The State of South Carolina's Forests, 2001

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Susan Will-Wolf, and Christopher W. Woodall

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Spiderwort. (photo by Bill Lea)

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Mixed pine-hardwood forest in South Carolina. (photo by Bill Lea)

SOUTH CAROLINA FORESTRY COMMISSION

Bob Schowalter, State Forester

South Carolina is blessed with abundant natural resources including a diverse and productive forest cover. For thousands of years this resource seemed inexhaustible, supporting human needs as well as those of other species. Only within the last century have we considered that this great resource does indeed have limits.

Recognizing the need for sound information on the changes taking place in our forests, the first systematic inventory of the nation's forests was completed in the 1930s. Periodic inventories measuring the area, number and volume of trees, and growth-harvest ratios have been conducted continuously for the past 65 years. Decision makers, cognizant of rapidly accelerating changes during the 1990s, realized a better system of measurements was needed.

Nowhere was this need more apparent than in the high yield forests of the southern United States. To meet this challenge, a new partnership was formed between the state forestry agencies and the USDA-Forest Service Research Stations. State forestry agencies began the task of collecting field data on a five-year cycle with the USDA-FS responsible for analyzing the data and publishing reports.

Because South Carolina's forests were significantly impacted by Hurricane Hugo, the Forestry Commission committed to an accelerated plan of completing the survey in three years instead of five. Despite a plunging budget and severe personnel shortages, the Commission has been unwavering in its commitment to the Forest Inventory and Analysis effort.

This is the result: South Carolina now presents the nation's first published report under the new Forest Inventory and Analysis program. Recognizing that there is more to our forests than numbers and volumes of trees, this report also includes information on forest health, its ecological values, its socio-economic benefits, and the goals and objectives of the forest landowners who own much of it.

This broader view of forest values is an important milestone for the Forest Inventory and Analysis program. I applaud this innovation as we strive to make forestry relevant to all in the 21st century.

Bob Schowalter
State Forester

OUR MISSION - To protect and develop the forest resources of South Carolina

This resource bulletin highlights changes in South Carolina's forest resources as interpreted from the first cycle of annual measurements. Annual surveys of U.S. forests were mandated by the Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill). They feature: (1) a nationally consistent, fixed-radius, four-point plot configuration; (2) a systematic national sampling design consisting of a base grid derived by subdividing the Environmental Monitoring and Assessment Program grid into approximately 6,000-acre hexagons; (3) integration of the forest inventory and forest health monitoring sampling designs; (4) annual measurement of a fixed proportion of permanent plots; (5) reporting of data or data summaries within 6 months after yearly sampling; (6) a default 5-year moving average estimator, with provisions for optional estimators based on techniques for updating information; and (7) a summary report every 5 years. Additional information about annual surveys is available at http://fia.fs.fed.us/.

In 1998, Forest Inventory and Analysis Research Work Unit (FIA) of the Southern Research Station and the South Carolina Forestry Commission began implementing the new annual survey strategy in South Carolina. The strategy involves rotating measurements of five systematic samples (or panels), each of which represents approximately 20 percent of all plots in the State. A panel may take more than or less than 1 year to complete. For South Carolina, data collection for all five panels was completed in just over 3 years. This report provides statistics and discusses the principal findings from the first full complement (all five panels) of data from the mapped-plot design. Forest land estimates and inventory volume, growth, removals, and mortality statistics are summarized from the data collected for the five panels. Seven previous periodic inventories completed in 1936, 1947, 1958, 1968, 1978, 1986, and 1993 provide statistics for measuring changes and trends.

The Forest and Rangeland Renewable Resources Research Act of 1978 authorized surveys of U.S. forest resources. These surveys are part of a continuing, nationwide undertaking by the U.S. Department of Agriculture Forest Service through its regional research stations. FIA—operating from its headquarters in Knoxville, TN, and offices in Asheville, NC, and Starkville, MS—is responsible for surveying 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. The primary goal of these surveys is to develop and maintain the resource information needed to formulate sound forest policies and programs.

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

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

Acknowledgments

The Southern Research Station gratefully acknowledges the South Carolina Forestry Commission for its role in collecting the field data. We also appreciate the cooperation of other public agencies and private landowners in providing access to measurement plots.

Contents

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Turk's-cap lily. (SRS photo)

Area

• Area of forest land totaled 12.4 million acres in 2001, a decline of more than 230,000 acres (2 percent) since 1993. Forests occupy 64 percent of the land area of South Carolina.

• Timberland amounted to 12.2 million acres. Hardwood and oak-pine timber types combined occupy over half the State's timberland (6.2 million acres); this represents a decline of 10 percent since 1993.

• Planted pine stands amounted to 3.1 million acres in 2001, outnumbering stands of natural pine by 150,000 acres.

Hooded pitcher plant. (SRS photo)

Ownership

• Forest industry timberland declined by 312,000 acres to 2.0 million acres. Corporate timberland increased by 261,000 acres to 1.9 million acres.

• Family forest owners dominate the private ownership group with 357,000 landowners who collectively control 7.1 million acres of forest land in the State.

• Eighty percent of the family forest land in the State is owned by people who have harvested trees from their land.

Volume

• Volume of all live trees amounted to 19.7 billion cubic feet in 2001, surpassing all previous inventory estimates. Softwood forests account for 9.4 billion cubic feet, and hardwood totals 10.3 billion cubic feet.

• Volume of loblolly pine increased 30 percent since 1993, and totals 7.1 billion cubic feet in 2001.

Growth and Removals

• Statewide, annual net growth of softwoods is nothing short of phenomenal as Conservation Reserve Program (CRP) plantings and fast-growing, young stands have begun to pay dividends. Net annual growth of all live softwoods doubled since 1993, rising to 692 million cubic feet per year. Softwood timberlands are producing more wood now than at any other time since surveys began in 1936.

• Hardwood growth rose 63 percent and averaged 306 million cubic feet annually since the previous survey.

• Total removals of all live trees averaged 765 million cubic feet per year between 1993 and 2000.

• Statewide growth-to-cut ratios are positive for both hardwoods and softwoods, reversing the negative relationship driven by Hurricane Hugo's impact on net growth and removals.

Forest Health and Water Quality

• Tree mortality, driven to abnormally high levels by Hurricane Hugo, has declined substantially. Annual mortality of all live softwoods is down 70 percent to 76 million cubic feet. Annual mortality in hardwoods averaged 121 million cubic feet, a 37-percent decline since 1993.

• The two costliest southern pine beetle outbreaks in recorded South Carolina history peaked in 1995 and 2002 with combined losses totaling $525 million.

• Between 1999 and 2002, results from biomonitoring indicate that 94 percent of all plants sampled showed no sign of ozone damage, an indication of good air quality in South Carolina.

• Silviculture is a minor contributor to nonpoint source impairment, and research supports the conclusion that forested watersheds produce the State's highest level of water quality.

Economic Impact

• Forestry, logging, primary wood products, and furniture manufacturing contribute $14.7 billion annually to the State's economy.

• Approximately 40,000 individuals are directly or indirectly employed in logging, forestry, and other wood-processing industries with a combined income of $1.7 billion.

• Total output of timber products, including domestic fuelwood, averaged more than 775 million cubic feet per year between 1993 and 2000, a 6-percent decline from the previous period (1986 to 1992).

• Softwood species accounted for 75 percent of the total product output volume.

• Pulpwood—391 million cubic feet produced by South Carolina's mills in 2000—remains the primary wood product output.

• Preliminary results for the 2001 timber product assessment for South Carolina indicate a substantial decline in product output for both softwoods and hardwoods.

Southern swamp, Francis Beidler Forest, South Carolina. (photo by Bill Lea)

Pitcher plants on the Francis Marion and Sumter National Forests. (photo by Bill Lea)

A New Way to Monitor Forest Resources

The eighth survey of South Carolina's forests marks an important shift from its predecessors, both in the scope of its measurements and in its timeliness. The first seven surveys provided valuable information about timberland—area, volumes, and growth-to-removal relationships (Conner 1998, Tansey and Hutchins 1988)—but only a cursory assessment of the ecological relationships that influence forest health. Previous survey cycles ranged from 6 to 10 years, depending on fluctuations in Federal budgets and staffing.

Demands from South Carolina and other forest-dependent States for timely information prompted Congress to establish an annual cycle as the national standard for forest surveys. With a new mapped-plot design and the resources to measure one 20-percent panel of the total sample locations each year, it is now possible and practical to monitor emerging resource issues by providing yearly "snapshot" updates and longer term (5-year) trend analyses. The resulting improvements in timeliness, combined with the incorporation of forest health measurements and data from the recently established National Woodland Owner Survey (www.fs.fed.us/woodlandowners), have transformed the survey into a tool for detecting and analyzing the issues, ecological relationships, and human activities that will shape the forest resources of South Carolina.

This resource bulletin consolidates data from all five panels in the first cycle of annual measurements and uses that information to describe the current issues affecting the status and condition of the State's forests. It builds on and completes earlier estimates that followed the first three panels (Conner and Sheffield 2001).

Forces of Change

Forest land throughout South Carolina is undergoing changes—both naturally occurring and those caused by humans. Forces of change are as varied as the forest itself, as are the impacts that they have on current and future forest conditions.

Urbanization and agriculture are the primary causes of forest land loss in South Carolina. Of these, the loss of forests to urbanization is perhaps more important to monitor because it is usually permanent. Although clearing for agricultural use also results in losses of forest land, those losses are more likely to be reversed when agricultural land is left idle. Additionally, other acres cleared for agriculture are reforested as landowner objectives and economics change in favor of investment in forest land.

Natural forces typically do not result in loss of forest land. Insects and disease are always present and often influence stand structure throughout all stages of development. However, cyclic insect infestations—like the current southern pine beetle epidemic—can cause inordinately high levels of mortality over a relatively short period of time. Other natural events can reshape the State's forests in a matter of hours, as did Hurricane Hugo in 1989.

Whether natural or human-induced, long term or short term, permanent or temporary, South Carolina's forest lands are changing constantly. These changes are reflected in the current condition of the State's forests as evidenced by trends in land use; stand composition; estimates of wood volume; and rates of net annual growth, removals, and mortality. The effects extend to overall forest health, as well as water quality, recreation potential, future timber availability, and other aspects of forest land use and condition.

Urbanization and agriculture are the primary causes of forest land loss in South Carolina. (Top photo by Bill Lea, bottom photo by SRS)

South Carolina now has 12.4 million acres of forest land, which represent 64 percent of its total land area (table 1).

Timberland—defined as forested acres capable of producing at least 20 cubic feet of wood per acre per year and not removed from management by statute or administrative regulation—is the primary component, occupying 12.2 million acres. The remaining 194,000 acres are in State parks, natural areas, watersheds, and other holdings reserved for recreation, wildlife, and municipal water supplies.

Since 1968, agricultural land has dropped from 5.2 million acres to 3.6 million acres, a decline of 32 percent that is typical for the South. In the past, idle farms and cropland have been the primary sources for "new" forest land. They will continue to play a key role in future efforts to increase forest land area.

More important is the increase in urban land area—over 2.6 million acres or nearly three times the acreage in 1968. Urbanization is a growing concern because it can further reduce or fragment forest land both in South Carolina and throughout the South.

Human Populations Growing

Increasing human populations, the root cause of increased urbanization, can signal changes in demands on forest resources. In

Table 1—Land and water area by land use in South Carolina for selected surveys, 1968 to 2001

Land use	Year 1968	1978	1986	1993	2001
			acres		
Forest land					
Timberland	12,426,584	12,502,906	12,178,756	12,454,925	12,221,404
Productive reserved	70,500	72,399	78,216	190,632	194,081
Woodland	12,655	3,893	—	—	—
Total forest land	12,509,739	12,579,198	12,256,972	12,645,557	12,415,485
Agriculture					
Cropland	3,178,098	3,296,240	3,185,044	2,607,357	2,188,940
Pasture	1,029,342	1,006,997	898,212	875,214	826,881
Idle	854,039	310,717	388,058	443,883	482,652
Other farm	164,915	208,414	150,617	131,864	61,038
Total agriculture land	5,226,394	4,822,368	4,621,931	4,058,318	3,559,511
Urban	962,901	1,206,634	1,661,884	1,976,857	2,611,513
Marsh	489,164	511,199	525,867	544,228	586,509
Total nonforest land	6,678,459	6,540,201	6,809,682	6,579,403	6,757,533
Water					
Noncensus	191,660	230,308	253,898	37,424	89,365
Census	509,216	525,493	591,667	1,222,167	1,222,160
Total water	700,876	755,801	845,565	1,259,591	1,311,525
Total land and water area[a]	19,889,074	19,875,200	19,912,219	20,484,551	20,484,543
Total land area[b]	19,379,858	19,349,707	19,320,552	19,262,384	19,262,383

— = no sample for the cell.

[a] U.S. Department of Commerce, Bureau of the Census (1991).

[b] Excludes census water.

Counties with a forest population density of 0 to 100 are generally considered to be rural. (Photo by Rod Kindlund)

2000, 4 million people lived in South Carolina, a 15-percent increase since 1990 compared to an 18-percent increase Southwide (U.S. Department of Commerce, Bureau of the Census 2000). As of 2000, one-third of the people living in the United States made their home in the South.

Increasing human populations can also interfere with forest management by reducing the size of holdings and the management options available. Forest population density (FPD) is the number of people per square mile of forest land measured at the county level. Counties with an FPD of 0 to 100 are generally considered to be rural. An FPD approaching 1,000 indicates a "saturated" urban center (Wear 2002). As shown below, increases in FPD are expected to reach 43 percent across all Southern States (not counting Oklahoma) in 2020:

State	Year 1992	Year 2020	Percent change
Florida	762.6	1,327.2	74
Tennessee	281.5	406.6	44
Texas	279.4	391.3	40
Kentucky	250.4	301.9	21
Virginia	255.0	363.3	42
North Carolina	247.6	381.4	54
Louisiana	216.6	259.7	20
South Carolina	191.0	288.5	51
Georgia	193.9	297.0	53
Alabama	129.3	167.6	30
Mississippi	102.4	122.1	19
Arkansas	98.9	120.0	21
South	232.1	332.7	43

Although 2020 estimates show that South Carolina will continue to rank eighth in FPD, only three other Southern States—Florida, North Carolina, and Georgia—are projected to grow faster.

FPD changes are not likely to be consistent throughout South Carolina due to varied changes in forest area and fluctuations in population within a county. Urban centers tend to establish and expand along transportation corridors, such as the U.S. I-85 corridor in the northern part of the State (fig. 1).

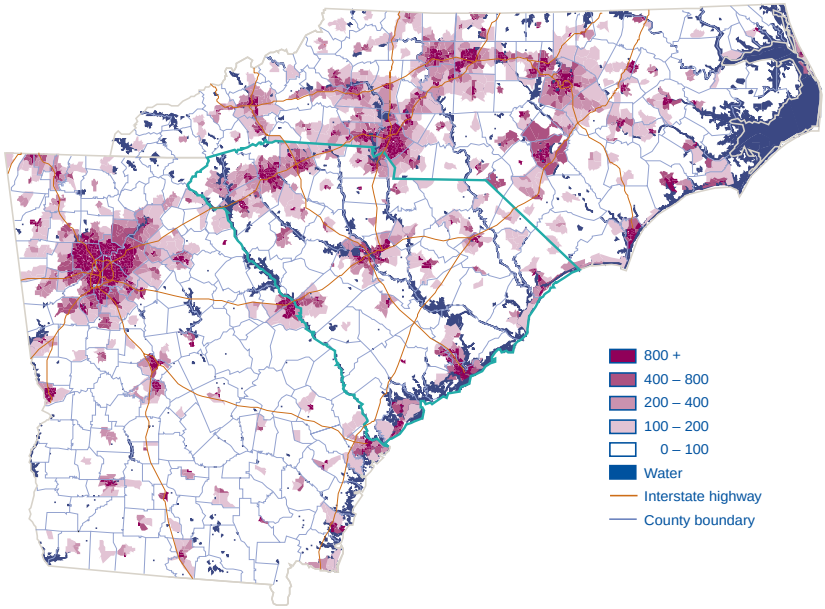


Figure 1—Forest population density for North Carolina, South Carolina, and Georgia (Harper 2001).

Human Choices are the Key to Sustainability

The role of agriculture and urbanization—Forest land has declined substantially from the levels thought to be present before European settlement. Agricultural clearings remained the primary cause of forest land losses until supplanted by urbanization in the mid-1980s (Conner and Hartsell 2002). Figure 2A shows the trends for diversions of forest land to agriculture and urban land uses over the past five surveys. Between 1958 and 1968, 236,000 acres were cleared for agricultural uses, compared with 154,000 acres for urban use. As recently as 1978, diversions

to agricultural uses remained the leading cause of forest land loss. However, between 1979 and 1986 the balance shifted slightly, with 300,000 acres lost to an urban use and 261,000 acres for crops. Today, urbanization, the biggest foreseeable threat to forest land throughout the South (Wear and Greis 2002), has become the leading cause of deforestation in South Carolina, producing losses of 500,000 acres between 1994 and 2001. Over this 8-year period, for every acre lost to agriculture, nearly three were cleared for urban use.

Prognosis for afforestation and reforestation efforts—Early Federal incentives—such as the Agricultural Conservation Program of the 1930s, the Soil Bank Program in the 1950s, and the CRP of the 1980s—encouraged tree planting on idle croplands to prevent further soil loss. Many of the acres planted then still remain in forest today. In the fourth survey (1958 to 1968), forest land increased by 899,000 acres (fig. 2B)—the largest gain since the 1930s—but diversions to agriculture, urbanization, and water reduced the net gain to 478,000 acres. Since then, trends have shifted radically, with net gains of the fifth survey (69,000 acres from 1969 to 1978) and seventh survey (389,000 acres from 1987 to 1993) offset by the losses in the years that followed each period of gain. The 12.4 million acres reported in 2001 reflects a reduction of 230,000 acres since 1993. This most recent loss in forest land occurred despite the addition of 388,000 acres of "new" forest resulting from planting and natural reversion on idle agricultural land.

Land use changes over the 33 years since the fourth survey have resulted in a small but important loss of forest area. Urbanization and other forces of change will continue to reduce South Carolina's forest land base. The degree to which these losses will be offset by landowner reforestation efforts or by natural regeneration depends on continued vigilance and diligence of forest land owners and managers and on the decisions of private owners, many of whom cannot afford to maintain or increase their forested acreage. Government incentives that have encouraged reforestation in the past may come into play again to maintain forest resources at present levels.

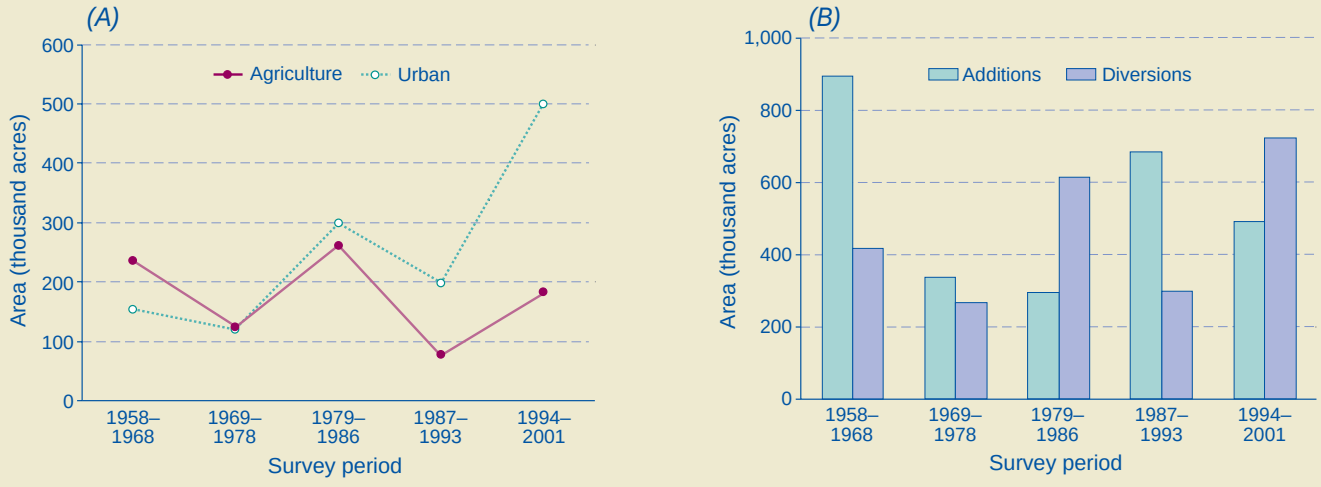


Figure 2—(A) diversion of forest land to agriculture and urban land use in South Carolina, and (B) change in area of forest land in South Carolina.

A Brief History of South Carolina Forests

Before the surveys that began in the mid-1930s, much of what was known about the South's forest resources was based on conjecture and reports from early settlers, who described an open, parklike forest dominated by expanses of longleaf pine in the Coastal Plains, giving way to hardwood stands of oak, hickory, and pine in the uplands of the Piedmont and mountain regions (Carroll and others 2002). Land

Mixed pine-hardwood forest in South Carolina. (photo by Bill Lea)

clearing for homesites and agriculture and introduced diseases such as chestnut blight (Owen 2002) have drastically reshaped the South's forest environment. Like the rest of the South, South Carolina's forests had changed substantially before the first attempt at an extensive, science-based survey of forest resources.

Estimates from the first South Carolina survey reveal a mixture of longleaf, slash, loblolly, and shortleaf pine species (Faulks 1939, Faulks and Spillers 1939, Hicks 1939). Undoubtedly, many of the pine stands had a hardwood component, but mixed pine-hardwood stands were not reported as a separate classification until the third survey which was completed in 1958. These "oak-pine" stands have been defined as predominantly hardwoods with at least 25 percent of the stocking in pines. From 1958 forward, hardwood and oak-pine stands combined have accounted for 6.4 to 6.9 million acres, compared to 5.4 to 5.6 million acres for pine timberland (fig. 3).

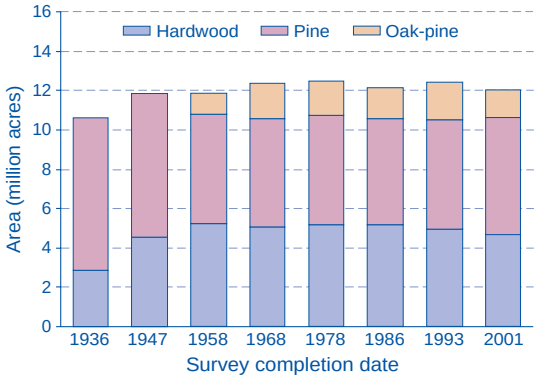


Figure 3—Area of timberland by forest-type group in South Carolina.

