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Incidence and Impact of Damage and Mortality Trends to South Carolina's Timber, 1986

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ABSTRACT

On South Carolina's 12.2 million acres of timberland, 186 million cubic feet of timber were lost annually to mortality and cull between 1978 and 1986. The estimated annual monetary loss was $97.3 million. Among broad management types – natural pine, planted pine, upland hardwoods, and bottomland hardwoods – the greatest loss occurred in natural pine stands. About three-fourths of the loss occurred in nonindustrial private forests. Fusiform rust caused greatest damage to pines, but shoot- and stem-boring insects, littleleaf disease, pitch canker, and pine bark beetles also caused major losses. A significant increase in mortality of both upland and bottomland hardwoods was attributed to a complex of factors that includes stand dynamics and drought.

Keywords: Insect damage, disease damage, fusiform rust, bark beetles, forest insects, forest diseases.

Foreword

The damage information presented here was gathered during the fifth and sixth inventories of the State's forest resources. More information was gathered in this latest inventory than in previous ones. This information makes it possible to estimate damage incidence and trends in mortality.

The Southeastern Forest Experiment Station, headquartered in Asheville, NC, periodically inventories and evaluates forest resources in Florida, Georgia, North Carolina, South Carolina, and Virginia. The Southern Region, Forest Pest Management Staff unit, headquartered in Atlanta, GA, provides training and field support and helps evaluate the data on forest insects, diseases, and other damaging agents.

Damage incidence and mortality trends are described here, but appropriate measures for preventing damage are not described. Residents of South Carolina requiring technical assistance with forestry problems on State and private land should contact:

State Forester
South Carolina State Commission of Forestry
P.O. Box 21707
Columbia, SC 29221

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During the fifth (1978) and sixth (1986) inventories of South Carolina's forests, field crews noted damage to and mortality of sample trees. Where possible, they identified causes of mortality and damaging agents. This Bulletin reports the damage and mortality observed during the sixth survey and the changes in mortality between the two surveys. It was impossible to compare damage trends between surveys, because new damage categories were added in the sixth survey, but estimates of economic losses associated with damage and mortality are reported.

Inventory Procedures

Inventory procedures are described in detail in a handbook by the USDA Forest Service (1985). Some of those procedures influence the kinds of information about damage that can be compiled and the ways in which some data can be interpreted. The procedures and definitions that affect understanding of the results presented here are provided.

In each inventory, plots are visited only once, and the visit may take place at any time of year. Hence, it is possible to keep records only on agents that produce symptoms or signs in all seasons. On the basis of these "durable" symptoms and signs, damaging agents recognized in the 1986 survey were:

Insects
Hardwood borers
Bark beetles
Terminal shoot & stem borers
Other insects

Diseases
Fusiform rust
Root rots
Littleleaf disease
Hardwood cankers
Branch stubs
Basal defects
Pitch canker
Other diseases

Fire

Animals
Beaver
Sapsucker

Weather
Flooding
Lightning

Other damaging agents
Suppression & stagnation
Damage caused by people
Logging & related
Form (damaging)
Dieback

Symptoms and signs associated with each category are described in the Definitions section of this Bulletin.

Before the field survey, qualified people from Region 8, State & Private Forestry, Forest Pest Management, trained the field crews in the use of a damage identification handbook that was used throughout the survey. During the survey, data collected by field crews were field checked to ensure accuracy and consistency. Crew members also received specimen kits and forms to help them identify types of damage. It should be realized, however, that the data reported here were gathered by people trained and experienced in forest inventory rather than by entomologists and pathologists.

Limitations were created by the requirements that damaging agents or damage had to be easily identifiable, present throughout the year, and present on trees at least 1 inch in diameter at breast height (d.b.h). Effects of seedling diseases like brown-spot needle blight of longleaf pine and effects of hardwood defoliation (which is not apparent in winter) cannot be included in this report.

There are three reasons why values presented here understate the incidence and impact of damage to South Carolina's timber. First, as just explained, certain types of damage, such as that caused by hardwood defoliators, had to be excluded. Second, the damage caused by some agents, such as root decay organisms, is extremely difficult to identify. Third, some damaging agents cause trees to die rapidly and persons conducting the inventory cannot determine the cause of death. As a result, mortality estimates are accurate but the amounts of mortality attributable to specific agents are underestimated.

