenh.
Black oak	*Q. velutina* Lam.
Live oak	*Q. virginiana* Mill.
Black locust	*Robinia pseudoacacia* L.
Willow	*Salix* spp. L.
Sassafras	*Sassafras albidum* (Nutt.) Nees
American basswood	*Tilia americana* L.
White basswood	*T. heterophylla* Vent.
Winged elm	*Ulmus alata* Michx.
American elm	*U. americana* L.
Slippery elm	*U. rubra* Muhl.
Rock elm	*U. thomasii* Sarg.

[a] Scientific and common names of tree species > 1.0 inch in d.b.h. occurring in the FIA sample.

[b] Little (1979).

Glossary

Afforestation. Area of land previously classified as nonforest that is converted to forest by planting trees 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 <0.5 inch in diameter at the point of occurrence on sapling-size trees is included but is excluded on 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.

Composite panels. Roundwood products manufactured into chips, wafers, strands, flakes, shavings, or sawdust and then reconstituted into a variety of panel and engineered lumber products.

CRP. The Conservation Reserve Program, a major Federal afforestation program authorized by the 1985 Farm Bill.

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. Two-inch diameter classes are commonly used by Forest Inventory and Analysis, 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.

Down woody material. Woody pieces of trees and shrubs that have been uprooted (no longer supporting growth) or severed from their root system, not self-supporting, and are lying on the ground. Previously named down woody debris.

Forest land. Land at least 10 percent stocked by forest trees of any size, or formerly having had 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. Stands that (1) have been artificially regenerated by planting or direct seeding, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Natural pine. Stands that (1) have not been artificially regenerated, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

Oak-pine. Stands that have at least 10 percent stocking and classed as a forest type of oak-pine.

Upland hardwood. Stands that have at least 10 percent stocking and classed as an oak-hickory or maple-beech-birch forest type.

Lowland hardwood. Stands that have at least 10 percent stocking with a forest type of oak-gum-cypress, elm-ash-cottonwood, palm, or other tropical.

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, in which case the stand would be classified 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, in which case the stand would be classified 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 sample plot.

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

Fuelwood. Roundwood harvested to produce some form of energy, e.g., heat and steam, in residential, industrial, or institutional settings.

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 the 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 fuelwood.

Land area. The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains (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. 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 which is 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 (NIPF) land. Privately owned land excluding 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, 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 from timber utilization through statute or administrative regulation.

Pulpwood. A roundwood product that will be reduced to individual wood fibers by chemical or mechanical means. The fibers are used to make a broad generic group of pulp products that includes paper products, as well as fiberboard, insulating board, and paperboard.

Reforestation. Area of land previously classified as forest that is regenerated by planting trees 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 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 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 (roundwood logs). Logs, bolts, or other round sections cut from trees for industrial or consumer uses.

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 fuelwood, that is produced from roundwood.

Salvable dead trees. Standing or downed dead trees that were formerly growing stock and 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. A group of several red oak species composed of cherrybark, Shumard, and northern red oaks. Other red oak species are included in the “other red oaks” group.

Select white oaks. A group of several white oak species composed 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, of which one-half or more of total stocking is in poletimber and sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

Sapling-seedling stands. Stands at least 10 percent stocked with live trees of which more than one-half of total stocking is 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 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 plants having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

Tree grade. A classification of the saw-log portion of sawtimber trees based on: (1) the grade of the butt log or (2) the ability 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 minimum top diameter 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Veneer log. A roundwood product either rotary cut, sliced, stamped, or sawn into a variety of veneer products such as plywood, finished panels, veneer sheets, or sheathing.

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.

Metric Equivalents

1 acre = 4,046.86 m^2 or 0.404686 ha

1 cubic foot = 0.028317 m^3

1 inch = 2.54 cm or 0.0254 m

Breast height = 1.4 m above the ground

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

1 square foot per acre basal area = 0.229568 m^2/ha

1 pound = 0.454 kg

1 ton = 0.907 MT

Brown, Mark J.; New, Barry D.; Oswalt, Sonja N. [and others]. 2006. North Carolina's Forests, 2002. Resour. Bull. SRS–113. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 63 p.

In 2002, forests covered 18.3 million acres in North Carolina, of which 17.7 million were classified as timberland. Hardwood forest types prevailed on 72 percent of timberland and planted pine stands occupied 15 percent. Nonindustrial private forest landowners controlled 78 percent of timberland, forest industry holdings declined to 8 percent, and publicly owned timberland totaled 13 percent. Volume of all live trees on timberland totaled 33 billion cubic feet, 66 percent of which was hardwood. Planted pines made up 3.1 billion cubic feet of the total. Loblolly pine was the dominant individual species with 6.7 billion cubic feet. Net annual growth of all live trees averaged 1.2 billion cubic feet, and annual removals averaged 1.2 billion cubic feet. Softwoods made up 51 percent of the growth and 59 percent of the removals. However, softwood removals exceeded their growth by 105 million cubic feet, whereas hardwood growth exceeded their removals by 104 million cubic feet. There were 249 sawmills, pulpwood mills, and other primary wood-processing plants across the State. The Coastal Plain accumulated more fuels than other regions of the State due to hurricane impacts on coastal forests.

Keywords: FIA, forest health, forest ownership, fuels, pulpwood, timberland, timber growth, timber removals, timber volume, timberland, wood-processing plants.