Artificially regenerating sites to create "pine plantations" is a relatively recent forest management practice. The simple practice of planting trees, however, is not. Planting on old pasture and abandoned cropland and replanting a site after tree harvest have been in practice throughout the South for decades. In South Carolina for instance, records show that millions of seedlings were planted since the late 1920s, although the rate at which planting occurred did not accelerate appreciably until the availability of government incentives beginning in the mid-1950s. Rates peaked during the 1959-to-1960 planting season when the level reached 187 million trees (fig. 4). That level was not approached again until the mid-to-late 1980s when landowners took advantage of CRP incentives. Although unintended, these incentive programs marked the beginning of pine plantation management in the South (Frederick and Sedjo 1991).

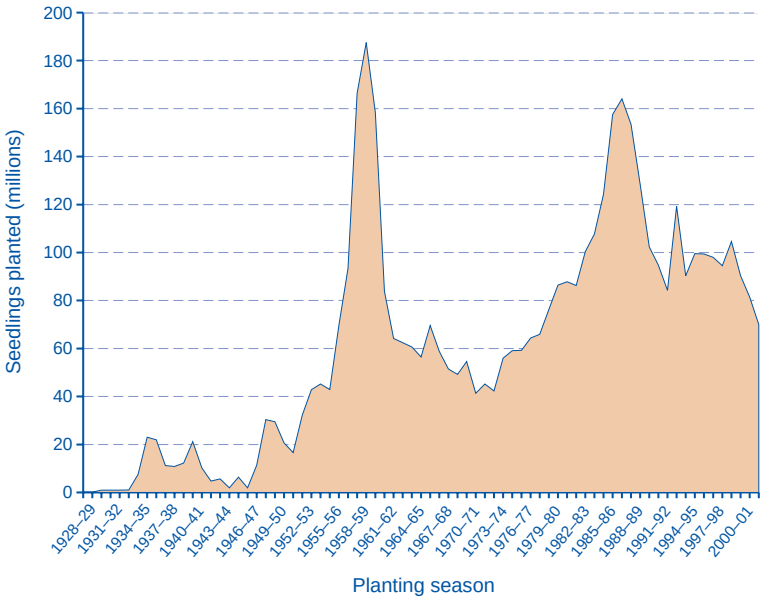


Figure 4—Number of seedlings planted in South Carolina from 1928 to 2001.

Hurricane Hugo and Recovery

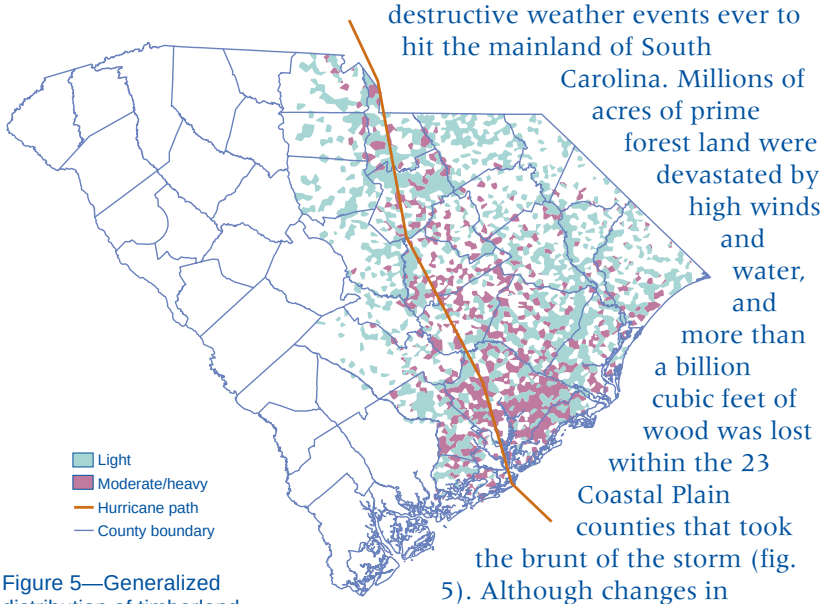


Figure 5—Generalized distribution of timberland in South Carolina damaged by Hurricane Hugo by degree of damage (Sheffield and Thompson 1992).

September 1989 marked one of the most destructive weather events ever to hit the mainland of South Carolina. Millions of acres of prime forest land were devastated by high winds and water, and more than a billion cubic feet of wood was lost within the 23 Coastal Plain counties that took the brunt of the storm (fig. 5). Although changes in volume, growth, and removals on timberland in other parts of the State have offset much of the loss, the storm's impacts are still being felt many years later.

Due to efforts by landowners, progress toward full recovery has been rapid. In the decade following the storm, most of the forests have returned to productive status through planting or natural regeneration. By 1993, timberland area in storm-damaged counties increased to 6.7 million acres (table 2). Timber salvage followed by regeneration produced an increase of 360,000 acres in planted stands (to 1.4 million acres) and an increase of 425,000 acres in loblolly pine plantations (to 1.2 million acres). With the exception of a 21,000-acre increase of redcedar area, all other softwood forest types declined within 3 years after the storm; and hardwood forest types declined by 50,000 acres.

The Continuing Role of Pine Plantations

A little more than 40 years ago, planted pine stands occupied less than 2 million acres in the South. By the late 1990s, pine plantations accounted for nearly half of all pine stands (Conner and Hartsell 2002). The dramatic increase in pine plantations has become one of the defining issues in southern forest management, and is an issue in South Carolina as well.

Pine stands are often artificially regenerated after harvest to ensure the site remains in production as a pine forest type. The prevailing concern is that they may arise at the expense of natural stands. This concern has proven to be justified to varying degrees in the past but is less of an issue for the 386,000-acre net increase since 1993

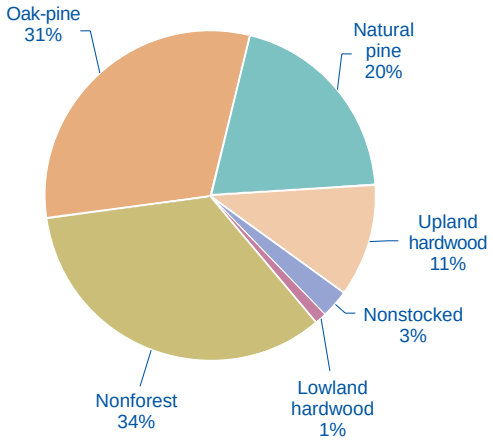


Figure 6—Sources of new pine plantations in South Carolina from 1993 to 2001.

Table 2—Area of South Carolina timberland damaged by Hurricane Hugo by forest type and stand origin

Forest type	1986			1993			2001		
	Natural	Planted	Total	Natural	Planted	Total	Natural	Planted	Total
	acres								
Softwoods									
Longleaf pine	215,857	23,653	239,510	166,134	28,663	194,797	163,086	73,045	236,131
Slash pine	16,150	161,616	177,766	25,922	91,186	117,108	45,744	11,865	57,609
Loblolly pine	1,268,419	790,565	2,058,984	1,100,268	1,216,053	2,316,321	1,283,597	1,459,004	2,742,601
Shortleaf pine	156,101	6,044	162,145	92,136	0	92,136	52,222	0	52,222
Virginia pine	26,745	0	26,745	13,984	0	13,984	16,735	0	16,735
Pond pine	164,356	4,815	169,171	104,271	2,801	107,072	85,767	0	85,767
Spruce pine	0	0	0	0	0	0	0	2,780	2,780
Redcedar	8,458	0	8,458	29,287	0	29,287	15,875	0	15,875
Total softwoods	1,856,086	986,693	2,842,779	1,532,002	1,338,703	2,870,705	1,663,026	1,546,694	3,209,720
Oak-pine	794,471	56,685	851,156	983,232	83,976	1,067,208	639,510	26,900	666,410
Total pine/oak-pine	2,650,557	1,043,378	3,693,935	2,515,234	1,422,679	3,937,913	2,302,536	1,573,594	3,876,130
Hardwoods	2,814,283	27,757	2,842,040	2,783,555	8,365	2,791,920	2,609,930	32,595	2,642,525
All types	5,464,840	1,071,135	6,535,975	5,298,789	1,431,044	6,729,833	4,912,466	1,606,189	6,518,655

(fig. 6). The majority of land converted to plantations (37 percent) were either nonstocked or previously nonforested and represent "new" timberland acres. Another 31 percent were natural oak-pine sites with a major (25 to 50 percent) pine component, leaving only 20 percent converted from natural pine stands.

With a quarter of the total timberland area and nearly a fifth of the total growing-stock volume, planted pines contribute significantly to the timber resources of South Carolina and compare favorably with natural (table 3). Annual rate of growth on planted pine stands outpaced annual removals by 76 percent, whereas annual removals exceeded net growth on natural stands. When well managed, planted pines have substantially lower mortality rates and higher rates of net annual growth, averaging nearly 128 cubic feet of wood growth per acre per year, compared to 76 cubic feet for natural pine stands.

Table 3—Comparison of planted to natural stands in South Carolina, 2001

Timberland component	Area	Volume	Mortality	Net annual growth	Annual removals
	million acres	*million cubic feet of growing stock*			
Planted pine	3.1	3,491.8	22.5	396.4	225.4
Natural pine	2.9	4,534.2	38.3	221.6	241.2
Oak-pine	1.4	1,641.8	18.2	88.1	70.6
Hardwoods	4.8	8,367.0	79.1	253.5	193.9
All types	12.2	18,013.6	158.1	960.2	731.3

Nearly all of the 12.4 million acres of forest land in South Carolina qualifies as timberland, which means that it can produce at least 20 cubic feet of wood per acre per year and that it has not been removed from management by statute or administrative regulation. Two distinct periods mark the long-term changes in South Carolina timberland: increasing area from 1936 to a peak in 1978, followed by the oscillations that closely follow general trends for forest land:

Survey year	Timberland area million acres
1936	10.7
1947	11.9
1958	11.9
1968	12.4
1978	12.5
1986	12.2
1993	12.5
2001	12.2

Between 1986 and 1993, timberland increased by more than 276,000 acres, followed by a decline of 234,000 acres. By 2001 the area of timberland had fallen back to the 1986 level. Even with the latest loss, timberland acreage is well above the 1936 level.

In 1952, natural pine occupied 5.9 million acres but dropped to less than 2.9 million acres by 2001, a downward trend occurring in tandem with corresponding increases in planted pines (fig. 7). With the addition of

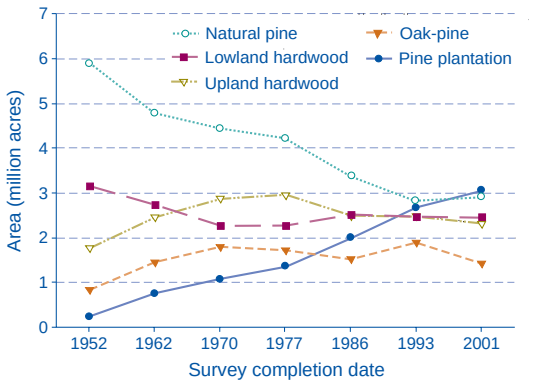


Figure 7—Area of timberland by forest-management type in South Carolina.

386,000 acres since 1993, planted pine stands now outnumber natural pine by 151,000 acres, representing a net change after reclassification and regeneration of planted pine stands to natural stands and conversion of plantations to nonforest uses. Loblolly pine remained the species of choice for planting, comprising 94 percent of pine plantation acres in 2001.

Lowland and upland hardwood forest types have been relatively stable since the mid-1980s. Oak-pine types have declined by 480,000 acres since 1993, predominately in counties damaged by Hurricane Hugo.

Forest Composition and Stand Structure

Trends in stand structure (species composition and tree size) are an accumulation of changes in forest-type distribution and stand-size classification. These changes are common and can result from natural causes (weather, insects and disease, or natural succession); from logging; or from other human activities and disturbances.

The 2001 estimates show slight reductions in hardwoods (218,000 acres) and mixed oak-pine species (479,000 acres) and increases in pines since 1993. For the first time ever, "pure" hardwood stands (oak-hickory, oak-gum-cypress, and elm-ash-cottonwood forest types combined) fell below 5.0 million acres. Pine forest types increased to 6.0 million acres—400,000 acres more than any other survey period since the first—largely because of a substantial increase (692,000 acres) in loblolly pine.

As the predominance of tree sizes changes within a stand, so also does the stand-size classification. The acres classified as sawtimber were significantly reduced between 1986 and 1993 by Hugo-related mortality of large-diameter trees. The downward trend of sawtimber stands continued for the next 8 years with the reduction of another 400,000 acres to 4.4 million acres (fig. 8). Statewide, sawtimber stands occupied 36 percent of South

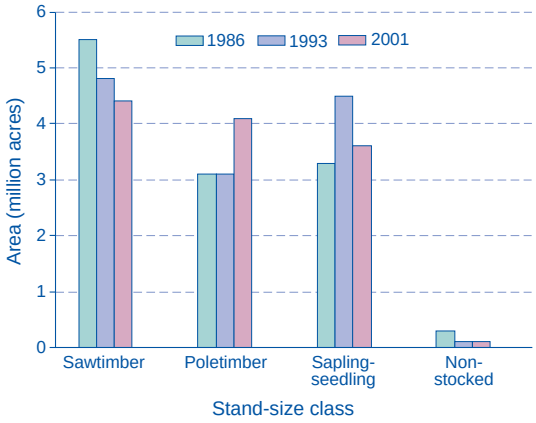


Figure 8—Area of timberland by stand-size class in South Carolina.

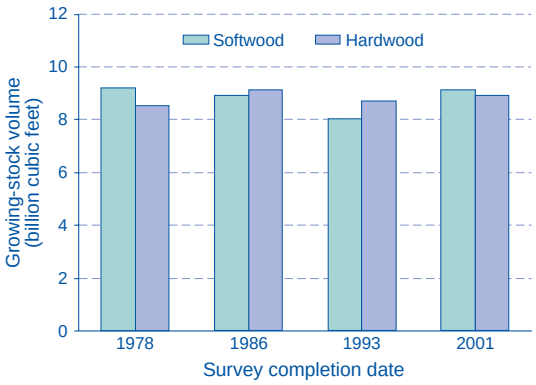


Figure 9—Growing-stock volume by softwood and hardwood in South Carolina.

Carolina's timberland area in 2001, compared to 45 percent in 1986 and 38 percent in 1993. Poletimber stands increased by 1.0 million acres since 1993, reflecting the growth of saplings and seedlings. The 4.1 million acres of poletimber, if managed to maximize growth, would help the State return to pre-Hugo sawtimber levels. Mirroring the increase in poletimber stands was a nearly equal decline in stands dominated by saplings and seedlings. Stands in this smaller size class dropped by 819,000 acres to 3.6 million acres, marking a return to the pre-Hugo ratio of this class to the others.

Growing-Stock Volume has Increased

Despite the drop in total timberland area from 1993 to 2001, total growing-stock volume increased by 1.3 billion cubic feet to 18.0 billion cubic feet, exceeding pre-Hugo levels and surpassing any other period since the original 1936 survey.

Softwoods, which suffered the largest Hugo volume losses, enjoyed an extraordinary rebound in the 12 years since the 1989 storm. The 9.1 billion cubic feet of softwood growing-stock volume in 2001 exceeds the pre-Hugo levels by 293 million cubic feet, and reflects a 1.1-billion-cubic-foot increase since 1993 (fig. 9). There is virtually as much softwood volume present in 2001 as there was in 1978.

The driving force behind the rise in softwoods is the dramatic increase in loblolly pine, with 6.9 billion cubic feet of volume reflecting increases of 1.3 billion cubic feet over 1986, and 1.5 billion cubic feet over 1993 (fig. 10). Because of extensive planting in the mid-1980s and restocking of Hugo-damaged pine acres, the proportion of loblolly pine to total softwoods rose to 76 percent in 2001. Volume of eastern white pine more than doubled since 1986, rising from 33.4 million cubic feet to 68.2 million cubic feet. Other softwoods have not fared as well and continue to show significant declines. Of these species, only baldcypress and spruce pine showed increases in growing stock since 1993.

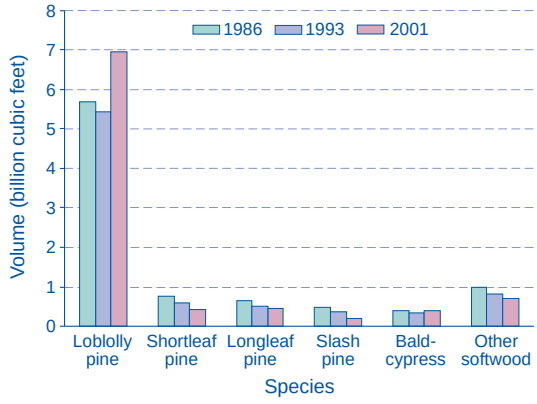


Figure 10—Growing-stock volume on timberland by softwood species in South Carolina.

Hardwoods failed to recover fully to the pre-Hugo level of 9.1 billion cubic feet but did not miss the mark by much. The 2001 growing-stock volume of 8.9 billion cubic feet was an increase of 235 million cubic feet. Other red oaks (1.8 billion cubic feet) and sweetgum (1.7 billion cubic feet) remain the predominant species (fig. 11). The other important hardwoods that increased were select red oaks, yellow-poplar, and select white oaks.

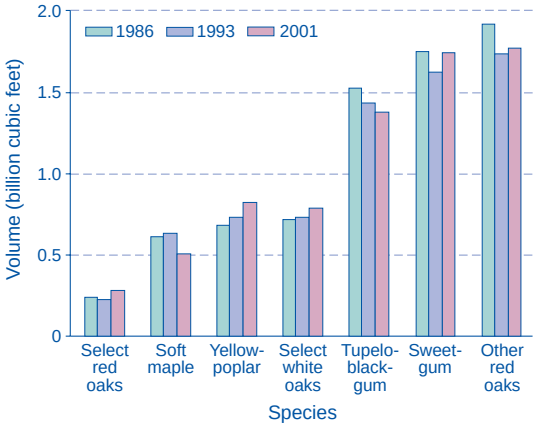


Figure 11—Growing-stock volume on timberland by hardwood species in South Carolina.

Timberland Net Annual Growth and Removals—A Return to Sustainable Levels

If trends in growing-stock volume measure changes in timberlands, the relationship between net annual growth and removals helps to explain the reasons for those changes. From 1948 to 1985, growth-to-removal relationships essentially remained at sustainable levels both for softwoods (fig. 12) and hardwoods (fig. 13). The net result was an increase in growing-stock volume throughout the 37 years, with only one small decline in softwood volume reported for the 1978 to 1985 survey period.

The seventh survey of South Carolina (1986 to 1992) reported abnormal Hugo-related mortality (Conner 1998), which lowered net growth to levels recorded more than 30 years earlier. At the same time, post-Hugo recovery and salvage efforts helped to drive up removal rates. For the first time ever, removals significantly

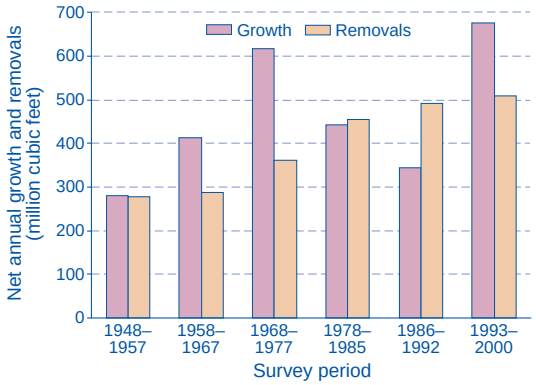


Figure 12—Growth and removals of softwood growing stock on timberland in South Carolina.

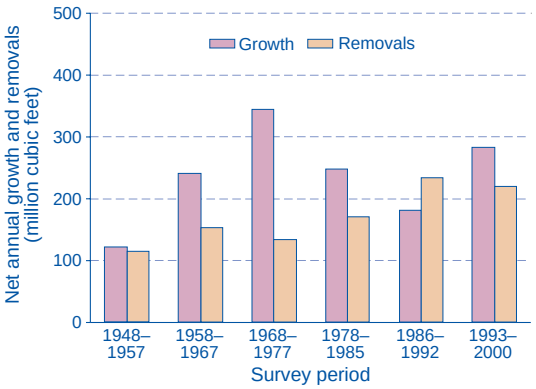


Figure 13—Growth and removals of hardwood growing stock on timberland in South Carolina.

Removals exceeded growth after Hurricane Hugo but was short-lived. (SRS photo)

exceeded net growth, with survey results showing a substantial decline in softwood growing stock and an unprecedented decline in hardwood volume.

The growth-removals imbalance was short lived. Mortality rates have returned to prestorm levels, and net annual growth again exceeds removals for both softwoods and hardwoods. Statewide, annual net growth of softwoods is nothing short of phenomenal, reaching levels never before seen in South Carolina as CRP plantings and fast-growing, young stands have begun to pay dividends. Between 1993 and 2000, softwood annual net growth averaged 677 million cubic feet for a total of 5.4 billion cubic feet for the period (fig. 12). Annual removals averaged 510 million cubic feet for a total of nearly 4.1 billion cubic feet for the period. Even with the slight increase in removals, the growth-to-cut ratio was 1.3 cubic feet of wood grown for each cubic foot harvested.

Post-Hugo changes for hardwood net growth and removals, although not as dramatic, were nonetheless substantial, revealing a return to sustainable levels. From 1993 to 2000, net annual growth rose 56 percent to 284 million cubic feet, and removals declined 6 percent to 222 million cubic feet (fig. 13). Overall, hardwood net growth was 2.3 billion cubic feet compared to 1.8 billion cubic feet in removals for the period, for a growth-to-cut ratio of 1.3, which equaled the softwood ratio.

Report on Post-Hugo Recovery

Changes in the distribution of timberland by forest types, stand origin, and stand age on Hugo-damaged acres illustrate how the forest in place now differs from what it replaced in the 23 affected counties.