In spite of these problems, data reported here are important. They show that losses are significant, and they should help managers to plan protection programs.

Sampling Procedures

The inventory employs a sampling procedure designed to provide reliable statistics primarily for the whole State, for large groups of counties, and for species with relatively

large total volumes in the State. Accordingly, errors associated with relatively minor species like cottonwood exceed those for such major species like loblolly pine. Procedures are documented in "South Carolina's Forests" (Tansey and Hutchins 1988).

Computations

Tree-size categories were: saplings, 1.0 to 5.0 inches d.b.h.; softwood poles, 5.0 to 9.0 inches d.b.h.; hardwood poles, 5.0 to 11.0 inches d.b.h.; softwood sawtimber, 9.0 inches d.b.h. and above; and hardwood sawtimber, 11.0 inches d.b.h. and above.

Volume measurements of standing and felled trees in South Carolina and similar measurements of other trees throughout the Southeast were used to derive volume prediction equations. These equations were used to compute merchantable and total cubic volume.

The symptoms used to identify the cause of damage to living trees on the sampled plots are listed in "Definitions." The percentage of incidence and the volume of cull associated with each damage class were determined for each species. Damage entries do not imply total tree loss. Only a part of the volume lost due to cull would fail to qualify for some commercial use, such as firewood. The volume loss was determined by totaling the volume of cull associated with each damaging agent, by species.

Although mortality of individual trees often could not be attributed to a specific agent, the volume loss to mortality was determined accurately for each tree species on each plot. By using total mortality by tree species, it was possible to calculate total volume loss for poles and sawtimber by species.

To estimate the value of the loss, an average age of harvest was estimated from Forest Inventory and Analysis (FIA) "removal" data by age, ownership, and species category. For each age class and type of loss, FIA data on volume of loss in thousand cubic feet were converted to volumes per acre and "grown" to this assumed rotation age using growth factors contained in "The South's Fourth Forest: Alternatives for the Future" (USDA Forest Service 1988). Such a process treats each age class as a group of acres in that class. Mortality is incorporated into the specific age class, species, and ownership growth factor employed. Because estimates cover large areas, they are not site specific. It is assumed that overestimates of volume due to slow growth of trees in fully stocked stands are canceled out by underestimates of volume in trees of a particular age class in understocked stands.

If the age class for volume loss was greater than the assumed rotation age, no growth was calculated; we assumed that the damaged trees could be harvested immediately. The resulting future harvest volumes were converted to thousand board feet and cords with divisor factors of 200 cubic feet per thousand board feet and 90 cubic feet per cord. Average statewide stumpage prices for the species and year of FIA survey were taken from Timber Mart-South (Norris 1986) and were increased from the year of the survey to 2030 by the real rates of increase for hardwood and softwood stumpage estimated in "The South's Fourth Forest: Alternatives for the Future." No further real increase in stumpage was assumed to occur after 2030. The resulting future stumpage values were multiplied by the estimated harvest volumes at rotation age. All owners except forest industry were assumed to have a sawtimber product at rotation. For industry, a proportion of the volume less than 25 years old was calculated as a cordwood product. Each age class future value was discounted to the present at a 4-percent real rate of interest and a time factor that was equal to the difference between the assumed rotation age and the age class. We did not assume that there would be a market available for all the lost timber. The analysis was restricted to exclude affected timber on steep slopes where cost of logging may be prohibitive. Thus, expected volume loss is understated in all categories because of the location restriction. We considered timber to have value only in areas where logging is economically feasible. Furthermore, we ignored the possibility of ingrowth that would result from trees dying and we ignored the possibility that mortality would increase the growth rate of residual stems. At least in the case of southern pine beetles, the procedure seems reasonable. In studies conducted by Burkhart and others (1989), growth of stems remaining alive after southern pine beetle attacks was insignificant when the number of trees lost was low.

Volumes and present values for mortality and cull loss are for the entire period between measurements. For South Carolina, this time was 8.3 years. The volume and loss data were converted to an annual basis by dividing volume by 8.3 and by calculating the annuity amount for the present value of the loss over the 8.3 years, respectively. Mortality can be assumed to have occurred between surveys; however, cull loss is a cumulative volume in many

cases and incremental loss between survey periods cannot be estimated until two survey periods are compared. Data exhibited in the accompanying graphs are calculated annual averages.