Forest type and stand origin (table 2 and fig. 14)—In 1986, natural softwood stands outnumbered planted acres by nearly two to one. Loblolly pine comprised 72 percent of the softwood timberland and 80 percent of softwood plantations. By 2001, softwood plantations increased to 1.5 million acres (25 percent of total timberland) compared to 1.7 million acres in natural stands. Loblolly pine increased 426,000 acres to 2.7 million acres. Planted loblolly pine stands increased by 85 percent to 1.5 million acres. Similar to Statewide trends, the area of all other softwoods combined declined from 204,000 acres to 121,000 acres. Mixed oak-pine stands declined from 1.1 million acres to 666,000 acres. Overall, natural stands of all types declined by 10 percent to below 5.0 million acres, and pine and oak-pine plantations increased by 51 percent.

Stand age—As expected, much of the timberland in the area is in young age classes (fig. 15). One out of four stands is below 11 years, and nearly one in two—48 percent—is at or below 20 years. The two youngest age classes also hold 1.3 million acres in planted pine and planted oak-pine stands, meaning that 80 percent of the planted stands are below 21 years. The predominance of young stands bodes well

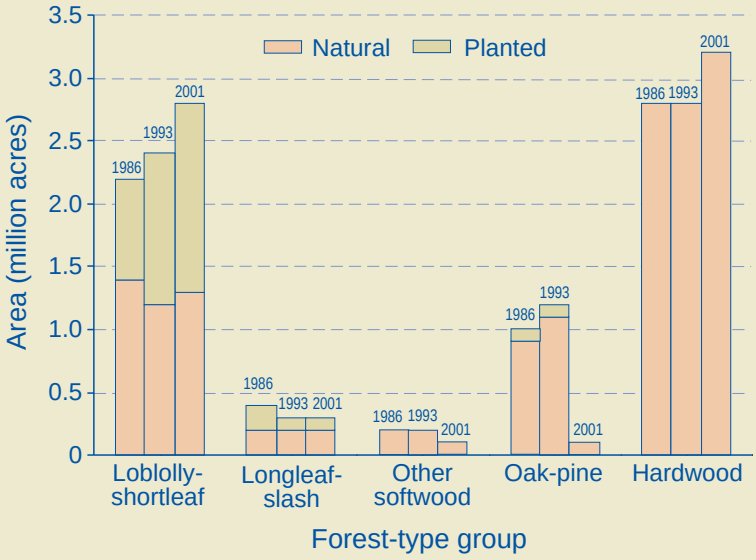


Figure 14—Hurricane Hugo-damaged timberland in South Carolina counties by forest-type group and stand origin.

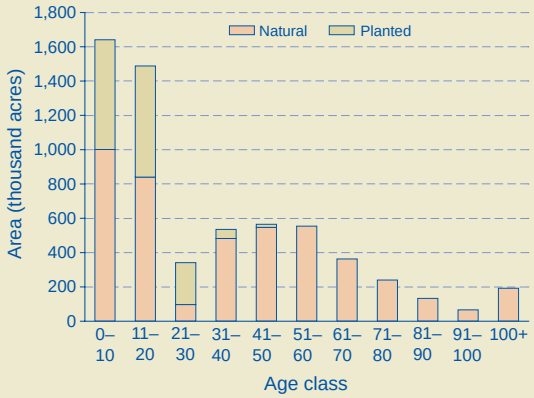


Figure 15—Hurricane Hugo-damaged timberland in South Carolina counties by age class and stand origin in 2001.

for net annual growth and future volume increases. With so many stands in the early stages of development, volumes have not yet reached pre-Hugo levels, although softwood and hardwood gains have been significant.

Volume—From 1986 to 1993, growing-stock volume fell by 1.7 billion cubic feet due to storm-related mortality and to the salvage and other harvesting that followed, and softwood volume dropped by 1.0 billion cubic feet to 3.8 billion:

Species group	1986	1993	2001
	million cubic feet		
Softwoods	4,815.1	3,750.0	4,262.7
Hardwoods	5,002.3	4,398.4	4,131.3
Total	9,817.4	8,148.5	8,394.0

Although still lagging behind prestorm levels by 1.4 billion cubic feet, total growing-stock volume increased by 3 percent to 8.4 billion cubic feet since 1993. The dramatic increase in acres of pines, especially in planted stands, has done much to improve softwood volume, which increased to 4.3 billion cubic feet (14 percent) but remains 552 million cubic feet below prestorm levels. Planted stands hold 1.5 billion cubic feet of softwood growing-stock volume. Overall, volume in planted stands is double what it was 15 years ago. About 63 percent of the current softwood volume is in stands below 41 years. These young, fast-growing stands have the potential to add substantially more volume over the next few years.

The loss of 387,000 acres of hardwood and oak-pine stands since 1986, coupled with typically slower growth rates, has meant a slower recovery in hardwood volume. Hurricane Hugo played a major role in reducing hardwood growing stock by 604 million cubic feet from 1986 to 1993, followed by an additional loss of 267 million cubic feet from 1993 to 2001. The current volume is 871 million cubic feet less than prestorm levels.

Mortality, growth, and removals—As shown below, storm-driven mortality reached levels never before witnessed in South Carolina. Although softwood mortality dropped back to below prestorm levels, hardwoods are showing signs of continuing losses. Hardwood mortality has fallen considerably, but the 47.1 million cubic feet lost annually since 1992 is still 49 percent above prestorm levels.

Species group	1978–85	1986–92	1993–2000
	million cubic feet		
Softwoods	35.7	216.3	28.5
Hardwoods	31.6	125.8	47.1
Total	67.3	342.1	75.6

Lower softwood mortality rates and fast-growing stands translate into higher net annual growth rates. In fact, net annual growth for softwoods averaged 359.2 million cubic feet between 1993 and 2000, exceeding prestorm growth rates by 45 percent (fig. 16). With that recovery, net growth for softwoods exceeds annual removals (266.9 million cubic feet), reversing the storm-driven negative relationship reported in 1993.

Hardwoods have yet to reach 1985 growth levels, but the current estimate of 129.9 million cubic feet per year is more than double the 1992 level. Removals exceeded net growth in 1992 and again in 2000, but by a much smaller margin. The annual removals rate of 135.3 million cubic feet

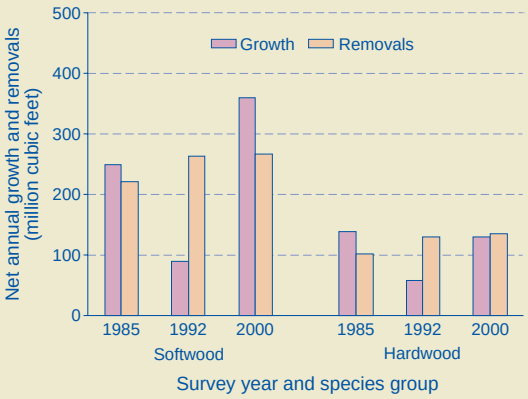


Figure 16—Growth and removals of growing stock in South Carolina counties damaged by Hurricane Hugo, by species group.

exceeds net annual growth by a mere 4 percent. This situation is likely to be short lived if mortality continues to decline.

Prognosis for future gains—Recovery from one of the worst storms to hit South Carolina is progressing well, particularly for softwoods in planted stands. Hardwoods and oak-pine stands have suffered losses, but what remains is in good condition. Hardwood and softwood volumes are increasing, but remain below prestorm levels. With mortality rates near "normal," net annual growth is rising and the growth-to-removals relationships are approaching sustainable levels. More time is needed for full recovery, but the evidence shows that a turnaround is well underway.

The camera point is located on the Francis Marion National Forest off Highway 52, just south of Bonneau, SC. The top photo shows the damage following Hurricane Hugo. The bottom photo was taken September 4, 2003. (photos by South Carolina Forestry Commission)

Longleaf pine stand on the Wambaw/Witherbee Ranger District, Francis Marion National Forest. (photo by Bill Lea)

Forest Ownership is Changing

Forest land ownership often dictates the availability and use of forest resources. The general distribution of forest ownership in South Carolina has remained relatively constant since the mid-1980s, especially on the 1.5 million acres managed by public agencies (Butler and Leatherberry, manuscript in preparation). The most expansive of these are the Francis Marion and Sumter National Forests, which span 13 counties, followed by land managed by the U.S. Department of Energy, the U.S. Department of Defense, and the Fish and Wildlife Service of the U.S. Department of the Interior (fig. 17). Next are the State agencies—including the Department of Natural Resources; the Department of Parks, Recreation, and Tourism; and the Forestry Commission—that collectively control 380,000 acres. Local governments are responsible for recreation, water quality, and other purposes on the acreage—less than 1 percent—that they manage.

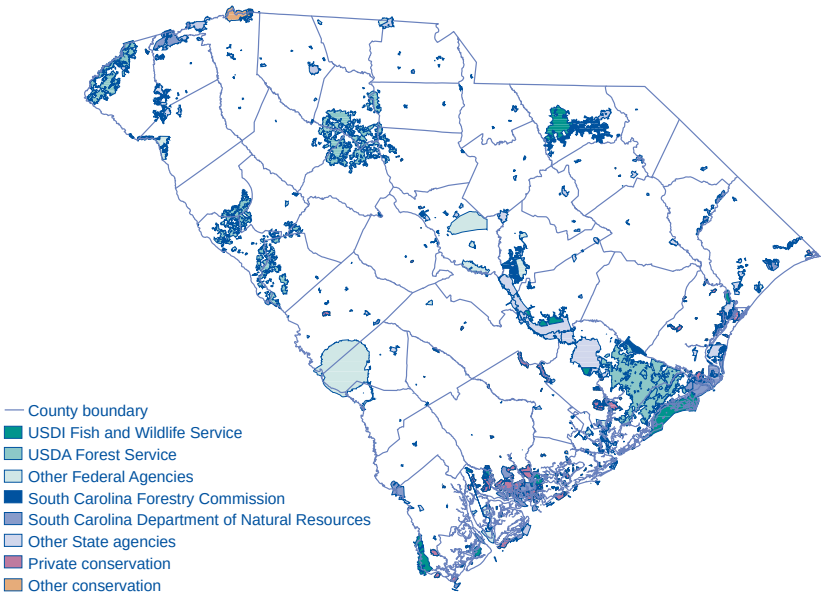


Figure 17—Distribution of South Carolina's reserved and protected lands in 2001.

In contrast to the 1.5 million acres in public ownership, an estimated 363,000 private owners (table 4) collectively hold 11.0 million acres or 88 percent of the forest land in the State, down from 11.3 million acres in 1993 (table 5). These private owners include families or individuals with 7.1 million acres and businesses with 3.8 million acres, approximately half of which are held by forest products companies (fig. 18). Between 1986 and 1993, 15 percent of the forest land in South Carolina moved from one ownership category to another (table 6). This statistic does not capture the untold number of acres that were sold, but remained in the same ownership category.

The largest shifts of acreage have been from individuals or families (52 percent) and from forest products companies (38 percent) to other businesses, partially offset by reversions of nearly 245,000 acres to

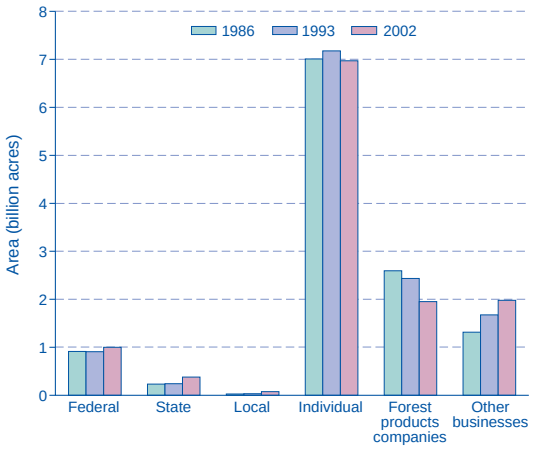


Figure 18—Change in timberland area by owner class in South Carolina.

Table 4—Area and number of privately owned South Carolina forests by size of landholdings and owner type, 2003

Size of forested landholdings	Area			Ownerships			
	Acres	Percent	Standard error	Number[a]	Percent	Standard error	Count
acres							
				Family			
1 – 9	357,000	3.3	64,000	212,500	58.5	32,600	30
10 – 49	1,380,000	12.6	120,000	98,900	27.2	7,300	116
50 – 99	1,000,000	9.1	104,000	22,600	6.2	1,800	84
100 – 499	2,630,000	24.0	154,000	20,700	5.7	1,200	221
500 – 999	714,000	6.5	89,000	1,800	0.5	200	60
1,000 – 4,999	881,000	8.0	98,000	900	0.2	100	74
5,000 +	155,000	1.4	43,000	100	0.0	10	13
Subtotal 10 – 4,999	6,604,500	60.3	258,100	144,900	39.9	7,600	555
Total	7,116,200	64.9	269,300	357,400	98.5	33,500	598
				Business[b]			
1 – 499	82,000	0.7	24,000	4,800	1.3	1,200	12
500 – 999	68,000	0.6	21,000	400	0.1	0	10
1,000 – 4,999	190,000	1.7	36,000	300	0.1	0	28
5,000 +	3,503,000	32.0	127,000	100	0.0	10	515
Subtotal 10 – 4,999	81,600	0.7	47,300	2,200	0.6	200	49
Total	3,842,900	35.1	136,000	5,600	1.5	1,200	565
				All private			
1 – 9	364,000	3.3	65,000	215,800	59.4	32,700	31
10 – 49	1,387,000	12.7	120,000	99,400	27.4	7,300	117
50 – 99	1,006,000	9.2	104,000	23,000	6.3	1,800	85
100 – 499	2,691,000	24.6	156,000	21,400	5.9	1,200	230
500 – 999	782,000	7.1	91,444	2,200	0.6	200	70
1,000 – 4,999	1,071,000	9.8	104,403	1,200	0.3	100	102
5,000 +	3,658,000	33.4	134,082	200	0.1	14	528
Subtotal 10 – 4,999	6,686,100	61.0	262,398	147,100	40.5	7,603	604
Total	10,959,100	100.0	136,000	363,000	100.0	1,200	1,163

[a] Butler and Leatherberry, manuscript in preparation.

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

individuals, 135,000 to forest products companies, and 125,000 acres to nonforest uses. Forest products companies continue to own many of the planted pine stands—1.1 million acres in 2001, down slightly from 1993. Many forest products companies are partly or completely divesting forest land to pay down existing debts and are concentrating their resources into increasingly specialized core businesses. The result is that 1.7 million acres—55 percent—of South Carolina's pine plantations are in the hands of other private owners, more than doubling the area in this ownership since 1986. This change reflects the overall decline of timberland owned by forest products companies.

Table 5—Forest land area in South Carolina by ownership type and year

Year	All ownerships	Public				Private		
		Total[a]	Federal[a]	State[a]	Local[a]	Total[a]	Family	Business[b]
					acres			
2003	12,415,000	1,456,000 (55,000)	1,000,000 (44,000)	380,000 (32,000)	76,000 (14,000)	10,959,000 (99,000)	7,116,000 (269,000)	3,843,000 (136,000)
1993	12,646,000	1,184,000 (38,000)	909,000 (31,000)	242,000 (20,000)	33,000 (13,000)	11,341,000 (75,000)	6,419,000[c] (546,000)	4,587,000[c] (800,000)

Numbers in parentheses are standard errors.

[a] Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis database http://ncrs2.fs.fed.us/4801/fiadb/.

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

[c] Birch (1996).

Table 6—Ownership transition matrix for South Carolina, 1986 to 1993

Transferring from	Transferring to						
	Federal	State	Local	Forest industry	Other corporations	Individual	Nonforest
	acres						
Federal		30,000	w	15,000	5,000	15,000	30,000
State	15,000		w	10,000	w	5,000	10,000
Local	w	5,000		5,000	5,000	10,000	15,000
Forest industry	50,000	15,000	w		490,000	280,000	80,000
Other corporations	15,000	50,000	w	135,000		245,000	125,000
Individual	25,000	25,000	15,000	215,000	675,000		480,000
Nonforest	w	10,000	10,000	45,000	115,000	735,000	

w = fewer than 5,000 acres detected.

At the same time, a new group of businesses, timber investment management organizations (TIMO), have begun amassing large landholdings to diversify investment portfolios and generate revenue for pension funds and other institutional investors. TIMOs have only recently been subject to tracking as a separate ownership, but future surveys will provide estimates of their involvement in South Carolina's wood-fiber production industry. For now, available information suggests that TIMOs own 4 to 8 million acres of forest land throughout the South (Siry 2002) and will likely increase their future holdings. In addition to TIMOs, a number of local or regional forest management firms have been acquiring sizable holdings on their own behalf, for their clientele, or for both.

Shifts between forest land held by individuals and land held for nonforest uses were also significant, with 480,000 acres converted to nonforest uses more than offset by 735,000 acres converted or reverted from nonforest uses to forests (table 6).

Landowner Characteristics and Possible Influences on South Carolina Forests

Parcel Size Influences Harvesting Decisions

The flow of goods and services from South Carolina's forests is largely determined by the 363,000 private individuals and groups in control of 88 percent of the State's forest resources. Although most forest

landowners in South Carolina have relatively small holdings, most of the forest land is owned by a few large-parcel holders. The 3.7 million acres controlled by forest products companies and other businesses and by families and individuals with large landholdings (5,000+ acres) can reasonably be assumed to be available for timber harvesting. Since harvesting costs increase and opportunities for harvesting decrease as the size of landholdings decreases, landowners with forested holdings below a given threshold typically are not considered working forest land where commercial forestry activities can reasonably be conducted. This is one reason that the 0.4 million acres in holdings of less than 10 acres are assumed to be unavailable for timber production. Another reason involves the relationship between landowner objectives and parcel sizes. The average parcel size of people who own land as part of their home is 37 acres, compared to 69 acres for those with timber production objectives.

Characteristics of Family Forest Owners

It is the diverse and dynamic group of family forest owners with 10 to 5,000 acres of land that is the most difficult to predict. These 145,000 families own 53 percent of the total forest land in the State. Some of the characteristics of these family owners that will affect forest sustainability are their ownership objectives, management practices, investment and environmental concerns, and longevity.

How they manage their forests—Eighty percent of family forest land is owned by people who have harvested some trees on their land, and 33 percent of these owners have done so within the past 5 years (table 7). Other common forestry activities include fire hazard reduction, tree planting, and site preparation work (table 8).

Table 7—Area and number of South Carolina family owned forests[a] by timber harvesting activities, 2003

	Area			Ownerships			
Timber harvesting activities	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Timber harvest							
Yes	5,248,000	79.5	181,000	84,300	58.2	5,400	441
No	1,249,000	18.9	115,000	57,400	39.6	5,300	105
No answer	83,000	1.3	31,000	2,800	1.9	1,100	7
Products harvested							
Veneer logs	809,000	12.2	94,000	5,700	3.9	900	68
Saw logs	4,189,000	63.4	176,000	53,500	36.9	3,800	352
Pulpwood	4,343,000	65.8	177,000	61,000	42.1	4,400	365
Firewood	1,214,000	18.4	113,000	21,500	14.8	2,500	102
Posts and poles	833,000	12.6	96,000	9,600	6.6	1,700	70
Other	107,000	1.6	36,000	900	0.6	200	9
Professional consultation	3,391,000	51.3	167,000	34,400	23.7	2,700	285
Recent harvest (5 years)	2,749,000	41.6	157,000	27,900	19.3	2,700	231

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

Table 8—Area and number of South Carolina family owned forests[a] by recent (past 5 years) forestry activity, 2003

	Area			Ownerships			
Activity[b]	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Timber harvest	2,749,000	41.6	157,000	27,900	19.3	2,700	231
Collection of NTFPs	321,000	4.9	61,000	6,800	4.7	1,400	27
Tree planting	2,273,000	34.4	146,000	16,900	11.7	1,800	191
Fire hazard reduction	2,725,000	41.3	156,000	27,600	19.0	2,500	229
Site preparation	1,725,000	26.1	132,000	22,500	15.5	2,700	145
Application of chemicals	1,309,000	19.8	117,000	9,700	6.7	1,500	110
Road/trail maintenance	2,190,000	33.2	144,000	24,500	16.9	2,600	184
Posting	2,154,000	32.6	144,000	26,700	18.4	2,500	181
Private recreation	2,487,000	37.7	151,000	37,200	25.7	3,400	209
Public recreation	321,000	4.9	61,000	5,100	3.5	1,100	27
Wildlife habitat improvement	1,583,000	24.0	127,000	13,100	9.0	1,300	133
Conservation easement[c]	464,000	7.0	73,000	5,100	3.5	900	39
Green certification[c]	381,000	5.8	66,000	1,300	0.9	200	32

NTFPs = nontimber forest products.

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

[b] Categories are not exclusive.

[c] Not limited to past 5 years.

Although many landowners have engaged in some type of forest management, few (27 percent) have sought advice and even fewer (8 percent) have a written management plan (table 9). Of those who have harvested timber, 41 percent involved a professional forester during their last harvest. These findings suggest the need for a greater role for the forestry community.

What they want—As a group, family forest owners have multiple objectives that shape how they view their land and whether they are willing to harvest timber (fig. 19, table 10). Family legacy—inheritances from previous generations, bequeathing to future generations (through an estate or other transfer mechanisms), or both—was an important objective for 71 percent of the family forest land. Almost as important were financial motives, either land kept for investment (62 percent) or managed for timber (57 percent). Rounding out the "top five" objectives for ownership were aesthetics and privacy. Whether the land is owned in conjunction with a home or farm added another level of complexity (table 11).

Their concerns—The worries or concerns of landowners will affect their ability or willingness to contribute to the State's timber supply. Top among the concerns of families with large holdings were fires and insect infestations, especially southern pine beetles (table 12), both of which can force salvage logging before landowners are ready and potentially cause an oversupply of timber. Next were sociopolitical concerns including family legacy, trespassing, dumping, and property taxes. Conversely, families with smaller holdings were more likely to rate noise, wild animals, and forest regeneration as major issues.

Longevity—A stable land base is of vital importance if forests are to remain an economic and social asset for South Carolina. The family forest land base is reasonably stable with tenure usually exceeding 10 years and commonly exceeding 25 years (table 13). But many South Carolina landowners are aging (table 14) and many lands will soon be changing ownership. It is at the time of transfer that the fate of the forest is often decided.