Nature of Results

The survey results are presented in detailed tables that report mortality and cull by broad management class, ownership class, tree species, and damaging agent. Interpreting some of the numbers presented in the detailed tables requires information on forest acreage by broad management class and forest type. Table 1 provides those acreages for 1978 and 1986. Figures 1-5 show the geographic distribution of broad management classes across the State.

In 1986, South Carolina had 12.2 million acres of timberland—3 percent less than in 1978. Between surveys, the area of planted pine increased from 1.4 to 2 million acres, while the area of natural pine decreased from 4.2 to 3.4 million acres. Oak-pine and upland hardwood acreages each decreased by about 10 percent, while bottomland hardwood acreage increased by 13 percent. These changes must be considered when damage totals in the two surveys are compared.

Table 2 shows the percentage of trees damaged and volume of associated cull, by broad management class and tree size. In individual management classes, the proportion of saplings with damage ranged from 14 to 19 percent. As one might expect, the proportion of trees with damage increased with tree size, ranging from 21 to 25 percent for poletimber and from 23 to 32 percent for sawtimber trees. Incidence of cull was highest in bottomland hardwoods; fire may be the largest cause for that damage.

Table 3 shows the percentage of trees damaged and the associated cull damage in each broad management class, by tree species and type of damage. A type of damage was entered in the table only if at least 3 percent of the trees in one of the size classes displayed that type of damage. Form damage, suppression, and stagnation were excluded from table 3 because they occur very often but may not be indicators of a serious problem. In a dense stand, some suppression of overtopped trees must be expected.

Fusiform rust was the most serious damaging agent in plantations and natural stands of loblolly and slash pine and in oak-pine stands (fig. 6). Terminal shoot and stem borers also caused significant damage, particularly to shortleaf but also to loblolly pine. Littleleaf disease was found on about 4 percent of shortleaf pine poletimber and sawtimber trees. Pitch canker was present on 5 percent of the sawtimber-size pines in oak-pine stands. Where it occurred, weather damage was quite severe on slash pine in all types.

For hardwoods, the most common damage was basal defect. Most of these defects probably were caused by injuries from fire or logging. Borers and dieback also caused considerable damage to South Carolina's hardwoods.

Table 4 presents the thousands of trees, thousands of cubic feet, and volume of associated cull, by broad management class, host species, and type of damage.

Table 5 shows mortality and annual harvest, by broad management type and species for 1978 and 1986. There was an overall increase in mortality between surveys, even after changes in forest acreage were taken into account. The acreage in natural pine stands decreased markedly. Despite that decrease, there was a 30-percent increase in loblolly pine mortality between surveys. There was also an increase in pine mortality in planted stands, but that increase is no larger than would be expected when the major increase in plantation acreage is taken into account.

Among bottomland hardwoods, mortality of blackgum, elm, red maple, and sweetgum poletimber and sawtimber increased significantly. The threefold increase in sweetgum sawtimber mortality between surveys may reflect a resurgence of sweetgum blight.

A complex of factors, including drought, probably explains the general increase in mortality for a large number of species.

Economic Losses

From 1978 to 1986 the average annual loss to cull and mortality was 185.9 million cubic feet of timber. The estimated value of the loss was $97.3 million per year. Averaged over the State's 12.2 million acres of timberland, the loss was a little under $8 per acre per year.

About 75 percent of the volume and value losses occurred on nonindustrial private forests (fig. 7). The next greatest losses occurred on forest industry land. Among the broad

management classes, losses were greatest in natural pine stands. Natural pine stands cover about 31 percent of the State's timberland, but 51 percent of the value loss was in these stands. Bottomland hardwoods accounted for 30 percent of the volume loss but for only 18 percent of the value loss. Other management classes accounted for relatively small percentages of the volume and value losses (fig. 8).

Figures 9-12 stratify losses by management class and ownership category. Natural pine had the greatest percentage of losses across all ownership categories. On forest industry land, however, bottomland hardwoods and pine plantations also had significant losses.

Table 6 shows average annual losses of volume and value, by ownership and broad management class. About $72.8 million was lost annually in nonindustrial private forests, and $49.1 million was lost in natural pine stands.

Definitions

Damaging Agents and Their Symptoms

Hardwood borers. All hardwoods. The initial symptom is a dark sap spot on the bark surface (often mixed with frass). Eventually, coarse boring particles appear in bark cracks and crevices beneath the point of attack. Old damage appears as knobby overgrowths or scars on the bark surface.

Bark beetles. All pines. Cream to yellow and pinkish globs of resin resembling popped corn on bark surface. If the infestation is well established and some trees still retain their foliage, tunnels or egg galleries are evident on the inner-bark surface and on the sapwood surface. Streaks caused by blue stain fungi are often evident on sapwood. Foliage gradually yellows, then reddens.

Terminal shoot and stem borers. All species. Fresh attacks show boring dust and frass at the entrance holes, located most often at the base of leaf petioles and buds. White to pinkish globs of resin may appear at attack points. Attacks lead to terminal or branch dieback. Shoots turn yellow, then red, and finally brown needle color.

Other insects. All tree species. All damage caused by insects not identified in separate categories. Includes hardwood defoliators (e.g., variable oak leaf caterpillars) and pine defoliators (e.g., redheaded pine sawfly and pine weevils).

Fusiform rust. Slash, loblolly, pitch, pond, and shortleaf pines. These rusts typically cause the formation of spindle-shaped galls on the stem or branches; many older galls appear as cankers with sunken rotten centers encircled by a callus ridge. Witches'-broom is common at galls. The fungus fruit in the spring, producing bright-orange spores. For reporting purposes, consider all stem cankers but only those branch cankers occurring within 12 inches of the bole.

Root rots. All species. Look for groups of dead or windthrown trees—trees with tufted, thin crown which may be yellowing. Conks (fruiting bodies) of various fungi may be present on or near the base of diseased trees. Disease is more frequent in trees of reduced vigor, in thinned stands, and in trees with butt or root injury. Bark beetles often attack the weakened trees.

Littleleaf disease. Shortleaf and loblolly pines; shortleaf is more susceptible. Affected trees occur in groups. Typically seen are yellow needles, reduced shoot growth, and large crops of undersized cones. This disease usually occurs where heavy soils having poor internal drainage dominate the site.

Hardwood cankers. All hardwoods. Affected trees have dead sunken areas on the stem, frequently with annual callus ridges around the dead areas.

Branch stubs. All species. Branch holes or stubs greater than 4 inches in diameter on the stem (trees 5.0 inches d.b.h. and larger). Branch holes or stubs greater than 1 inch in diameter on stem (trees 1.0 and 4.9 inches d.b.h.).

Basal defects. All species. Butt swelling, curls, V-shaped stump sprouts, frost seams, and low stubs below d.b.h. are symptoms of basal defect. Conks of decay fungi are often associated with defect.

Pitch canker. Virginia, slash, shortleaf, longleaf, loblolly, eastern white, Scotch, Table Mountain, and pitch pines (primarily slash, loblolly, and shortleaf). Flagging at ends of branches, pitch flow from affected area, slight swelling on affected stems and twigs; commonly there are crooks in main stems and wilting of new shoots. In early stages, there is a slight bark depression.

Other diseases. All species. All damage caused by diseases not separately identified is entered here. Examples are red heart of pine, brown spot, and leaf diseases.

Fire. All species. Fire scars are usually at base of stem; widespread occurrence in stand. Usually on uphill side on slopes. Signs of charring are generally present on the stem.

Animal. All tree species. Branches clipped off or broken, the bark removed, holes in stem, tears and toothmarks in the wood are all common animal activity symptoms.

Beaver. All species. Beavers leave toothmarks and remove bark from the bole of the tree. Trees are often flooded by water impoundment.

Sapsucker. All species. Look for horizontal rows of small holes that may encircle the tree's bole. The bark below the hole is usually streaked or stained by oozing sap.

Weather. All species. Windthrow, ice, frost crack (above d.b.h. for report), broken top, broken branches, marginal leaf burn, and winter burn are the common symptoms.

Flooding. All species. Yellowing and/or curling downward of leaves, premature leaf-fall, branch and top dieback, tree mortality, and high water and silt marks on tree boles are the most common flooding effects.