Table 9—Area and number of South Carolina family owned forests[a] by management plan and advice sought, 2003

Management plan and advice sought	Area			Ownerships			
	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Written management plan							
Yes	1,547,000	23.4	126,000	10,900	7.5	1,200	130
No	4,439,000	67.2	177,000	120,600	83.2	7,500	373
No answer	619,000	9.4	83,000	13,300	9.2	2,100	52
Sought advice							
Yes	3,689,000	55.9	171,000	39,200	27.1	3,000	310
No	2,725,000	41.3	156,000	100,400	69.3	6,900	229
No answer	190,000	2.9	47,000	5,100	3.5	1,500	16
Advice source[b]							
State forestry agency	1,725,000	26.1	132,000	17,300	11.9	1,800	145
Extension service	738,000	11.2	91,000	7,800	5.4	1,300	62
Other State agency	131,000	2.0	39,000	900	0.6	200	11
Federal Agency	940,000	14.2	101,000	7,600	5.2	900	79
Private consultant	2,201,000	33.3	145,000	14,700	10.1	1,300	185
Forest industry forester	1,059,000	16.0	107,000	7,900	5.5	1,000	89
Logger	535,000	8.1	78,000	7,700	5.3	1,400	45
Other landowner	488,000	7.4	75,000	3,900	2.7	600	41

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.
[b] Categories are not exclusive.

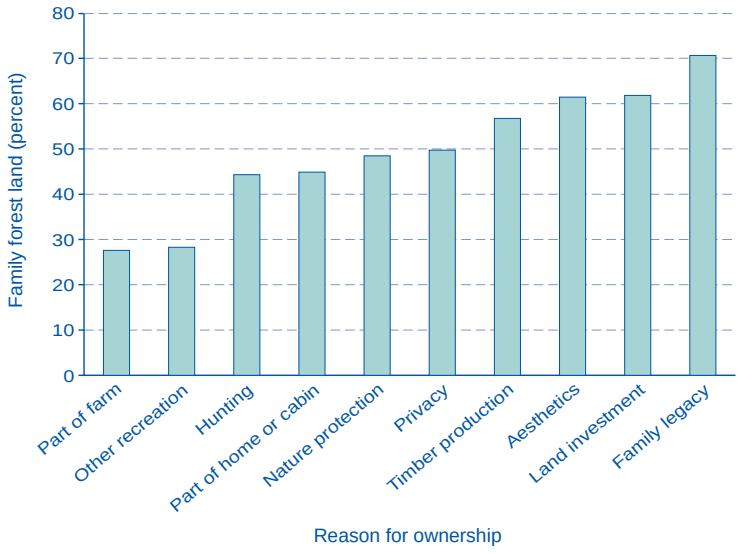


Figure 19—Distribution of South Carolina's family forest land by reason for ownership in 2002.

Table 10—Area and number of South Carolina family owned forests[a] by reason for owning forest land, 2003 (includes those who ranked each objective as very important or important on a seven-point Likhert scale)

	Area			Ownerships			
Reason[b]	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Aesthetics	4,058,000	61.4	174,000	90,200	62.2	6,300	341
Nature protection	3,201,000	48.5	164,000	69,100	47.7	5,100	269
Land investment	4,082,000	61.8	175,000	77,600	53.6	5,600	343
Part of home or cabin	2,963,000	44.9	160,000	79,900	55.1	5,900	249
Part of farm	1,821,000	27.6	134,000	43,500	30.0	4,100	153
Privacy	3,284,000	49.7	166,000	79,900	55.1	5,800	276
Family legacy	4,665,000	70.6	179,000	91,200	62.9	6,100	392
Nontimber forest products	809,000	12.2	94,000	18,600	12.8	2,500	68
Firewood production	524,000	7.9	77,000	12,500	8.6	1,900	44
Timber production	3,748,000	56.7	171,000	54,000	37.3	4,200	315
Hunting	2,927,000	44.3	160,000	44,700	30.8	3,600	246
Other recreation	1,868,000	28.3	136,000	33,400	23.1	3,300	157
No answer	131,000	2.0	39,000	4,600	3.2	1,600	11

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

[b] Categories are not exclusive.

Table 11—Area and number of South Carolina family owned forests[a] that are part of a farm, primary residence, or secondary residence, 2003

	Area			Ownerships			
Part of farm or residence	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Part of farm							
Yes	2,392,000	36.2	149,000	44,800	30.9	3,800	201
No	3,963,000	60.0	174,000	91,900	63.4	6,300	333
No answer	250,000	3.8	54,000	8,100	5.6	2,000	21
Part of primary residence							
Yes	3,261,000	49.4	165,000	86,800	59.9	6,200	274
No	2,963,000	44.9	160,000	50,700	35.0	4,200	249
No answer	381,000	5.8	66,000	7,300	5.0	1,600	32
Part of secondary residence							
Yes	916,000	13.9	100,000	8,100	5.6	1,200	77
No	5,057,000	76.6	180,000	124,000	85.6	7,600	425
No answer	631,000	9.6	84,000	12,700	8.8	2,000	53

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

Table 12—Area and number of South Carolina family owned forests[a] by landowners' concerns, 2003 (includes those who ranked each issue as a very important or important concern on a seven-point Likhert scale)

	Area			Ownerships			
Concern[b]	Acres	Percent	Standard error	Number	Percent	Standard error	Count
Endangered species	1,452,000	22.0	122,000	23,700	16.4	2,900	122
Property taxes	2,892,000	43.8	159,000	52,000	35.9	4,000	243
Family legacy	3,594,000	54.4	170,000	66,700	46.0	5,000	302
Lawsuits	1,642,000	24.9	129,000	29,200	20.2	3,000	138
Harvesting regulations	2,071,000	31.4	141,000	29,400	20.3	3,000	174
Land development	1,987,000	30.1	139,000	44,000	30.4	3,900	167
Noise pollution	1,368,000	20.7	119,000	28,300	19.5	2,800	115
Trespassing	3,106,000	47.0	163,000	52,400	36.2	3,900	261
Timber theft	1,630,000	24.7	129,000	30,300	20.9	3,000	137
Dumping	3,058,000	46.3	162,000	54,800	37.8	4,200	257
Air or water pollution	2,142,000	32.4	143,000	49,500	34.2	4,300	180
Exotic species	1,464,000	22.2	123,000	28,500	19.7	3,000	123
Domestic animals	512,000	7.8	76,000	10,100	7.0	1,500	43
Wild animals	809,000	12.2	94,000	19,500	13.5	2,400	68
Fire	3,748,000	56.7	171,000	68,400	47.2	4,900	315
Insects	4,046,000	61.3	174,000	68,800	47.5	4,700	340
Regeneration	952,000	14.4	102,000	22,000	15.2	2,500	80
Storms	2,582,000	39.1	153,000	36,800	25.4	3,000	217

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.
[b] Categories are not exclusive.

Table 13—Area and number of South Carolina family owned forests[a] by length of land ownership tenure, 2003

	Area			Ownerships			
Tenure	Acres	Percent	Standard error	Number	Percent	Standard error	Count
years							
< 10	619,000	9.4	83,000	18,700	12.9	2,900	52
10 – 24	1,404,000	21.3	121,000	29,900	20.6	3,100	118
25 – 49	1,666,000	25.2	130,000	28,700	19.8	2,800	140
50 +	416,000	6.3	69,000	5,400	3.7	1,400	35
No answer/ did not remember	2,499,000	37.8	152,000	62,200	42.9	5,000	210

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

Table 14—Area and number of South Carolina family owned forests[a] by age of owner, 2003

	Area			Ownerships			
Age	Acres	Percent	Standard error	Number	Percent	Standard error	Count
years							
< 35	71,000	1.1	29,000	1,500	1.0	500	6
35 – 44	274,000	4.1	56,000	9,200	6.3	2,200	23
45 – 54	881,000	13.3	98,000	19,800	13.7	2,500	74
55 – 64	1,440,000	21.8	122,000	27,100	18.7	2,900	121
65 – 74	1,345,000	20.4	119,000	25,600	17.7	2,800	113
75 +	1,249,000	18.9	115,000	25,400	17.5	3,100	105
No answer	1,345,000	20.4	119,000	36,500	25.2	3,900	113

[a] Only includes family forests with total forested landholdings between 10 and 5,000 acres.

Whether the land is sold to a like-minded individual, a real estate developer, or a forest products company will determine the availability of the land for production of timber and other uses.

Timber Products Output

South Carolina's forest products industry is an important component of the State's economy. Forestry, logging, primary wood products, and furniture manufacturing contribute $14.7 billion annually to the State's economy; together they are the third-ranking manufacturer in terms of value of shipments and value added (Harper 2001). In 2000, nearly a hundred sawmills, pulpwood mills, and other wood-processing plants (fig. 20) directly employed 40,000 individuals for a combined income of $1.7 billion (Abt and Wear, unpublished data).

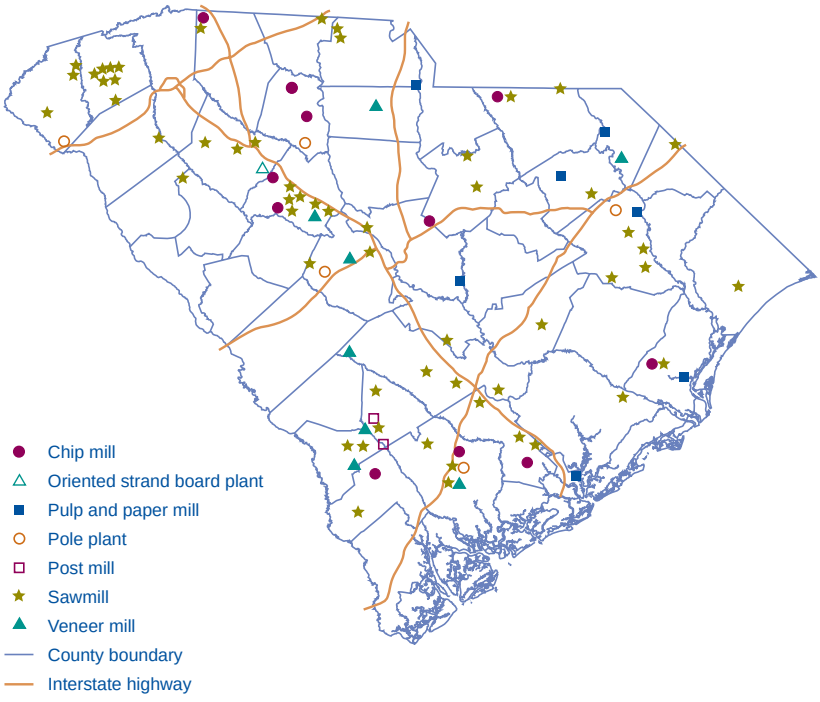


Figure 20—Location of South Carolina's primary forest manufacturing facilities in 2002. Source: R. Harper, Clemson Extension Forestry and Natural Resources, using data from the U.S. Department of Agriculture Forest Service, South Carolina Forestry Commission, and Clemson Extension Forestry and Natural Resources.

Timber Products Output and Removals

Total output of timber products, including domestic fuelwood, averaged 775 million cubic feet per year between 1993 and 2000 (table 15), a 6-percent decline from the previous period (1986 to 1992). Roundwood products contributed 87 percent of the total output, with the remainder from plant byproducts. Three-quarters or 585 million cubic feet were from softwood species.

With only minor fluctuations, the distribution of total volume among products has remained relatively constant over the last four survey periods. Pulpwood has been and remains the primary wood product of South Carolina's mills. Although pulpwood production declined nearly 5 percent from 411 million cubic feet in 1993 to 391 million cubic feet in 2000 (fig. 21), it comprised half of the total volume, continuing a 30-year trend: 53 percent from 1968 to 1977, 49 percent from 1978 to 1985, and 50 percent from 1986 to 1992. Although saw logs, used mainly for dimension lumber, declined 9 percent from 277 million cubic feet in 1993 to 253 million cubic feet, a third of the total output was from saw logs. Veneer and composite panels combined ranked third in product output at 70 million cubic feet or 9 percent of total volume.

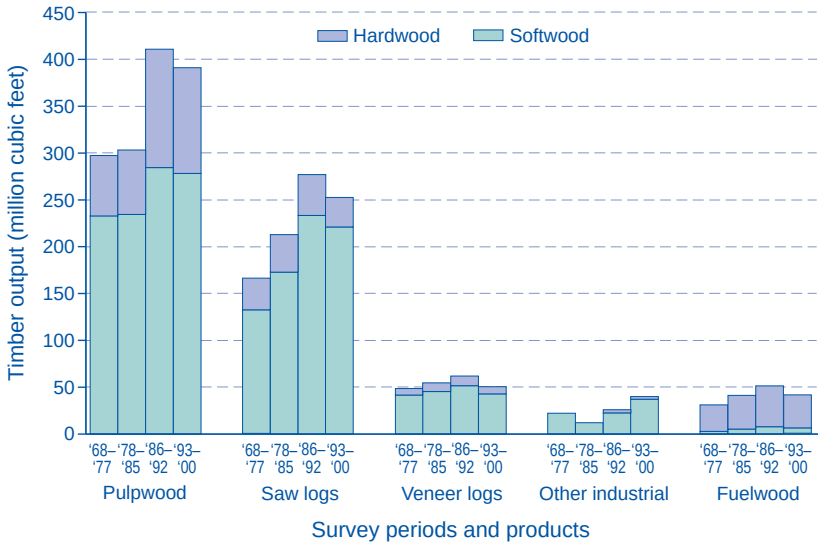
Average annual output of roundwood products (including fuelwood) declined 9 percent from 736 million cubic feet in the previous survey period, to an average of 673 million cubic feet (table 16). Ninety-two percent of the roundwood products volume came from growing-stock trees, with 72 percent in sawtimber and 28 percent in poletimber. Other sources—which include cull trees, salvable dead, and stumps and tops of harvested trees—dropped to 53 million cubic feet from 131 million cubic feet in the previous survey period, whose output was inflated by the 77 million cubic feet of storm-damaged timber salvaged in the aftermath of Hurricane Hugo.

Table 15—Average annual output of South Carolina timber products by product, species group, and type of material, 1993 to 2000

Product and species group	Total output	Roundwood products	Plant byproducts
		million cubic feet	
Saw logs			
Softwood	221.0	219.7	1.4
Hardwood	31.6	31.6	0.0
Total	252.7	251.2	1.4
Veneer logs			
Softwood	42.9	42.9	—
Hardwood	7.6	7.6	—
Total	50.5	50.5	—
Pulpwood[a]			
Softwood	278.3	219.6	58.7
Hardwood	112.8	105.1	7.8
Total	391.1	324.7	66.4
Composite panels			
Softwood	18.3	1.3	17.0
Hardwood	0.8	0.2	0.5
Total	19.1	1.6	17.5
Other industrial[b]			
Softwood	18.9	4.1	14.9
Hardwood	2.0	—	2.0
Total	20.9	4.1	16.8
Total industrial products			
Softwood	579.5	487.6	91.9
Hardwood	154.8	144.5	10.3
Total	734.3	632.1	102.2
Fuelwood[c]			
Softwood	5.7	5.4	0.3
Hardwood	35.3	34.9	0.4
Total	41.1	40.3	0.7
All products			
Softwood	585.2	493.0	92.2
Hardwood	190.1	179.5	10.7
Total	775.3	672.5	102.9

— = no sample for the cell; 0.0 indicates a value of > 0.0 but < 0.05 for the cell.
[a] Roundwood figures include an estimated 10.3 million cubic feet of roundwood chipped at other primary wood-using plants.
[b] Includes litter, mulch, particleboard, charcoal, and other specialty products.
[c] Excludes approximately 44.6 million cubic feet of wood residues and 55.0 million cubic feet of bark used for industrial fuel.
Numbers in rows and columns may not sum to totals due to rounding.

Total timber removals—averaged over the time period as the sum of roundwood products, logging residues, and other removals from growing stock and nongrowing stock sources—totaled 927 million cubic feet (table 17), 67 percent of which were softwoods. Of the total volume, 73 percent became roundwood products, leaving 18 percent in logging residues and 9 percent in other removals.



What is total output?

Total output, averaged over each 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, obtained from canvasses of all primary wood-using mills conducted every 2 years by the South Carolina State Commission of Forestry; the Cooperative Extension Service; Clemson University; and the U.S. Department of Agriculture Forest Service, Southern Research Station.

Pulpwood has been and remains the primary wood product of South Carolina's mills. (photo by Bill Lea)

Table 16—Average annual output of South Carolina roundwood products by product, species group, and source of material, 1993 to 2000

Product and species group	All sources	Growing-stock trees[a]			Other sources[b]
		Total	Sawtimber	Poletimber	
	million cubic feet				
Saw logs					
Softwood	219.7	208.0	205.1	2.9	11.7
Hardwood	31.6	29.7	29.2	0.6	1.9
Total	251.2	237.7	234.3	3.4	13.6
Veneer logs					
Softwood	42.9	41.4	40.7	0.7	1.5
Hardwood	7.6	7.5	7.5	—	0.1
Total	50.5	48.9	48.3	0.7	1.6
Pulpwood					
Softwood	219.6	201.1	92.7	108.4	18.5
Hardwood	105.1	96.2	45.1	51.1	8.9
Total	324.7	297.3	137.9	159.5	27.4
Composite panels					
Softwood	1.3	1.2	0.5	0.7	0.1
Hardwood	0.2	0.2	0.1	0.1	0.0
Total	1.6	1.4	0.6	0.8	0.1
Other industrial					
Softwood	4.1	3.3	3.2	0.2	0.7
Hardwood	—	—	—	—	—
Total	4.1	3.3	3.2	0.2	0.7
Total industrial products					
Softwood	487.6	455.0	342.3	112.7	32.6
Hardwood	144.5	133.7	81.9	51.8	10.8
Total	632.1	588.7	424.2	164.5	43.4
Fuelwood					
Softwood	5.4	2.1	1.1	0.9	3.4
Hardwood	34.9	28.3	22.6	5.7	6.6
Total	40.3	30.4	23.7	6.6	10.0
All products					
Softwood	493.0	457.1	343.4	113.6	35.9
Hardwood	179.5	162.0	104.5	57.5	17.4
Total	672.5	619.1	448.0	171.1	53.4

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 indicates a value of > 0.0 but < 0.05 for the cell.
[a] On timberland.
[b] Includes trees less than 5.0 inches in diameter, tree tops and limbs from timberland, or material from other forest land or nonforest land such as fence rows or suburban areas.

Table 17—Volume of South Carolina timber removals by removals class, species group, and source, 1993 to 2000

Removals class and species group	All sources	Source	
		Growing stock	Nongrowing stock
	million cubic feet		
Roundwood products			
Softwood	493.0	457.1	35.9
Hardwood	179.5	162.0	17.4
Total	672.5	619.1	53.4
Logging residues			
Softwood	98.7	28.1	70.6
Hardwood	68.0	26.6	41.4
Total	166.7	54.7	111.9
Other removals			
Softwood	29.1	25.0	4.2
Hardwood	58.4	33.1	25.3
Total	87.5	58.1	29.5
Total removals			
Softwood	620.8	510.2	110.6
Hardwood	305.8	221.7	84.1
Total	926.7	731.9	194.8

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

Preliminary results for the 2001 timber product assessment for South Carolina indicate a substantial decline in product output for softwoods and hardwoods with a resulting decline in total removals. Figures for employment in the forest products sector for 2002 also showed substantial declines.

Changing Demands: Effects on the Use of South Carolina's Forests

The demand for wood and wood products from South Carolina's forests likely will remain high in the foreseeable future. However, a growing demand for recreation and other amenities will increasingly influence future forest uses. Land managers may face continual change in attitudes about forest management and may have to balance the need for a continued wood supply against the pressures of more people, changing demographics, and competing motivations and desires.

Increasing Demand for Recreation

South Carolina's population grew 54 percent from 2.6 million to more than 4 million over the past three decades, making it the 10th fastest growing State in the Nation. More people making their home in the South will undoubtedly increase the demand for more opportunities to "get away from it all."

Directly or indirectly, forests support outdoor recreation in South Carolina by providing venues for activities like hiking, hunting, viewing or photographing natural scenery and wildlife, or visiting nature centers. The 194,000 acres of wildlife refuges, parks, and other protected and reserved land in South Carolina provide some of the resources needed to meet this demand (fig. 17). National forests are becoming increasingly popular as sources for outdoor recreation, as well.

Collectively, South Carolina has over a million acres of State and Federal forest recreation facilities. National forests in South Carolina offer over 525 miles of trails. The largest all-terrain vehicle trail system in the State is on State forests. These and other growing recreational demands, such as mountain biking and geocaching, are placing new demands on public lands.

Wildlife Management Areas—Increasing Public Access to Forest Lands

Recreation demands are increasing while access to private lands continues to decline. South Carolina's Wildlife Management Area (WMA) Program provides public access for hunting and fishing on public and private forest lands. Since 1978, the number of acres in the State's WMA Program has declined from 1.5 million acres to just over 1 million acres. The percent of WMA acreage that is public has increased from 60 percent in the 1970s to 89 percent in 2003. This, combined with significant numbers of conversions from forest and agricultural lands to residential and commercial development uses, is slowly shifting recreation demand to the public land base.

Changing demands seem to point to the emergence of nontimber uses of forests as a major factor in management and utilization, particularly on public forest land. While private lands still depend on traditional timber harvests to provide cash flow, recreation and other nontimber uses are increasingly restricting forest management on public lands.

South Carolina's increasing demand for recreation includes fishing, boating, and viewing wildlife. (SRS photos)

Defining forest health is a complicated undertaking that requires measuring and analyzing trends in a wide variety of variables with scales ranging from individual trees to stands to parts of entire ecosystems. Traditional timber survey information includes tree species distributions and diversity, tree stocking levels, site disturbance history and recovery, harvest/regeneration relationships, levels of tree damage and mortality, net growth rates, and estimates of site productivity. All of these measurements are useful in assessing important aspects of forest health. However, tracking changes in the magnitude and cause of tree mortality over time may be the best indicator of current forest condition.

Mortality of growing-stock trees from all causes was 158.9 million cubic feet per year between 1993 and 2001, 53 percent or 84.4 million cubic feet from hardwoods. Combined mortality of loblolly and shortleaf pine species was 52 million cubic feet per year—77 percent of total softwood mortality.

Most losses were a result of natural causes, primarily insects and disease. Although a constant presence in forests, tree mortality caused by insect and disease populations is often within sustainable levels. However, cyclic events, such as the current southern pine beetle outbreak, do occur and can cause sudden and widespread losses.

Southern Pine Beetles

Southern pine beetle populations recently reached epidemic status in the South. Native to southern pine forests, beetle populations are typically held in check by natural predators and the defense systems of healthy trees. However, with multiple overlapping generations, beetle populations can build rapidly in response to declining tree health caused by overstocking, poor soils, long-term drought, or other environmental stresses.

In South Carolina, an extended drought created conditions suitable for the most costly southern pine beetle outbreak on record. At the peak of the drought, all 46 counties were in extreme drought status, with cumulative deficits ranging from 12 to 60 inches. Throughout the State, tree growth and vigor have been reduced in all but the wettest soils.

Southern pine beetle populations have cycled twice since the last 1993 survey, peaking in 1995 and again in 2002. During that period, beetles destroyed 2.3 million cords of pulpwood and 1.6 billion board feet of sawtimber, worth an estimated $525 million (South Carolina Forestry Commission 2002) and equivalent to the standing volume of all sawtimber in Georgetown, Newberry, or Oconee Counties. The lumber that was lost to southern pine beetles could have constructed approximately 150,000 homes.

Southern pine beetle outbreaks occurred on all land ownerships. Although loblolly and shortleaf pines were the most common hosts, outbreaks extended to white pine, longleaf pine, and other softwood species. In general, older unmanaged natural pine stands tended to be more susceptible than those that were actively managed. However, young planted stands can quickly succumb to attacks if not properly thinned to promote growth and vigor.

In South Carolina, conditions conducive to greater pine beetle activity increased in the 1990s with a dramatic increase in pine plantations approaching their first thinning and reduced harvesting on Federal lands. With 8 percent (approximately 1 million acres) of the State's timberland in Federal management, changes in management intensity can have a measurable impact on the general health of the State's forests. An example is the 345,000-acre Sumter National Forest where timber harvesting declined 50 percent from the 1980s, creating an overstocking of overmature loblolly pine that has increased the forest's vulnerability to extensive beetle outbreaks (Ward and Mistretta 2002).

From 1993 to 2001, the combined area of planted pine and planted oak-pine

increased by 11 percent (125,000 acres per year) and comprised 25 percent of the State's timberland area. CRP incentives resulted in 251,000 acres of new pine plantations, of which 190,000 acres were established before 1990. These stands ranged from 10 to 15 years old by 2000. From 1993 to 2002, 30 counties were at one time or another declared in southern pine beetle outbreak status (fig. 22).

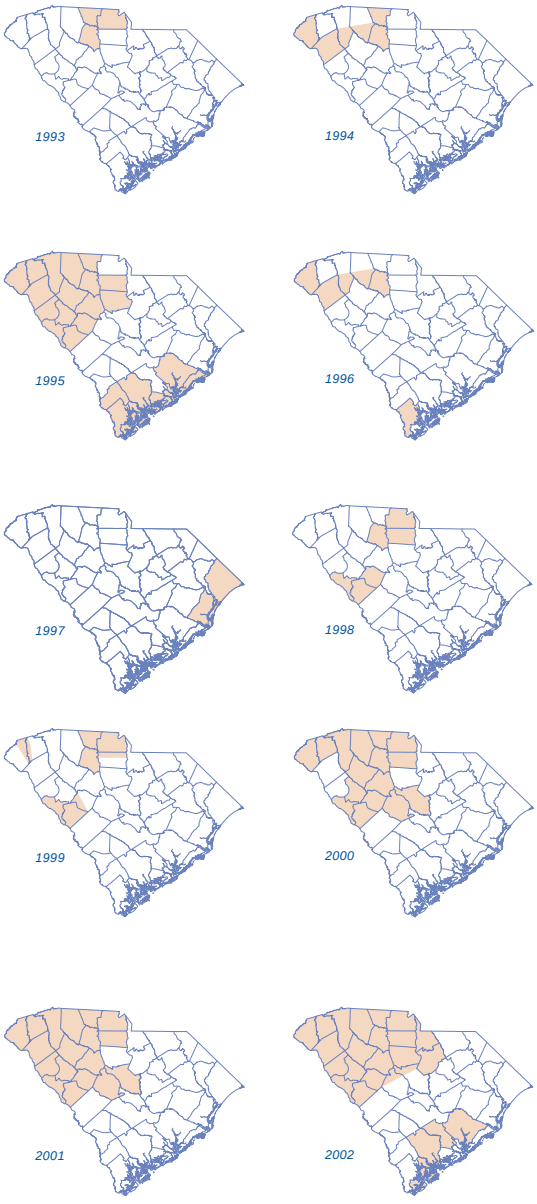


Figure 22—Southern pine beetle outbreak zones, 1993 to 2002.

Counties are considered in outbreak status when they have an average of one or more multiple tree infestations per thousand acres of pine host type. Although primarily affecting loblolly pine stands in the Piedmont, severe outbreaks extended into several coastal counties, including Horry and Georgetown. Timely thinning to promote stand health is essential for minimizing the risk of southern pine beetle outbreaks in these young stands.

Minor Disease Problems Cause Limited Damage and Mortality

As is true in most Southern States, South Carolina's forests must endure periodic but generally less widespread losses to other minor disease problems. For example, oak wilt disease was identified in a handful of counties, primarily on the northern Coastal Plain. Although the disease appears to be static and causing losses only to low-value oaks, periodic surveys have been tracking any potential spread to more valuable trees in forest and urban settings.

Dutch elm disease has been confirmed in several scattered counties and is expected to gradually spread through the State because its primary agent, the European elm bark beetle, already occurs Statewide.

In 1988, dogwood anthracnose was found for the first time in South Carolina. The disease usually kills infected trees in 2 to 3 years. Symptoms include foliage blighting, canker formation, and progressive deterioration. The South Carolina Forestry Commission participates in a Southwide effort to monitor the spread and has established 19 permanent plots in the counties known to harbor infections of the fungus.

To address the factors that affect forest ecosystem health, annual surveys now incorporate the following forest health indicator variables into data collection procedures: ozone damage, vegetation density and structure, crown condition, down woody material, lichen community composition, and soil condition.

Each indicator addresses an individual factor influencing some aspect of forest health (Stolte and others 2002). For most of the indicators, data collection began in the last year or two, limiting efforts to use the results in analyses of forest health. Although valuable for baseline information, the data are presented in this bulletin as a way to introduce the forest health indicators to prospective users. Further collection, testing, and refinement will undoubtedly reveal the best way to combine the results from individual indicators into an overall assessment of forest health.

Ozone Injury Indicator: Is Ozone Damaging South Carolina's Forests?

Ozone is the product of a chemical reaction that takes place in the air when volatile organic compounds (VOC) and nitrogen oxides (NOX) mix in the presence of sunlight. In South Carolina, most VOCs come from trees and other vegetation, although industrial and vehicular emissions are also a significant source. NOXs come almost entirely from the combustion of organic compounds such as gasoline, coal, wood, and natural gas. Weather plays a key role in the formation of ozone with hot, dry, calm, cloudless days providing the ideal conditions for VOCs and NOXs to react before they can disperse in the atmosphere.

Ground-level ozone is one of the most significant air pollutants affecting human and plant health in the State. During summer months, ozone concentrations can aggravate asthma and other respiratory diseases. Using data from 23 stations representing urban, suburban, rural, and near pristine areas, the South Carolina Department of Health and Environmental Control (SCDHEC) found that most areas meet National Ambient Air Quality Standards, which are based on a 1-hour peak concentration of 0.12 parts per million each day (fig. 23). The State is reviewing a new standard that is based on an 8-hour averaging period each day; applying this more conservative standard to existing data suggests that exceedance may be more prevalent than previously assumed (fig. 24).

Ozone not only acts as an oxidant that inhibits breathing, it can also damage the leaves of plants. The severity of ozone damage varies according to factors that include weather patterns, proximity to pollution sources, plant species, and plant physiology. Symptoms are more severe on older leaves than on newly formed foliage. Atmospheric condition is perhaps the biggest source of variation in plant injury. Long periods without rainfall will inhibit symptom development even on the most sensitive plants as they constrict foliar stomates to conserve moisture. In South Carolina, the severe drought from June 1998 to September 2002 may have limited plant exposure to ozone.

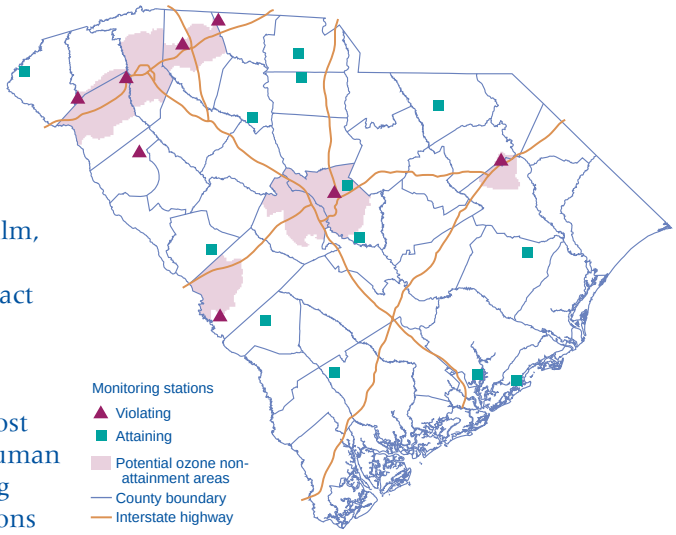


Figure 23—Areas failing to meet National Ambient Air Quality Standards in 2001. Source: South Carolina Department of Health and Environmental Control.

Several plant species—such as yellow-poplar, blackberry, black cherry, sassafras, and sweetgum—are sensitive to ozone exposures above normal background levels. These bioindicator species exhibit an upper surface foliar injury symptom that is easy to distinguish from other foliar injuries and easy to quantify. Monitoring these species can predict areas of reduced growth; reduced resilience to insects, pathogens, drought, and other stressors; and increased mortality.

The South Carolina Forestry Commission began an ozone biomonitoring program in 1999 as part of the National Forest Health Monitoring Program. Ozone phytotoxicity is evaluated during a 4-week period between late July and August. Crews sample 30 plants each of at least 3 susceptible species on each plot and rate the severity of foliar damage on a 6-point scale (with 0 indicating no damage and 5 indicating more than 75 percent damage).

Between 1999 and 2002, sampling of 7,094 plants revealed that 94 percent demonstrated no ozone damage (table 18). Of the plants that were injured, 3.7 percent (257 plants) had moderate-to-severe injury (injury severity codes 3, 4, and 5). Ninety-three percent of all ozone symptoms occurred in 1999 and 2002, combined. These results correlate well with SCDHEC air quality monitoring for the period.

Vegetation Diversity and Structure Indicator

The vegetation indicator measures the type, abundance, and vertical position of all trees, shrubs, herbs, grasses, ferns, and fern allies (horsetails and club mosses) within each forest plot. Its purpose is to assess change and trends in species richness, diversity, and overall vegetation structure of native and introduced species.

The vegetation indicator provides data to classify plot vegetation into community types, allowing analysts to extrapolate other forest health indicator results with more accuracy than by simple forest type.

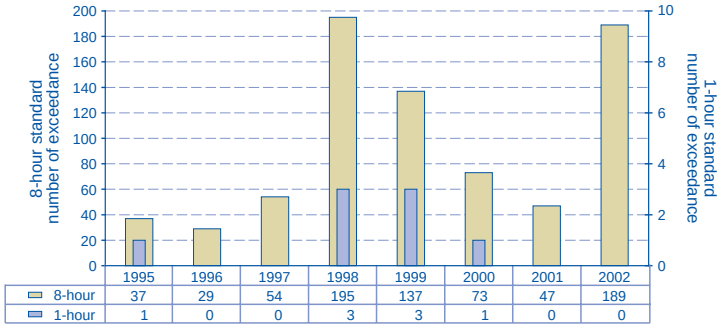


Figure 24—National Ambient Air Quality Standards exceedances for ozone in South Carolina, 1995–2002. Source: South Carolina Department of Health and Environmental Control.

Table 18—Ozone bioindicator plot data in South Carolina

Year	Plots evaluated	Plants sampled	Injury severity[a] 0	1	2	3	4	5
	number		percent of plants sampled					
1999	15	851	80.2	1.8	4.5	6.2	5.4	1.9
2000	23	1,288	99.6	0.0	0.0	0.2	0.2	0.0
2001	26	2,011	98.3	0.0	0.3	0.9	0.5	0.0
2002	29	2,944	93.5	0.5	2.3	2.0	1.3	0.4

[a] Injury severity is an estimate of the mean severity of symptoms on injured foliage (0 = no injury; 1 = 1 to 6 percent; 2 = 7 to 25 percent; 3 = 26 to 50 percent; 4 = 51 to 75 percent; 5 = ≥75 percent).

South Carolina Forestry Commission foresters evaluate severity of ozone damage on sweetgum in Lexington County. (photos by South Carolina Forestry Commission)

Collecting forest health data.

Procedures used to collect the forest health indicator data discussed in this bulletin have undergone an extensive process of data quality assurance techniques as a part of the quality assurance program described in the appendix. When fully implemented, the program will provide the operational techniques and activities needed to control, correct, and document measurement uncertainty and produce complete, accurate, and unbiased forest health information of known quality (Stolte and others 2002). A detailed description of the data collection procedures is available from U.S. Department of Agriculture, Forest Service, Southern Research Station, Forest Health Monitoring, P.O. Box 12254, Research Triangle Park NC 27709.

Locally developed forest community types based on overstory and understory plant species are highly correlated with ecosystem properties, such as productivity, fuel load characteristics, wildlife habitat quality, and adaptability to disturbance.

Southern forest health can be noticeably affected by human-induced stresses, including the introduction of nonnative plant species (Miller 2003, Stapanian and others 1998). In addition to the costs associated with controlling nonnative plant species, environmental costs are high. Invasive species can transform entire ecosystems through modifications of soil, water, and light resources (Stapanian and others 1998, Stein and others 1996). In addition, some plant species prevent forest regeneration by forming thick rhizomatous mats in the forest soil (Jose and others 2002).

Among the most important mechanisms for the early detection and control is large-scale monitoring both for the presence of nonnative species and for the presence of sites that are vulnerable to disturbance (Jose and others 2002). Pilot studies are currently underway to develop a new forest health variable that describes vascular plant diversity and extent. One such pilot study was conducted for South Carolina from 2002 to 2003. On the 505 forested plots sampled in 46 counties, 41 percent contained at least one nonnative invasive species; 15 percent contained at least two; 3 percent contained at least three; and less than 1 percent contained four or more (fig. 25). The most abundant species identified in South Carolina was Japanese honeysuckle, occurring in 78 percent of all plots containing invasive plant species, and 32 percent of the total number of forested plots sampled (table 19).

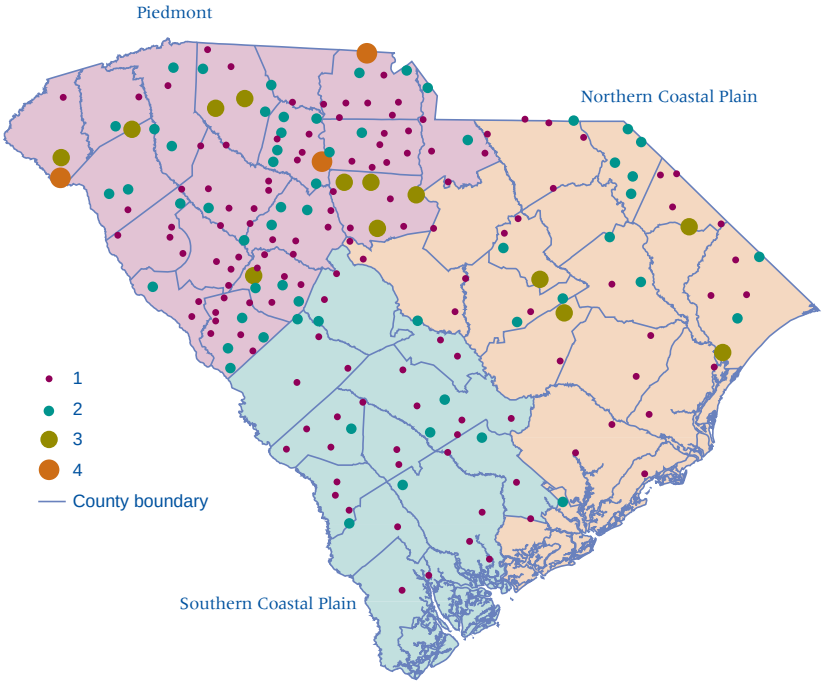


Figure 25—Number of invasive species per plot on South Carolina timberland, by physiographic region, in 2002.

The next step in the pilot study was to record the presence of all vascular plants occurring on a subset of the plots. Although few plots were fully completed, species from 102 plant families were recorded. Of these, muscadine grape was the most abundant, occurring in 73 percent of subplots measured, and 77 percent of plots. Red maple followed closely, occurring in 68 percent of subplots and 71 percent of plots (table 20).

Of the species identified, 5 percent were nonnative, 54 percent of which were also invasive. Nonnative species occurred in 80 percent of the plots. In contrast, 73 percent of native species occurred in less than 10 percent of the plots and 48 percent occurred in only a single measured plot. As in the data from the larger study, Japanese honeysuckle was the most abundant nonnative invasive, occurring in 28 percent of the 71 subplots and 45 percent of the 31 plots. Chinese privet followed in abundance, occurring in 17 percent of subplots and 32 percent of plots (table 21).

The ability to make confident conclusions about the impact of nonnative species on the forests of South Carolina is limited by the small sample sizes and the single sample season of the pilot study. However, these preliminary data suggest that nonnative species may present a potential threat. Although nonnative species comprise only a small portion of the

vascular plants found throughout the State, those few plants were alarmingly widespread. Currently, Japanese honeysuckle and Chinese privet present the largest immediate threat. The ability of these species to dominate the understory of disturbed stands could result in reduced regeneration of economically important species and a decline in species that support wildlife populations. Increased management efforts will be needed to limit the detrimental effects that these invasive species can have on South Carolina's forests.

Crown Condition Indicator

Because net primary production originates in the foliage, branches, and growing tips of the tree crown, tree crown dimensions logically correlate with general tree health. Large dense crowns have been associated with vigorous growth, while sparsely foliated crowns can indicate decline (Zarnoch and others 2004). The crown indicators currently measured are: uncompacted live crown ratio, crown density, crown dieback, foliage transparency, crown light exposure, and crown position (U.S. Department of Agriculture, Forest Service 2001). Crown variables can be combined to formulate composite values for detecting general trends or analyzed singly for further evaluation of any suspicious trends that are identified.

The latest available crown data from South Carolina were analyzed by combining field measurements of crown ratio, crown density, and tree length for each sampled tree with modeling estimates of crown diameter (Bechtold, in press). The resulting composite crown volume (CCV) estimates were adjusted for differences in species and stem diameter at breast height, both of which are obvious natural factors that influence crown size. The adjusted crown volumes were then examined for any spatial patterns among plots that warrant further investigation and any statically significant differences among stand-classification variables (such as forest type).

Table 19—Frequency occurrence of nonnative species across all measured forested plots in South Carolina, 2002 to 2003

Common name	Species	Frequency of occurrence in all forested plots
		percent
Japanese honeysuckle	*Lonicera japonica* Thunb.	31.88
Chinese privet	*Ligustrum sinense* Lour.	6.73
Japanese privet	*L. japonicum* Thunb.	6.14
Chinese lespedeza	*Lespedeza cuneata* (Dum.-Cours.) G. Don	3.56
Nonnative wisteria	*Wisteria* spp.	2.97
Tall fescue	*Lolium arundinaceum* (Schreb.) S.J. Darbyshire	1.58
Shrubby lespedeza	*Lespedeza bicolor* Turcz.	1.40
Chinaberrytree	*Melia azedarach* L.	1.40
Tallowtree	*Triadica sebifera* (L.) Small	0.99
Tree-of-heaven	*Ailanthus altissima* (P. Mill.) Swingle	0.40
Nepalese browntop	*Microstegium vimineum* (Trin.) A. Camus	0.40
Kudzu	*Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S. Almeida	0.40
Nonnative rose	*Rosa* spp.	0.40
Tropical soda apple	*Solanum viarum* Dunal	0.40
Mimosa	*Albizia julibrissin* Durazz.	0.20
Bush honeysuckle	*Lonicera* spp.	0.20

Table 20—Frequency by subplot of the most abundant species in South Carolina, 2003

Common name	Scientific name	Frequency by subplot
		percent
Muscadine	*Vitis rotundifolia* Michx.	73.24
Red maple	*Acer rubrum* L.	67.61
Cat greenbrier	*Smilax glauca* Walt.	57.75
Loblolly pine	*Pinus taeda* L.	56.34
Pond pine	*P. serotina* Michx.	54.93
Sweetgum	*Liquidambar styraciflua* L.	53.52
Common persimmon	*Diospyros virginiana* L.	49.30
Evening trumpetflower	*Gelsemium sempervirens* (L.) St. Hil.	47.89
Virginia creeper	*Parthenocissus quinquefolia* (L.) Planch.	47.89
White oak	*Quercus alba* L.	42.25
Blackgum	*Nyssa sylvatica* Marsh.	40.85
Laurel oak	*Q. laurifolia* Michx.	40.85
Sawtooth blackberry	*Rubus argutus* Link	40.85
Roundleaf greenbrier	*S. rotundifolia* L.	40.85
American holly	*Ilex opaca* Ait.	36.62
Water oak	*Q. nigra* L.	36.62
Flowering dogwood	*C. florida* L.	35.21
Southern red oak	*Q. falcata* Michx.	33.80
Eastern poison ivy	*Toxicodendron radicans* (L.) Kuntze	33.80
Farkleberry	*Vaccinium arboreum* Marsh.	32.39

Yellow-poplar flower. (SRS photo)

Table 21—Frequency by subplot and plot of the nonnative species recorded in South Carolina, 2003

Common name	Scientific name	Frequency by subplot	Frequency by plot	Invasive?
		----- percent ----		
Japanese honeysuckle	*Lonicera japonica* Thunb.	28.17	45.16	Y
Chinese privet	*Ligustrum sinense* Lour.	16.90	32.26	Y
Wartremoving herb	*Murdannia keisak* (Hassk.) Hand.-Maz.	7.04	12.90	Y
Nepalese browntop	*Microstegium vimineum* (Trin.) A. Camus	4.23	9.68	Y
Alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.	2.82	6.45	Y
Spadeleaf	*Centella asiatica* (L.) Urban	2.82	6.45	
Centipede grass	*Eremochloa ophiuroides* (Munro) Hack.	5.63	6.45	
Chinese lespedeza	*Lespedeza cuneata* (Dum.-Cours.) G. Don	4.23	6.45	Y
Bahiagrass	*Paspalum notatum* Flueggé	2.82	6.45	
Annual bluegrass	*Poa annua* L.	2.82	6.45	
Tree-of-heaven	*Ailanthus altissima* (P. Mill.) Swingle	1.41	3.23	Y
Clammy false oxtongue	*Blumea viscosa* (P. Mill.) Badillo	1.41	3.23	
Indian strawberry	*Duchesnea indica* (Andr.) Focke	1.41	3.23	
Hairy catsear	*Hypochaeris radicata* L.	1.41	3.23	
Japanese clover	*Kummerowia striata* (Thunb.) Schindl.	1.41	3.23	Y
Chinaberrytree	*Melia azedarach* L.	2.82	3.23	Y
Dallisgrass	*Paspalum dilatatum* Poir.	1.41	3.23	
Bristly oxtongue	*Picris echioides* L.	1.41	3.23	
Multiflora rose	*Rosa multiflora* Thunb. ex Murr.	1.41	3.23	Y
Common sheep sorrel	*Rumex acetosella* L.	1.41	3.23	
Common sowthistle	*Sonchus oleraceus* L.	1.41	3.23	
Common chickweed	*Stellaria media* (L.) Vill.	1.41	3.23	
Tallowtree	*Triadica sebifera* (L.) Small	1.41	3.23	Y
Common mullein	*Verbascum thapsus* L.	1.41	3.23	Y
Japanese wisteria	*Wisteria fibribunda* (Willd.) DC.	1.41	3.23	Y
Chinese wisteria	*W. sinensis* (Sims) DC.	1.41	3.23	Y

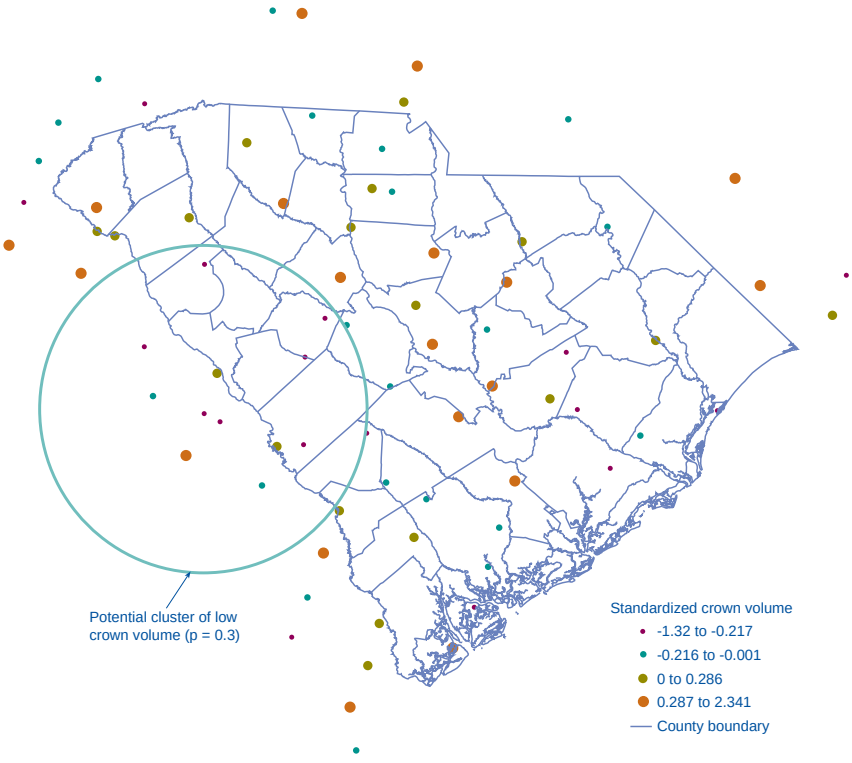


Figure 26—Distribution of forested plots with mean-plot-level standardized-residualized crown volumes below the 25th percentile (2000 to 2001).

Spatial distribution of the adjusted CCV into four quartiles detected a weak spatial cluster of low crown volume in the west-central part of the State, but nothing that reached the 0.05 level of significance (fig. 26). Results from the stand-classification analysis revealed no significant differences among the forest type, stand origin, ownership, industrial status, or physiographic region (table 22). Only two of the groups exhibited statistically significant differences: the crowns of surviving trees in stands that had been cut within the previous 5 years were significantly larger than the crowns of trees in uncut stands. This difference is attributed to the likelihood that the surviving trees in cutover stands benefited from release from competition with surrounding trees.

These results suggest the tree crowns in South Carolina forests are healthy. The cluster of below-average crowns in the west-central part of the State will require close monitoring for evidence of a potential problem as additional panels of data are measured, or if any other evidence of a potential problem surfaces.

Table 22—Results of one-way ANOVA to test for differences among sampled condition classes in South Carolina, 2000–2001

Condition-class variables and associated groups	n plots	n trees[a]	Class mean[b]	One-way ANOVA results[c]
Broad forest type				
Pine	20	585	0.07	A
Mixed pine-hardwood	9	175	0.22	A
Upland hardwood	13	190	0.01	A
Bottomland hardwood	8	166	0.04	A
Stand origin				
Natural	36	700	0.03	A
Planted	10	428	0.10	A
Treatment (past 5 years)				
None	39	1,068	-0.05	A
Cutting	7	60	0.70	B
Ownership class				
Public	5	100	-0.36	A
Corporate	10	318	0.03	A
Private	28	704	0.10	A
Industrial status				
Forest industry	8	252	0.00	A
Other owners	36	876	0.03	A
Physiographic class				
Flatwoods	14	269	0.01	A
Rolling uplands	18	555	-0.03	A

ANOVA = analysis of variance; n plots = number of plots with the group of interest (a few plots had greater than one group of interest); n trees = total number of trees in the group of interest across all plots, trees were nested within plots for the ANOVA.

[a] Groups where n plots less than five were excluded from testing and are not shown.

[b] Mean of standardized-residual crown volumes.

[c] Within a condition-class variable, groups with the same letter were not statistically different at the 0.05 level of significance (based on Tukey's test).

Down Woody Material Indicator

The down woody material (DWM) indicator estimates the amount of dead materials on the forest floor in various stages of decay including: coarse woody, fine woody, litter, herbs/shrubs, slash, duff, and fuel bed depth. An important element of productive and biologically diverse forests, DWM serves as a crucial component of forest productivity, wildlife habitat, fuel loading, soil erosion, and carbon storage.

In 2001, implementation began on an annual Statewide inventory of DWM in South Carolina's forests. Although only 24 forest plots were measured in 2001, subsequent years of annually established and remeasured DWM plots will allow both refined inventory analyses and evaluation of numerous forest health issues. The following analyses may be viewed strictly as a preliminary analysis of a recent inventory of DWM in South Carolina.

Comparisons to Other Southern States

Mean estimates and associated standard errors of various DWM components indicate no significant variation between South Carolina and its neighboring States (fig. 27). Estimates for fine and coarse woody debris both averaged about 2 tons per acre, nearly identical to estimates for Georgia, North Carolina, and Tennessee. The lingering effects of Hurricane Hugo would argue for higher volumes of coarse woody material in South Carolina, but the preliminary assessment showed no significant variation from neighboring States.

The Dynamics of DWM

Although the small sample size precludes more definitive conclusions, there appear to be some differences in the estimates of DWM among forest-type groups. The mixed pine/hardwood forest type had the most DWM, regardless of examined component (fig. 28), and significantly more fine and coarse woody debris than pine stands or hardwood stands. Based on the basal area per acre of standing live trees, the amount of fine and coarse woody debris appears to decrease with increasing stand density (fig. 29). Stands that have recently experienced density-reducing disturbances may have a corresponding increase in fine and coarse woody debris. For both forest-type and stand-density stratifications, the

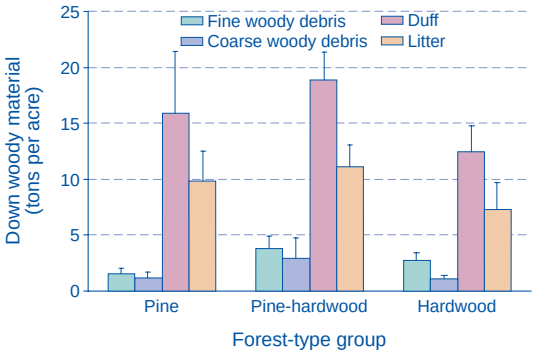


Figure 28—Components of down woody material and associated standard errors for forest-type group on 24 South Carolina plots in 2001.

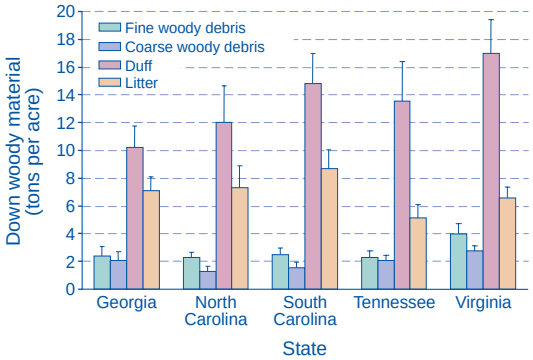


Figure 27—Components of down woody material and associated standard errors for five Southern States in 2001.

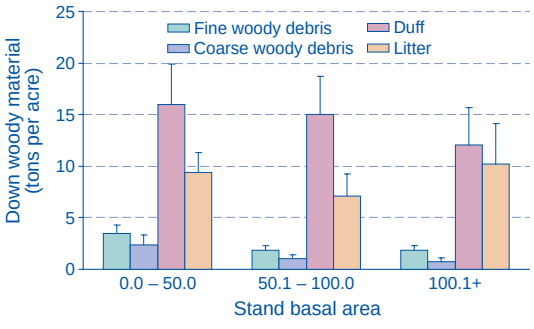


Figure 29—Components of down woody material and associated standard errors by stand basal area on 24 South Carolina plots in 2001.

large standard errors preclude more substantive conclusions.

These results indicate that low-density forest stands in South Carolina may have a high proportion of fresh decay classes to provide valuable habitat to numerous species, but that large logs were scarcer than expected. Because decay rates and stand development may be reversing the effects of Hurricane Hugo, this scarcity may be attributable to forest management activities. Additionally, although higher density forest stands have more large logs, the logs may be in the latter stages of decay. Decaying logs provide valuable habitat for certain flora and fauna, but the lack of new coarse woody recruitment raises questions of habitat sustainability. However, due to the diminishing effects of Hurricane Hugo and the limited sample sizes, these conclusions are speculative.

Lichen Community Composition Indicator

Lichens are indicators of air quality, climate, and biological processes. (SRS photo)

Lichens are symbiotic associations of fungi and algae that have important forest functions. Because they provide forage and habitat for a variety of invertebrates, lichens are indicators of forest ecosystem diversity. Their physiology makes them more responsive than most plants to air pollution and to the nitrogen and sulfur compounds found in acid rain. Changes in lichen community composition can provide information about changes in air quality, climate, and biological processes. The lichen community indicator has been shown to be a stable and repeatable estimator of lichen community response for estimation of patterns and trends in these aspects of forest health (McCune and others 1997b).

Lichen Species Richness Scores

Lichen species richness varies with climate and topography, and with site characteristics such as tree species composition and stand age. Lichen species richness scores are the number of macrolichen species recorded on a plot using standard survey methods. The highest diversity plots are concentrated in the Central Appalachian Ecoregion Province (fig. 30), but no strong distribution pattern of lowest diversity plots appears either by State or by ecoregion province. Scores for South Carolina were compared with the Southeastern Lichen Gradient Region (McCune and others 1997a), which is composed of Alabama, Georgia, North Carolina, South Carolina, and Virginia (table 23). Compared to the Gradient Region as a whole, South Carolina forests had higher average species richness, lower standard deviation, and lower species turnover rate. Because climate index scores

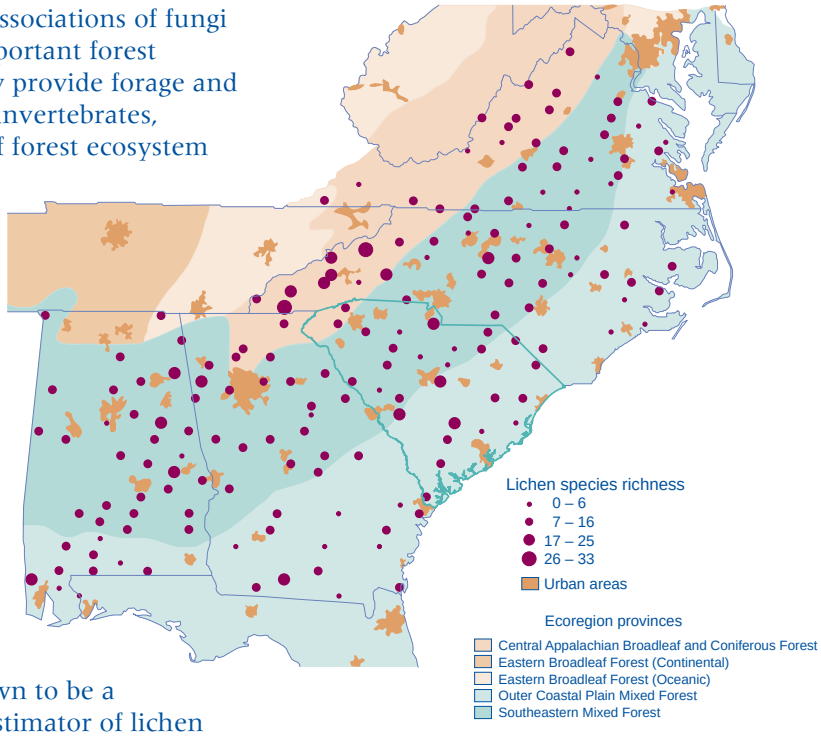


Figure 30—Lichen species richness scores for South Carolina and others States in the Southeastern Lichen Gradient Region in 1999. Plotted dots are located at forest health monitoring hexagon centers, not actual plot location.

Table 23—Lichen community indicator of species richness within the Southeastern Lichen Gradient Region, 1999

Parameter	Gradient Region	South Carolina
Number of plots surveyed	177	27
Number of plots by species richness score category[a,b]		
0 – 6 species per plot	43	7
7 – 15 species per plot	111	14
16 – 25 species per plot	21	6
>25 species per plot	2	0
Range of species richness score per plot (low to high)	0 – 33	0 – 21
Average species richness score per plot (alpha diversity)	10.3	11.3
Standard deviation of species richness score per plot	6.27	5.33
Species turnover rate (beta diversity)[c]	14.95	5.93
Total number of species per area (gamma diversity)	154	67

[a] Categories are based on a cumulative distribution function of plot species richness score for the Southeastern Lichen Gradient Region model.
[b] Plots with no lichens are included.
[c] Beta diversity is calculated as gamma diversity divided by alpha diversity.

are very similar across the Gradient Region, it is unlikely that South Carolina's higher scores can be explained by climate differences. However, air quality index scores of South Carolina plots indicate better average air quality than the Gradient Region as a whole. This suggests that South Carolina has higher species richness scores because its air is cleaner.

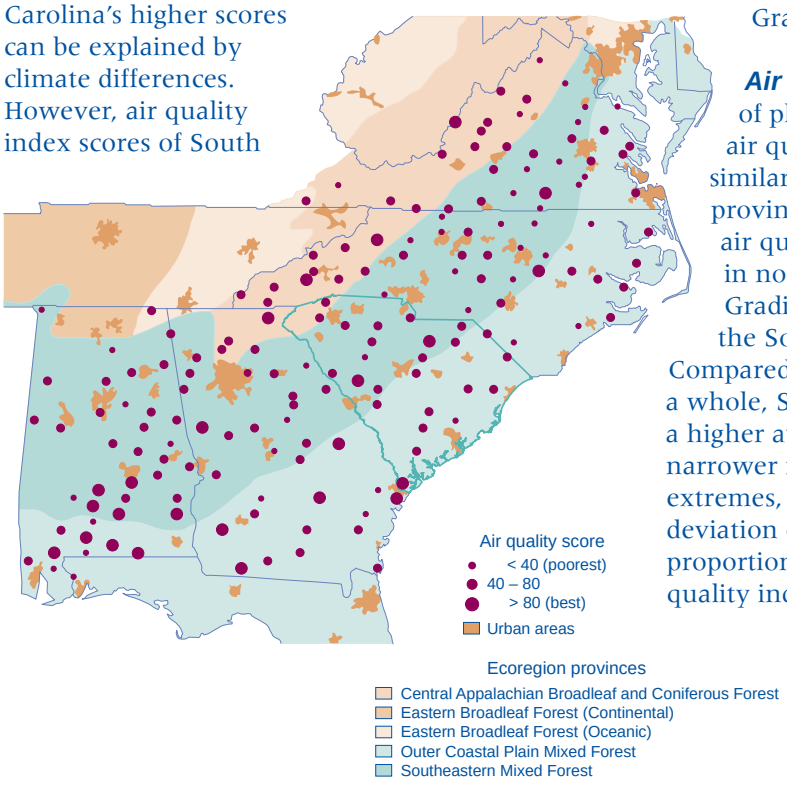


Figure 31—Air quality index scores for South Carolina and other States in the Southeastern Lichen Gradient Region in 1999. Plotted dots are located at forest health monitoring hexagon centers, not actual plot location.

Air Quality and Climate Index Scores

Air quality and climate index scores are derived from a multivariate gradient model (McCune and others 1997a) that uses variation in species composition to generate indexes and assign plot scores on gradients of response to air quality and climate/environment in the Gradient Region.

Air quality—The proportion of plots in the best and poorest air quality categories was similar across ecoregion provinces (fig. 31). The poorest air quality category scores were in northeastern part of the Gradient Region, just north of the South Carolina State line. Compared to the Gradient Region as a whole, South Carolina forests had a higher average air quality score, a narrower range of air quality extremes, a smaller standard deviation of scores, and a larger proportion of plots in higher air quality index categories, indicating that this State has better air quality (table 24).

Climate—Across the Gradient Region, climate index scores and ecoregion provinces corresponded as might be expected with cooler scores in the

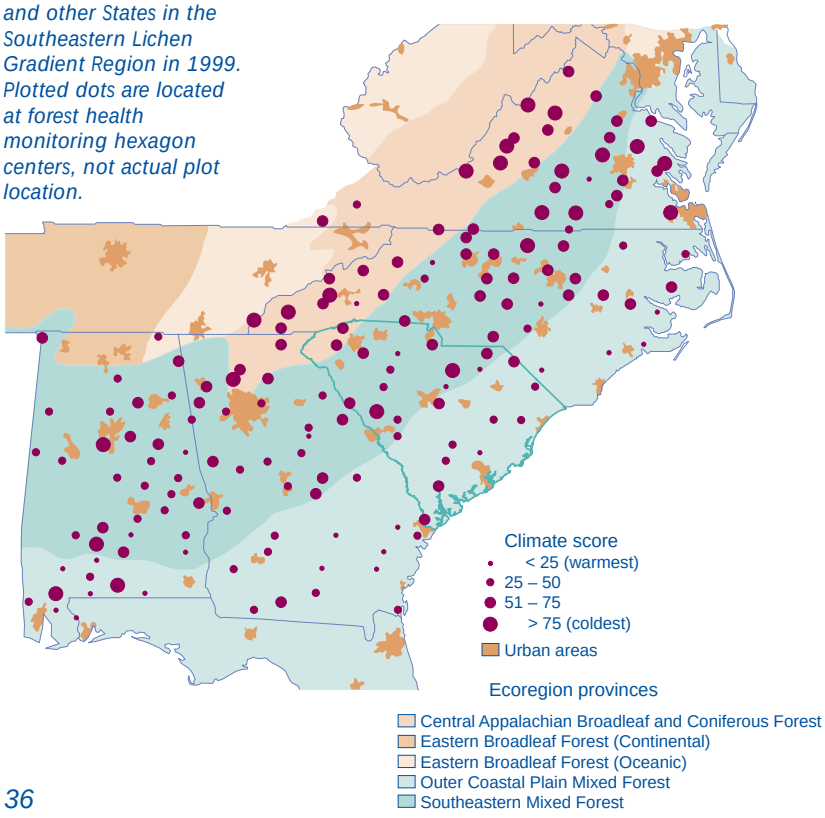
northernmost plots of the Southeastern Mixed Forest and Coastal Plain Provinces and more uniform scores across the Central Appalachians Province. Climate scores varied widely in South Carolina (fig. 32). Compared to the Gradient Region as a whole, South Carolina forests had a similar average climate score, range of scores,

Table 24—Lichen community indicator of air quality within the Southeastern Lichen Gradient Region, 1999

Parameter	Gradient Region	South Carolina
Number of plots surveyed	177	27
Number of plots by air quality index category[a]		
Lowest (poorest): index value < 40	46	2
Intermediate: index value 40 – 80	103	20
Highest (best): index value > 80	24	3
Range of air quality index scores (low to high)	2.01 – 119.47	20.58 – 119.47
Average score on air quality index	52.72	59.92
Standard deviation of air quality index scores	23.39	19.64

[a] 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.

Figure 32—Climate index scores for South Carolina and other States in the Southeastern Lichen Gradient Region in 1999. Plotted dots are located at forest health monitoring hexagon centers, not actual plot location.



Although they are not the only source of air pollution, industrial emissions contribute to the production of ozone. (photo by Bill Lea)

Table 25—Lichen community indicator of climate within the Southeastern Lichen Gradient Region, 1999

Parameter	Gradient Region	South Carolina
Number of plots surveyed	177	27
Number of plots by climate index category[a]		
Most coastal, southern, warmest: index value < 25	28	4
Warm: index value 25 – 50	53	9
Cool: index value 50 – 75	65	10
Most mountainous, northern, coolest: index value > 75	27	2
Climate index extremes	-8.56 – 114.99	-8.56 – 114.12
Average score on climate index	50.43	49.07
Standard deviation of climate index scores	26.08	24.46

[a] Categories are based on a cumulative distribution function of plot climate 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.

standard deviation of scores, and proportion of scores in the different categories (table 25). This indicates that South Carolina plots cover most of the climate variation present in the whole region.

Soil Condition Indicator

The soil condition indicator provides chemical and physical data about the physical status and fertility of forest soil, including erosion, compaction, soil nutrient levels (calcium, magnesium, potassium, and phosphorus), pH level, carbon and nitrogen, toxics, and soil bulk density. These data are also used in carbon budget and other ecological models.

The collection of data needed to assess the condition of South Carolina's soils is underway. Future reports will include analyses of the soil condition indicator data as they become available. Soils data analyses, when combined with findings from data for the other indicator variables, will provide the basis for the most comprehensive assessment of the health of South Carolina's forest resources ever undertaken.

Soils data analyses will provide the basis for the most comprehensive assessment of the health of South Carolina's forests. (SRS photo)

Edisto . . . Pee Dee . . . Santee . . . these and other familiar streams and rivers make up the intricate network of waterways flowing across South Carolina. The State has nearly 30,000 miles of rivers and 4.1 million acres of freshwater wetlands. With over 64 percent of the State forested, the management and status of its forested watersheds are reflected in the quality and availability of the State's water.

Still predominantly rural, South Carolina has succeeded in maintaining relatively high water quality. Aquatic life is rated as "fully supporting" on 79 percent of all rivers and 83 percent of all lakes, and recreational uses are rated as "fully supporting" on 58 percent of all rivers and 99 percent of all lakes (South Carolina Department of Health and Environmental Control, Bureau of Water 2002). The predominant causes of nonattainment for aquatic-life use are low dissolved oxygen in rivers and excessive nutrients in lakes. From 1988 to 1998, point-source discharges accounted for 60 percent of all impaired river and stream miles, and agriculture was the leading nonpoint source (NPS) of impairment:

Major source of impairment	Annual average impaired miles
Point sources	
Municipal	974
Storm sewers/runoff[a]	1,251
Industrial	804
Land disposal[a]	105
Total	3,133
Nonpoint sources	
Agriculture	1,540
Hydrologic/habitat modifications	98
Resource extraction	22
Construction	96
Silviculture	193
Natural	172
Total	2,122

[a] Includes both point and nonpoint sources.

Silviculture, which caused less than 4 percent of all impairments, ceased to be a source of river impairment in South Carolina after 1998. The State's Nonpoint Source Management Program coordinates overall efforts to protect water resources from NPS pollution by providing guidelines for forestry and eight other categories (South Carolina Department of Health and Environmental Control, Bureau of Water 1999). The guidelines for forestry include development of best management practices (BMP), education and outreach, and BMP monitoring and tracking.

South Carolina's BMP guidelines were first developed in the 1970s as a response to the Clean Water Act. In 1994, BMP guidelines were published for common practices such as timber harvesting, site preparation, road construction and maintenance, and lesser used practices such as minor drainage. The effectiveness of BMPs has been documented in two studies. The first, which involved 27 harvested sites, showed that BMP implementation during harvesting sufficiently protected water quality of associated streams (Adams and others 1995). The second, which was conducted from 1995 to 1998 on three watersheds at a typical Piedmont site, showed a tenfold decrease in suspended sediments when BMPs were followed during logging (Williams and others 1999).

The overall success of South Carolina's forestry Nonpoint Source Management Program has been documented by the South Carolina Forestry Commission through the Commission's implementation monitoring of BMP compliance. Timber harvesting and site preparation were monitored separately to control the sample size and to provide more accurate determination of each activity's compliance. Compliance with harvest-related BMPs improved from 85 percent in 1990 to 94 percent in the latest survey. Compliance with site preparation BMPs improved from 86 percent in 1995 to 96 percent in 2002 (fig. 33).

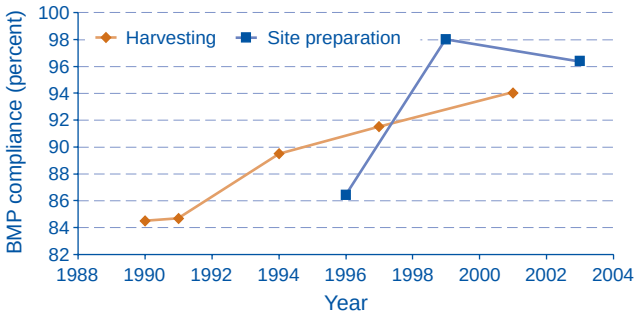


Figure 33—Best management practices (BMP) compliance trends for South Carolina from 1988 to 2002.

Pitcher plants. (photo by Bill Lea)

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Mixed trilliums dominate this South Carolina ground cover. (photo by Vic Shelburne)

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 under 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.

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.

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 (a) have been artificially regenerated by planting or direct seeding, (b) are classed as a pine or other softwood forest type, and (c) have at least 10 percent stocking.

Natural pine. Stands that (a) have not been artificially regenerated, (b) are classed as a pine or other softwood forest type, and (c) 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 less than 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 less than 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.

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 greater than 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 less than 200 feet wide, and lakes, reservoirs, and ponds less than 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 less than 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 or for consumer use or as fuel.

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

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

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

Productive-reserved forest land. Forest land sufficiently productive to qualify as timberland but withdrawn from timber utilization through statute or administrative regulation.

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 nonpulpwood mills, chipped, and then sold to pulpwood mills 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 less than 1.0 inch d.b.h. and greater than 1 foot tall for hardwoods, greater than 6 inches tall for softwood, and greater than 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 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 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 half of total stocking is saplings and seedlings.

Nonstocked stands. Stands less than 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

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.

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 square meters or 0.404686 hectare
1 cubic foot = 0.028317 cubic meter
1 inch = 2.54 centimeters or 0.0254 meter
Breast height = 1.4 meters above the ground
1 square foot = 929.03 square centimeters or 0.0929 square meter
1 square foot per acre basal area = 0.229568 square meter per hectare
1 pound = 0.454 kilogram
1 ton = 0.907 metric ton

Procedures

Inventory Methods

The Southern Research Station's Forest Inventory and Analysis unit (FIA) and the South Carolina Forestry Commission began the new annual inventory in 1998. The overall sampling scheme for annual inventories is a significant change from that of previous periodic inventories. In the annual inventory system for the South, the objective is to measure approximately 20 percent (one-fifth) of the periodic inventory plot total across an entire State each year. This annual subsample is referred to as a panel. The plots that are measured in a single panel are selected to ensure systematic coverage of individual counties. This systematic coverage includes forest and nonforest land. Estimates of forest characteristics can be derived using measurements from a single panel; however, the relatively small sample yields estimates with low precision. To achieve reliable statistics at the survey unit and State levels, panel data sets were combined using a moving average methodology. Estimates from plots that sampled forest land in all five panels were combined using the moving average procedure to produce the statistics in this bulletin.

FIA uses a three-phase sample of aerial photo points and permanent ground plots. Phase 1 (remote sensing) entails the use of aerial photography to determine the area of forest land in each county. Phase 2 (traditional FIA estimates) is based on a network of ground sample locations where field crews visit physical locations of plots and collect measurements of a variety of traditional mensurational FIA variables. Phase 3 (forest health estimates) comprises approximately a 1/16th sample of the phase 2 plots. Phase 3 measurements include the full complement of traditional FIA variables measured on phase 2 plots, plus additional measurements taken on tree crowns, soils, lichens, downed woody debris, and understory vegetation.

In phase 1, a forest-nonforest classification was derived by interpreting 93,369 points on aerial photographs. These photo classifications were adjusted based on ground observations at 5,629 sample locations. The plot installed at each ground sample location (phase 2) was a cluster of four points spaced 120 feet apart. Each point served as the center of a 1/24-acre circular subplot used to sample trees 5.0 inches in diameter at breast height (d.b.h.) and larger. A 1/300-acre microplot, located at the subplot center, was used to sample trees 1.0 to 4.9 inches d.b.h. and seedlings (trees less than 1.0 inch d.b.h.). These fixed-radius sample plots were established without regard to land use or land cover. Forest and nonforest condition classes were delineated and recorded on each plot. Condition classes were defined by six attributes: land use, forest type, stand origin, stand size, forest density, and major ownership class. The process of delineating a fixed-radius plot into numerous sections based on forest and land use conditions is called mapping. All trees tallied were assigned to their respective condition class.

The cluster of 4 fixed plots sampled timberland at 2,664 ground sample locations in South Carolina. Estimates of timber volume and forest classifications were derived from tree measurements and classifications made at these locations. Volumes for individual tally trees were computed using equations for each of the major species in South Carolina. Estimates of growth, removals, and mortality were determined from the remeasurement of 2,565 permanent sample plots established in the previous inventory. The plot design for the previous inventory was based on a

cluster of 10 points. Variable plots were systematically spaced within a single forest condition at three to five points. At each point, trees 5.0 inches d.b.h and larger were selected for measurement on a variable-radius plot defined by a 37.5-factor prism. Trees less than 5.0 inches d.b.h. were tallied on a fixed-radius plot around points 1 through 3.[1]

Reliability of the Data

A measure of reliability of inventory statistics is provided by sampling errors. FIA inventories supported by the full complement of sample plots are designed to achieve reliable statistics at the survey unit and State levels. However, users should note that sampling error increases as the area or volume considered decreases in magnitude. Sampling errors and associated confidence intervals are often unacceptably high for small components of the total resource.

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

Item	Sample estimate and confidence interval			Sampling error
				percent
Timberland (1,000 acres)	12,221.0	±	50.1	0.41
All live (million cubic feet)				
Inventory	19,720.6	±	356.1	1.81
Net annual growth	997.7	±	24.1	2.42
Annual removals	765.0	±	34.4	4.49
Annual mortality	197.6	±	8.2	4.14
Growing stock (million cubic feet)				
Inventory	18,013.5	±	339.3	1.88
Net annual growth	960.6	±	23.4	2.43
Annual removals	731.9	±	33.2	4.54
Annual mortality	158.9	±	7.4	4.64
Sawtimber (million board feet)				
Inventory	61,038.2	±	1,585.7	2.60
Net annual growth	3,271.9	±	87.4	2.67
Annual removals	2,570.2	±	133.6	5.20
Annual mortality	493.5	±	29.9	6.06

[1] U.S. Department of Agriculture, Forest Service. 1998. Field instructions for the southern forest inventory: remeasurement of prism plots. Version 3. [Not paged]. On file with: Southern Research Station, Forest Inventory and Analysis, 4700 Old Kingston Pike, Knoxville, TN 37919.

Statistical confidence may be computed for any subdivision of the State totals 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 State total
SE_t = sampling error for State total
X_s = sum of values for the variable of interest (area or volume) for subdivision of State
X_t = total area or volume for State

For example, the estimate of sampling error for softwood live-tree volume on forest industry land is computed as:

$$SE_s = 1.81 \frac{\sqrt{19{,}720.6}}{\sqrt{1{,}781.2}} = 6.02$$

Thus, the sampling error is 6.02 percent, and the resulting confidence interval (two times out of three) for softwood live-tree inventory on forest industry land is 1,781.2 ± 107.2 million cubic feet.

Water-adapted vegetation in bald cypress swamp in South Carolina. (photo by Bill Lea)

Index of Detailed Tables

Area

Inventory of Trees, Volumes, and Biomass

Pitcher plants. (photo by Bill Lea)

Growth, Removals, and Mortality

Detailed Tables

Table A–1—Land area by survey unit and land class, South Carolina (panels 1 through 5), 2001

Survey unit	Total land area[a]	Forest land				Other land[b]
		Total forest	Timberland	Productive reserved	Other	
	thousand acres					
Southern Coastal Plain	5,147.4	3,324.8	3,299.9	24.9	—	1,822.6
Northern Coastal Plain	7,423.5	4,628.9	4,550.9	78.0	—	2,794.6
Piedmont	6,691.5	4,461.8	4,370.5	91.3	—	2,229.8
All units	19,262.4	12,415.5	12,221.4	194.1	—	6,846.9

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.
[a] From the U.S. Bureau of the Census (1991).
[b] Includes 89.4 thousand acres of water according to Forest Inventory and Analysis standards of area classification, but defined by the Bureau of the Census as land.

Table A–2—Area of timberland by survey unit and ownership class, South Carolina (panels 1 through 5), 2001

Survey unit	All classes	Ownership class			
		National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
Southern Coastal Plain	3,299.9	—	233.0	531.1	2,535.8
Northern Coastal Plain	4,550.9	247.0	302.1	933.4	3,068.5
Piedmont	4,370.5	329.1	149.6	546.8	3,345.0
All units	12,221.4	576.1	684.7	2,011.3	8,949.3

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

Table A–3—Area of timberland by survey unit and forest-type group, South Carolina (panels 1 through 5), 2001

Survey unit	All groups	Forest-type group								
		White-red-jack pine	Longleaf-slash	Loblolly-shortleaf	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Tropical hardwood	Non-stocked
	thousand acres									
Southern Coastal Plain	3,299.9	—	271.7	1,446.3	338.4	350.2	838.4	53.1	1.1	0.7
Northern Coastal Plain	4,550.9	—	264.1	1,983.8	412.1	481.4	1,204.2	162.3	—	43.1
Piedmont	4,370.5	29.6	4.4	1,965.6	672.2	1,490.7	56.2	135.3	—	16.5
All units	12,221.4	29.6	540.1	5,395.7	1,422.7	2,322.3	2,098.9	350.8	1.1	60.2

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

Table A–4—Area of timberland by survey unit and stand-size class, South Carolina (panels 1 through 5), 2001

Survey unit	All classes	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Nonstocked
	thousand acres				
Southern Coastal Plain	3,299.9	1,336.3	1,016.1	946.9	0.7
Northern Coastal Plain	4,550.9	1,386.6	1,635.6	1,485.7	43.1
Piedmont	4,370.5	1,657.3	1,486.5	1,210.2	16.5
All units	12,221.4	4,380.2	4,138.2	3,642.8	60.2

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

Table A–5—Area of timberland by forest-type group, stand origin, and ownership class, South Carolina (panels 1 through 5), 2001

Forest-type group and stand origin	All classes	Ownership class			
		National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
Softwood types					
White-red-jack pine					
Planted	5.4	—	1.1	—	4.4
Natural	24.2	6.5	9.5	—	8.2
Total	29.6	6.5	10.5	—	12.5
Longleaf-slash pine					
Planted	175.4	2.2	57.8	13.8	101.6
Natural	364.8	10.7	93.2	17.0	243.8
Total	540.1	12.9	151.0	30.9	345.4
Loblolly-shortleaf pine					
Planted	2,877.4	81.9	75.2	1,135.1	585.2
Natural	2,518.2	242.3	153.9	147.2	1,974.9
Total	5,395.7	324.2	229.1	1,282.3	3,560.1
Total softwoods	5,965.4	343.7	390.6	1,313.1	3,918.1
Hardwood types					
Oak-pine					
Planted	48.3	—	—	6.4	41.9
Natural	1,374.4	54.8	54.1	69.7	1,195.8
Total	1,422.7	54.8	54.1	76.1	1,237.7
Oak-hickory	2,322.3	88.4	112.2	132.6	1,989.2
Oak-gum-cypress	2,098.9	76.5	114.7	396.3	1,511.3
Elm-ash-cottonwood	350.8	12.9	11.9	72.3	253.7
Tropical hardwood	1.1	—	1.1	—	—
Total hardwoods	6,195.8	232.5	294.1	677.3	4,991.9
Nonstocked	60.2	—	—	20.9	39.3
All groups	12,221.4	576.1	684.7	2,011.3	8,949.3

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

Table A–6—Number of live trees on timberland by species group and diameter class, South Carolina (panels 1 through 5), 2001

Species group	All classes	Diameter class (*inches at breast height*) 1.0–2.9	3.0–4.9	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
	thousand trees												
Softwood													
Yellow pine	2,734,242	1,159,911	618,162	422,769	266,544	127,917	64,853	35,344	19,157	10,066	5,375	4,050	94
Other softwoods	211,604	122,109	38,845	19,354	11,763	7,049	4,712	3,379	2,246	929	578	384	255
All softwoods	2,945,846	1,282,020	657,007	442,123	278,307	134,966	69,565	38,723	21,403	10,995	5,953	4,434	349
Hardwood													
Soft hardwood	3,121,817	2,172,633	465,879	196,670	107,831	66,441	43,122	27,055	18,487	10,257	6,528	6,055	859
Hard hardwood	2,633,549	1,810,036	425,837	162,656	90,601	54,309	32,922	21,657	13,910	8,247	5,263	6,881	1,231
All hardwoods	5,755,366	3,982,669	891,716	359,326	198,432	120,750	76,044	48,712	32,397	18,504	11,791	12,936	2,090
All species	8,701,212	5,264,688	1,548,723	801,449	476,739	255,717	145,609	87,436	53,800	29,499	17,745	17,370	2,439

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

Table A–7—Number of growing-stock trees on timberland by species group and diameter class, SouthCarolina (panels 1 through 5), 2001

Species group	All classes	Diameter class (*inches at breast height*) 1.0–2.9	3.0–4.9	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
	thousand trees												
Softwood													
Yellow pine	2,366,659	892,845	554,952	401,910	258,307	122,547	63,361	34,758	18,718	9,916	5,319	3,932	94
Other softwoods	154,047	76,958	32,903	16,478	10,101	5,949	4,380	3,097	2,184	868	578	325	226
All softwoods	2,520,706	969,803	587,855	418,388	268,408	128,496	67,741	37,855	20,902	10,784	5,897	4,257	320
Hardwood													
Soft hardwood	1,502,598	845,864	279,593	143,014	85,795	55,030	35,078	22,769	15,809	8,723	5,569	4,848	506
Hard hardwood	902,270	420,245	191,904	104,343	66,745	44,400	26,539	18,428	11,973	6,803	4,484	5,661	744
All hardwoods	2,404,868	1,266,109	471,497	247,357	152,540	99,430	61,617	41,197	27,782	15,526	10,053	10,509	1,250
All species	4,925,573	2,235,913	1,059,352	665,746	420,948	227,926	129,357	79,053	48,683	26,309	15,950	14,766	1,570

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

Table A–8—Volume of live trees on timberland by species group and diameter class, South Carolina (panels 1 through 5), 2001

Species group	All classes	Diameter class (*inches at breast height*) 5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
	million cubic feet										
Softwood											
Yellow pine	8,712.6	992.4	1,587.5	1,509.5	1,277.0	1,070.5	816.3	578.7	400.4	456.5	23.8
Other softwoods	637.4	52.7	73.8	79.8	85.4	88.8	82.2	43.9	37.0	35.3	58.5
All softwoods	9,350.1	1,045.1	1,661.4	1,589.3	1,362.4	1,159.4	898.5	622.6	437.3	491.9	82.3
Hardwood											
Soft hardwood	5,644.5	497.0	659.6	747.0	788.7	714.3	665.2	495.4	404.1	535.3	138.0
Hard hardwood	4,697.6	397.8	516.1	592.2	580.6	565.0	507.2	387.2	320.3	620.7	210.7
All hardwoods	10,342.1	894.8	1,175.7	1,339.2	1,369.2	1,279.2	1,172.4	882.6	724.4	1,156.0	348.7
All species	19,692.2	1,939.9	2,837.1	2,928.5	2,731.6	2,438.6	2,070.8	1,505.1	1,161.7	1,647.8	431.0

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

Table A–9—Volume of growing-stock trees on timberland by species group and diameter class, South Carolina (panels 1 through 5), 2001

Species group	All classes	Diameter class (*inches at breast height*) 5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
					million cubic feet						
Softwood											
Yellow pine	8,520.2	953.5	1,546.7	1,460.9	1,253.7	1,057.2	804.4	572.7	397.8	449.6	23.8
Other softwoods	594.5	45.9	65.6	69.9	81.1	83.5	80.9	41.8	37.0	31.6	57.4
All softwoods	9,114.7	999.4	1,612.2	1,530.8	1,334.8	1,140.7	885.2	614.5	434.8	481.1	81.2
Hardwood											
Soft hardwood	4,878.7	380.7	550.9	648.0	676.8	633.6	602.7	446.6	368.7	477.1	93.5
Hard hardwood	3,995.7	282.0	407.3	509.6	493.7	503.3	457.0	344.8	296.4	555.6	146.1
All hardwoods	8,874.4	662.8	958.2	1,157.6	1,170.5	1,136.9	1,059.7	791.4	665.1	1,032.7	239.6
All species	17,989.2	1,662.2	2,570.4	2,688.4	2,505.2	2,277.6	1,944.9	1,405.9	1,099.9	1,513.8	320.8

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

Table A–10—Volume of sawtimber on timberland by species group and diameter class, South Carolina (panels 1 through 5), 2001

Species group	All classes	Diameter class (*inches at breast height*) 9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
				million board feet					
Softwood									
Yellow pine	30,251.8	5,302.9	5,689.8	5,494.8	4,567.3	3,457.4	2,521.9	3039.4	178.3
Other softwoods	2,281.7	223.7	320.2	371.6	394.9	213.8	200.0	182.6	374.9
All softwoods	32,533.5	5,526.5	6,010.1	5,866.4	4,962.2	3,671.2	2,722.0	3221.9	553.2
Hardwood									
Soft hardwood	15,252.3	—	2,301.6	2,563.8	2,750.7	2,247.9	1,976.7	2799.5	612.1
Hard hardwood	13,129.7	—	1,753.1	2,069.0	2,078.0	1,678.5	1,525.7	3116.7	908.8
All hardwoods	28,382.1	—	4,054.7	4,632.8	4,828.7	3,926.3	3,502.4	5916.2	1,520.9
All species	60,915.6	5,526.5	10,064.8	10,499.2	9,791.0	7,597.5	6,224.4	9138.2	2,074.2

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

Table A–11—Volume of live trees on timberland by survey unit and species group, South Carolina (panels 1 through 5), 2001

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	6,150.0	3,262.5	3,013.3	249.2	2,887.5	1,682.5	1,205.0
Northern Coastal Plain	6,382.9	2,963.4	2,675.9	287.5	3,419.5	2,266.5	1,153.0
Piedmont	7,159.3	3,124.2	3,023.4	100.7	4,035.1	1,695.5	2,339.6
All units	19,692.2	9,350.1	8,712.6	637.4	10,342.1	5,644.5	4,697.6

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

Table A–12—Volume of growing stock on timberland by survey unit and species group, South Carolina (panels 1 through 5), 2001

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	5,652.1	3,194.1	2,954.8	239.4	2,458.0	1,458.0	1,000.1
Northern Coastal Plain	5,781.7	2,889.5	2,613.2	276.3	2,892.2	1,938.7	953.5
Piedmont	6,555.4	3,031.2	2,952.3	78.8	3,524.2	1,482.1	2,042.2
All units	17,989.2	9,114.7	8,520.2	594.5	8,874.4	4,878.7	3,995.7

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

Table A–13—Volume of sawtimber on timberland by survey unit and species group, South Carolina (panels 1 through 5), 2001

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million board feet						
Southern Coastal Plain	19,628.9	11,587.4	10,552.5	1,034.9	8,041.5	4,521.9	3,519.6
Northern Coastal Plain	18,913.8	10,290.1	9,210.8	1,079.3	8,623.7	5,564.6	3,059.1
Piedmont	22,372.4	10,656.0	10,488.5	167.5	11,716.8	5,165.8	6,551.0
All units	60,915.6	32,533.5	30,251.8	2,281.7	28,382.1	15,252.3	13,129.7

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

Table A–14—Volume of live and growing-stock trees on timberland by ownership class and species group, South Carolina (panels 1 through 5), 2001

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				Live trees (*million cubic feet*)			
National forest	1,105.6	653.0	607.4	45.5	452.7	256.8	195.9
Other public	1,486.3	796.2	764.1	32.1	690.2	308.4	381.8
Forest industry	2,948.0	1,780.3	1,672.6	107.7	1,167.7	773.4	394.3
Nonindustrial private	14,152.2	6,120.6	5,668.5	452.1	8,031.6	4,305.9	3,725.7
All classes	19,692.2	9,350.1	8,712.6	637.4	10,342.1	5,644.5	4,697.6
				Growing-stock trees (*million cubic feet*)			
National forest	1,053.3	646.3	602.4	43.9	407.0	231.3	175.7
Other public	1,396.3	784.4	752.4	32.0	611.9	282.0	329.9
Forest industry	2,718.9	1,729.0	1,630.4	98.6	989.8	663.9	325.9
Nonindustrial private	12,820.7	5,954.9	5,535.0	420.0	6,865.7	3,701.5	3,164.2
All classes	17,989.2	9,114.7	8,520.2	594.5	8,874.4	4,878.7	3,995.7

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

Table A–15—Volume of sawtimber on timberland by ownership class, species group, and size class, South Carolina (panels 1 through 5), 2001

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				All size classes (*million board feet*)			
National forest	4,129.6	2,879.3	2,695.5	183.8	1,250.3	738.1	512.2
Other public	5,499.1	3,383.5	3,324.5	59.0	2,115.6	933.2	1,182.4
Forest industry	7,918.8	4,730.0	4,333.6	396.4	3,188.8	2,059.8	1,129.0
Nonindustrial private	43,368.1	21,540.7	19,898.2	1,642.5	21,827.4	11,521.2	10,306.2
All classes	60,915.6	32,533.5	30,251.8	2,281.7	8,382.1	15,252.3	13,129.7
				Trees ≥15.0 inches d.b.h. (*million board feet*)			
National forest	2,683.2	1,815.9	1,694.2	121.7	867.3	538.6	328.7
Other public	3,281.1	1,690.6	1,687.6	3.0	1,590.5	636.7	953.8
Forest industry	3,751.4	1,458.8	1,230.3	228.6	2,292.6	1,420.3	872.2
Nonindustrial private	25,109.4	10,165.2	9,152.2	1,013.0	14,944.3	7,791.4	7,152.9
All classes	34,825.1	15,130.5	13,764.3	1,366.3	19,694.6	10,387.0	9,307.6

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

Table A–16—Volume of growing stock on timberland by forest-type group, stand origin, and species group, South Carolina (panels 1 through 5), 2001

Forest-type group and stand origin	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	8.9	7.7	7.7	—	1.2	0.7	0.5
Natural	77.8	39.4	32.8	6.6	38.4	21.1	17.4
Total	86.7	47.1	40.5	6.6	39.6	21.7	17.9
Longleaf-slash pine							
Planted	139.6	136.3	135.7	0.6	3.3	1.8	1.5
Natural	443.8	412.8	410.8	2.0	31.0	5.6	25.4
Total	583.4	549.0	546.5	2.6	34.4	7.4	27.0
Loblolly-shortleaf pine							
Planted	3,343.7	3,189.1	3,181.4	7.7	154.6	82.3	72.4
Natural	4,007.5	3,354.6	3,318.2	36.4	652.9	313.1	339.9
Total	7,351.2	6,543.7	6,499.6	44.0	807.6	395.3	412.2
Total softwoods	8,021.3	7,139.8	7,086.6	53.2	881.5	424.5	457.1
Hardwood types							
Oak-pine							
Planted	40.9	25.8	25.5	0.3	15.0	10.8	4.2
Natural	1,573.7	823.5	796.5	27.0	750.1	278.9	471.2
Total	1,614.5	849.3	822.0	27.3	765.1	289.7	475.4
Oak-hickory	3,501.9	380.1	348.4	31.7	3,121.8	1,303.2	1,818.6
Oak-gum-cypress	4,253.1	719.7	248.7	471.0	3,533.4	2,499.1	1,034.3
Elm-ash-cottonwood	592.4	24.2	13.6	10.6	568.2	358.2	210.0
Tropical hardwood	0.1	0.1	0.1	—	—	—	—
Total hardwoods	9,962.0	1,947.6	1,407.3	540.3	7,694.7	4,439.4	3,534.2
Nonstocked	5.8	1.6	1.0	0.6	4.2	4.1	0.2
All groups	17,989.2	9,088.9	8,520.2	594.5	8,874.4	4,878.7	3,995.7

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

Table A–17—Average net annual growth of live trees on timberland by survey unit, and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	324.7	245.2	240.2	5.0	79.5	42.0	37.5
Northern Coastal Plain	328.0	242.1	235.3	6.7	85.9	50.7	35.2
Piedmont	345.1	204.5	201.9	2.6	140.5	61.9	78.6
All units	997.7	691.8	677.4	14.4	305.9	154.6	151.3

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

Table A–18—Average net annual growth of growing stock on timberland by survey unit and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	313.7	238.8	234.2	4.6	75.0	40.7	34.2
Northern Coastal Plain	322.0	239.2	232.4	6.7	82.8	49.7	33.1
Piedmont	324.9	198.8	196.6	2.3	126.1	53.8	72.3
All units	960.6	676.8	663.2	13.6	283.9	144.2	139.7

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

Table A–19—Average net annual growth of sawtimber on timberland by survey unit and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million board feet						
Southern Coastal Plain	1,063.8	776.8	750.3	26.5	287.0	145.5	141.6
Northern Coastal Plain	1,053.4	760.3	730.4	29.9	293.1	167.8	125.3
Piedmont	1,154.7	640.6	631.5	9.0	514.1	215.3	298.8
All units	3,271.9	2,177.7	2,112.2	65.4	1,094.3	528.6	565.7

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

Table A–20—Average net annual removals of live trees on timberland by survey unit and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	201.4	128.3	125.2	3.1	73.0	37.5	35.5
Northern Coastal Plain	280.8	173.2	171.0	2.2	107.5	68.0	39.5
Piedmont	282.9	212.7	210.6	2.2	70.2	27.8	42.4
All units	765.0	514.3	506.8	7.5	250.7	133.4	117.3

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

Table A–21—Average annual removals of growing stock on timberland by survey unit and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Southern Coastal Plain	191.1	127.5	124.7	2.9	63.6	33.0	30.6
Northern Coastal Plain	264.0	171.4	169.2	2.1	92.7	58.9	33.8
Piedmont	276.8	211.4	209.2	2.2	65.4	26.2	39.2
All units	731.9	510.2	503.1	7.2	221.7	118.1	103.6

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

Table A–22—Average annual removals of sawtimber on timberland by survey unit and species group, South Carolina (panels 1 through 5), 1993 to 2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million board feet						
Southern Coastal Plain	679.2	463.8	450.7	13.1	215.4	112.1	103.3
Northern Coastal Plain	937.4	640.1	630.0	10.1	297.3	186.1	111.2
Piedmont	953.6	778.0	775.9	2.1	175.6	74.9	100.7
All units	2,570.2	1,881.9	1,856.6	25.3	688.3	373.1	315.2

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

Table A–23—Average net annual growth and average annual removals of live trees, growing stock, and sawtimber on timberland by species group, South Carolina (panels 1 through 5), 1993 to 2000

Species group	Live trees		Growing stock		Sawtimber	
	Net annual growth	Annual removals	Net annual growth	Annual removals	Net annual growth	Annual removals
	million cubic feet				*million board feet*	
Softwood						
Yellow pine	677.4	506.8	663.2	503.1	2,112.2	1,856.6
Other softwoods	14.4	7.5	13.6	7.2	65.4	25.3
All softwoods	691.8	514.3	676.8	510.2	2,177.7	1,881.9
Hardwood						
Soft hardwood	154.6	133.4	144.2	118.1	528.6	373.1
Hard hardwood	151.3	117.3	139.7	103.6	565.7	315.2
All hardwoods	305.9	250.7	283.9	221.7	1,094.3	688.3
All species	997.7	765.0	960.6	731.9	3,271.9	2,570.2

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

Table A–24—Average annual mortality of live trees, growing stock, and sawtimber on timberland by species group, South Carolina (panels 1 through 5), 1993 to 2000

Species group	Live trees	Growing stock	Sawtimber
	million cubic feet		*million board feet*
Softwood			
Yellow pine	72.7	71.2	223.6
Other softwoods	3.7	3.3	8.5
All softwoods	76.3	74.5	232.1
Hardwood			
Soft hardwood	61.7	40.4	115.0
Hard hardwood	59.6	44.0	146.4
All hardwoods	121.3	84.4	261.4
All species	197.6	158.9	493.5

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

Table A–25—Average net annual growth and average annual removals of live trees on timberland by ownership class and species group, South Carolina (panels 1 through 5), 1993 to 2000

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million cubic feet*)						
National forest	22.7	16.6	15.5	1.1	6.1	2.7	3.3
Other public	52.3	35.1	34.3	0.9	17.2	7.5	9.7
Forest industry	228.8	198.9	196.0	3.0	29.8	17.4	12.5
Nonindustrial private	694.0	441.1	431.7	9.4	252.8	127.0	125.8
All classes	997.7	691.8	677.4	14.4	305.9	154.6	151.3
	Average annual removals (*million cubic feet*)						
National forest	7.5	6.8	6.8	0.1	0.7	0.2	0.5
Other public	19.3	17.9	17.9	—	1.3	0.5	0.8
Forest industry	223.6	166.0	164.0	2.0	57.6	32.5	25.2
Nonindustrial private	514.6	323.5	318.2	5.4	191.1	100.2	90.9
All classes	765.0	514.3	506.8	7.5	250.7	133.4	117.3

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

Table A–26—Average net annual growth and average annual removals of growing stock on timberland by ownership class and species group, South Carolina (panels 1 through 5), 1993 to 2000

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million cubic feet*)						
National forest	22.4	16.3	15.2	1.1	6.1	2.5	3.7
Other public	50.2	34.6	33.8	0.9	15.6	6.5	9.1
Forest industry	223.9	194.5	191.6	2.9	29.3	17.8	11.5
Nonindustrial private	664.2	431.3	422.6	8.8	232.8	117.4	115.4
All classes	960.6	676.8	663.2	13.6	283.9	144.2	139.7
	Average annual removals (*million cubic feet*)						
National forest	7.4	6.8	6.8	0.1	0.6	0.2	0.4
Other public	18.5	17.6	17.6	—	0.9	0.5	0.4
Forest industry	215.5	164.9	163.0	1.9	50.7	28.5	22.2
Nonindustrial private	490.4	320.9	315.7	5.2	169.5	88.9	80.6
All classes	731.9	510.2	503.1	7.2	221.7	118.1	103.6

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

Table A–27—Average net annual growth and average annual removals of sawtimber on timberland by ownership class and species group, South Carolina (panels 1 through 5), 1993 to 2000

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million board feet*)						
National forest	101.0	76.6	68.7	7.8	24.4	10.0	14.4
Other public	198.1	146.0	145.3	0.7	52.0	23.0	29.0
Forest industry	618.4	508.0	493.7	14.3	110.3	58.3	52.0
Nonindustrial private	2,354.5	1,447.0	1,404.5	42.5	907.5	437.2	470.3
All classes	3,271.9	2,177.7	2,112.2	65.4	1,094.3	528.6	565.7
	Average annual removals (*million board feet*)						
National forest	32.1	31.7	31.2	0.5	0.4	—	0.4
Other public	61.6	60.7	60.7	—	0.8	0.5	0.4
Forest industry	688.4	510.2	502.9	7.2	178.3	96.1	82.1
Nonindustrial private	1,788.1	1,279.4	1,261.8	17.6	508.7	276.4	232.3
All classes	2,570.2	1,881.9	1,856.6	25.3	688.3	373.1	315.2

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

Table A–28—Average net annual growth of growing stock on timberland by forest-type group, stand origin, and species group, South Carolina (panels 1 through 5), 1993 to 2000

Forest-type group and stand origin[a]	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	—	—	—	—	—	—	—
Natural	1.7	0.9	0.6	0.3	0.8	0.0	0.8
Total	1.7	0.9	0.6	0.3	0.8	0.0	0.8
Longleaf-slash pine							
Planted	17.1	16.6	16.6	0.0	0.5	0.1	0.4
Natural	19.3	16.8	16.9	-0.1	2.5	1.3	1.3
Total	36.4	33.4	33.5	-0.1	3.0	1.4	1.6
Loblolly-shortleaf pine							
Planted	379.3	371.5	371.4	0.1	7.8	6.1	1.7
Natural	200.8	176.2	175.0	1.2	24.6	12.1	12.5
Total	580.1	547.6	546.4	1.3	32.4	18.2	14.2
Total softwoods	618.2	581.9	580.5	1.5	36.3	19.7	16.6
Hardwood types							
Oak-pine							
Planted	9.2	6.7	6.7	0.0	2.5	2.0	0.5
Natural	78.9	47.6	47.4	0.2	31.4	11.0	20.4
Total	88.1	54.2	54.1	0.2	33.9	13.0	20.8
Oak-hickory	125.6	17.7	17.1	0.6	107.9	42.8	65.1
Oak-gum-cypress	121.3	21.9	10.8	11.0	99.4	64.2	35.3
Elm-ash-cottonwood	6.6	0.5	0.2	0.3	6.1	4.4	1.7
Tropical hardwood	0.0	0.0	0.0	—	—	—	—
Total hardwoods	341.7	94.4	82.2	12.1	247.3	124.4	122.9
Nonstocked	0.5	0.2	0.2	—	0.3	0.1	0.2
All groups	960.3	676.5	662.9	13.6	283.9	144.2	139.7

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 indicates a value of > 0.0 but < 0.05 for the cell.
[a] Classifications at the beginning of the remeasurement period.

Table A–29—Average annual removals of growing stock on timberland by forest-type group, stand origin, and species group, South Carolina (panels 1 through 5), 1993 to 2000

Forest-type group and stand origin[a]	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	—	—	—	—	—	—	—
Natural	0.6	0.6	0.6	—	—	—	—
Total	0.6	0.6	0.6	—	—	—	—
Longleaf-slash pine							
Planted	37.1	35.9	35.7	0.2	1.2	1.1	0.1
Natural	14.2	14.0	13.9	0.1	0.2	0.2	—
Total	51.3	49.9	49.6	0.3	1.4	1.3	0.1
Loblolly-shortleaf pine							
Planted	188.3	184.5	184.5	—	3.8	2.7	1.1
Natural	226.4	209.9	208.6	1.3	16.5	9.7	6.8
Total	414.7	394.4	393.1	1.3	20.3	12.5	7.9
Total softwoods	466.6	444.9	443.3	1.6	21.7	13.7	8.0
Hardwood types							
Oak-pine							
Planted	4.2	3.4	3.4	—	0.8	0.7	0.1
Natural	66.4	39.5	39.0	0.5	26.9	7.1	19.8
Total	70.6	42.9	42.3	0.5	27.7	7.8	19.9
Oak-hickory	70.2	9.2	8.6	0.6	61.0	20.9	40.1
Oak-gum-cypress	120.4	12.2	7.8	4.4	108.1	72.9	35.2
Elm-ash-cottonwood	3.2	0.1	0.1	—	3.1	2.7	0.4
Tropical hardwood	0.1	0.1	0.1	—	—	—	—
Total hardwoods	264.4	64.5	59.0	5.5	200.0	104.3	95.6
Nonstocked	0.2	—	0.2	—	—	—	—
All groups	731.3	509.4	502.4	7.2	221.7	118.1	103.6

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.
[a] Classifications at the beginning of the remeasurement period.

Table A–30—Area of timberland treated or disturbed annually and retained in timberland by treatment or disturbance and ownership class, South Carolina, 1993 to 2001

Treatment or disturbance	All classes	Ownership class		
		Public	Forest industry	Nonindustrial private
		thousand acres		
Final harvest	189.3	5.6	56.4	127.3
Partial harvest[a]	74.3	6.3	4.5	63.5
Seed tree/shelterwood	7.1	1.8	—	5.3
Commercial thinning	76.1	5.3	19.4	51.5
Other stand improvement	7.7	0.7	2.5	4.4
Site preparation	88.3	3.1	42.9	42.3
Artificial regeneration[b]	124.9	4.7	47.7	72.5
Natural regeneration[b]	133.9	3.7	16.8	113.4
Other cutting	30.0	1.9	0.8	27.4
Natural disturbance				
Disease	3.3	0.8	1.2	1.3
Insects	12.3	4.6	1.1	6.7
Fire	29.4	7.0	4.4	17.9
Weather	29.6	3.6	4.1	21.8
Animals	12.1	1.2	1.3	9.5
Other disturbances				
Grazing	6.4	—	—	6.4
Other human-caused disturbance	26.2	1.0	2.5	22.6

Since some acres experience more than one treatment or disturbance, there are no column totals. Numbers in rows may not sum to totals due to rounding.

— = no sample for the cell.

[a] Includes high-grading and some selective cutting.

[b] Includes establishment of trees for timber production on forest and nonforest land.

Conner, Roger C.; Adams, T.; Butler, B. [and others]. 2004. The State of South Carolina's forests, 2001. Resour. Bull. SRS–96. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 67 p.

Forest land area in South Carolina amounted to 12.4 million acres, including 12.2 million acres of timberland. Nonindustrial-private timberland amounted to 8.9 million acres, a decline of less than 1 percent since 1993. Family forest owners dominate the private ownership group with 357,000 landowners who collectively control 7.1 million acres of forest land in the State. Timberland area under forest industry ownership continued to decline, falling from 2.3 million acres in 1993 to just over 2.0 million acres in 2001. Loblolly pine remains the predominant softwood forest type and occupied 5.0 million acres, up 16 percent since 1993. Planted pine stands amounted to 3.1 million acres and outnumbered stands of natural pine by 150,000 acres. Total volume in all live species amounted to 19.7 billion cubic feet, surpassing all previous inventory estimates. All live softwood volume increased 16 percent to 9.4 billion cubic feet, due primarily to an increase of 1.7 billion cubic feet in loblolly pine volume. Net annual growth for all live softwoods doubled since 1992, averaging 692 million cubic feet per year. Hardwood net growth rose 63 percent and averaged 306 million cubic feet per year since the previous survey. Growth exceeds removals for both species groups, reversing the negative relationship that resulted in the aftermath of Hurricane Hugo.

Keywords: Annual inventory, forest health indicators, forest ownership, Hurricane Hugo recovery, pulpwood, timber products output.

The Forest Service, United States Department of Agriculture (USDA), is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

October 2004

Southern Research Station
P.O. Box 2680
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South Carolina State Facts

South Carolina: The Palmetto State
Capital City: Columbia
Location: 34.03923 N, 080.88634 W
Origin of State's name: Named in honor of England's King Charles I
Population: 4 million
Geology: Land Area; 30,207 square miles; 40th
Highest Point: Sassafras Mountain; 3,560 feet
Inland water: 909 square miles
Largest City: Columbia
Lowest Point: Atlantic coast; sea level
Border States: Georgia - North Carolina
Coastline: 187 miles
Constitution: 8th State
Statehood: May 23, 1788

Bird: The Carolina wren is a member of the family Troglodytidae. It is present in all areas in South Carolina from the coast to the highest mountain. The song—which may be interpreted as tea-ket-tle, tea-ket-tle, tea-ket-tle, tea-ket-tle—may be heard the year-round, day and night, in all kinds of weather.

The Carolina wren is slightly smaller than an English sparrow and has a conspicuous white stripe over the eyes. The back of its body is rufous-red with underparts somewhat lighter in color. The tail, which is finely barred with black, is held erect when the bird is excited.

Agriculture: Tobacco, poultry, cattle, dairy products, soybeans, hogs.

Industry: Textile goods, chemical products, paper products, machinery, tourism.

Flag: Asked by the Revolutionary Council of Safety in the fall of 1775 to design a flag for the use of South Carolina troops, Col. William Moultrie chose a blue which matched the color of their uniforms and a crescent which reproduced the silver emblem worn on the front of their caps. The palmetto tree was added later.

Tree: Adopted as the "Official State Tree of the State of South Carolina" by Joint Resolution No. 63, approved March 17, 1939.

The South Carolina Palmetto is classified by the U. S. Department of Agriculture as "Inodes Palmetto (also called Sabal Palmetto) and commonly known as the Cabbage Palmetto." It has long been closely associated with the history of South Carolina, being represented on the State flag as well as on the State seal, where it is symbolical of the defeat of the British fleet by the fort, built of Palmetto logs, on Sullivan's Island.

The Palmetto is an attractive feature of the coastal areas of South Carolina and is also found in Georgia, Florida, and North Carolina. The large leafbud is highly prized as a salad vegetable for use in making pickles or relishes, and in Florida some use has been made of the fibers from the leaf bases. Such uses, however, are wasteful since the palm must be destroyed in either case and years must lapse before it can be replaced.

Flower: Officially adopted by the General Assembly on February 1, 1924, for the following reasons: it is indigenous to every nook and corner of the State; it is the first premonitor of coming spring; its fragrance greets us first in the woodland and its delicate flower suggests the pureness of gold; its perpetual return out of the dead winter suggests the lesson of constancy in, loyalty to and patriotism in the service of the State.

> No flower that blooms holds such perfume,
> As kindness and sympathy won.
> Wherever there grows the sheltering pine
> Is clinging a Yellow Jessamine vine.
>
> (From "Legend of the Yellow Jessamine,"
> by Mrs. Teresa Strickland of Anderson, SC)

The "Carolina or Yellow Jessamine" is defined by the New International Encyclopedia as "A climbing plant which grows upon trees and fences and bears a profusion of yellow, funnel-shaped flowers an inch in diameter, with a fragrance similar to that of the true Jasmine." Its odor on a damp evening or morning fills the atmosphere with a rare and delicate sweetness.

Mottoes: Animis opibusque parati (Prepared in mind and resources) — Dum spiro spero (While I breathe, I hope)

State information courtesy of www.imagesoft.net