Lightning. All species. Lightning causes bark stripping or cracks with damage running from strike point to ground, spirally or straight. Tops fading from root damage or top breakage. Bark beetles often invading struck trees.

Suppression and stagnation. All species. Suppressed and stagnated trees are characterized by poor form. Small crown-suppressed trees are overtopped and receive indirect sunlight. Stagnated trees have thin foliage and receive some direct sunlight. Stagnation is usually associated with poor growing sites or overstocked stands.

Damage caused by people. All species. Initials in bark, nails in tree, lantern burn, bark stripped, callused roots, wire around stem, and ax marks are examples.

Logging and related. All species. Logging scars on stem have callus ridges within 1 to 2 years after wounding. They are scattered in the stand and show no charring. Limb breakage and/or stem scar near crown caused by felling of other trees. Look for skid trails, stumps, etc.

Form (damaging). All species. All trees with form damage that cannot be classified in one of the other categories.

Dieback. All hardwoods. Tips of branches dead. Just a few branches are affected at first, but whole branches die in advanced stages. Tree death may occur.

Forest Inventory Terms

Acceptable trees. Growing-stock trees of commercial species that meet specified standards of size and quality, but not qualifying as desirable trees.

Accumulated volume loss. Percentage of trees affected times the percent cull times the volume for the species.

Associated cull. Percentage of affected trees containing cull associated with the indicated damaging agent.

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 as square feet of basal area per acre.

Commercial species. Tree species presently or prospectively suitable for industrial wood products.

Desirable trees. Growing-stock trees of commercial species having no serious defects in quality limiting present or prospective use for timber products, of relatively high vigor, and containing no pathogens that may result in death or serious deterioration before rotation age.

Diameter class. A classification of trees based on diameter outside bark, measured at breast height (4 1/2 feet above the ground). Two-inch diameter classes are commonly used by FIA, with even inches the approximate midpoints for classes. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Growing-stock trees. Live trees of commercial species qualifying as desirable or acceptable trees.

Incidence. Percentage of susceptible trees affected by the agent.

Poletimber trees. Growing-stock trees of commercial species at least 5.0 inches d.b.h. but smaller than sawtimber size.

Saplings. Live trees 1.0 to 5.0 inches in diameter at breast height.

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

Sawtimber trees. Live trees of commercial species containing at least a 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, and with at least one-third of the gross board-foot volume between the 1-foot stump and minimum saw log being sound. Softwoods must be at least 9.0 inches and hardwoods at least 11.0 inches in diameter at breast height.

Sawtimber volume. Net volume of the saw-log portion of live sawtimber in board-foot based on the International 1/4-inch rule.

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

Pines. Yellow pine species which include loblolly, longleaf, slash, shortleaf, pitch, Virginia, Table Mountain, sand, spruce pine, and pond pine.

Other softwoods. White pine, hemlock, cypress, eastern redcedar, whitecedar, spruce, and fir.

Stand-size class. A classification of forest land based on the size class of growing-stock trees on the area.

Sawtimber stands. Stands at least 16.7 percent stocked with growing-stock trees, with half or more of total stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Poletimber stands. Stands at least 16.7 percent stocked with growing-stock trees, with half or more of this stocking in poletimber and sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

Sapling-seedling stands. Stands at least 16.7 percent stocked with growing-stock trees, of which more than half of the stocking is saplings and seedlings.

Timberland. Forest land producing or capable of producing crops of industrial wood and not withdrawn from timber utilization.

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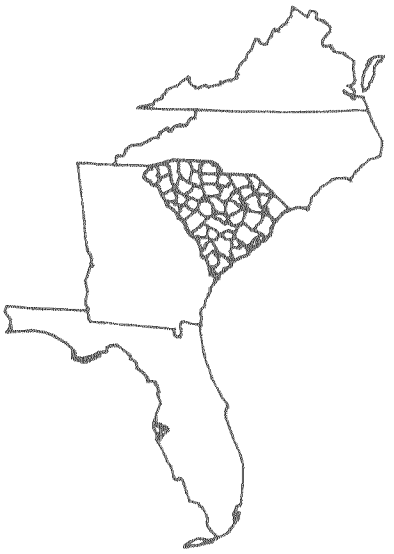

Figure 1 – Distribution of planted pine plots in South Carolina, 1986.

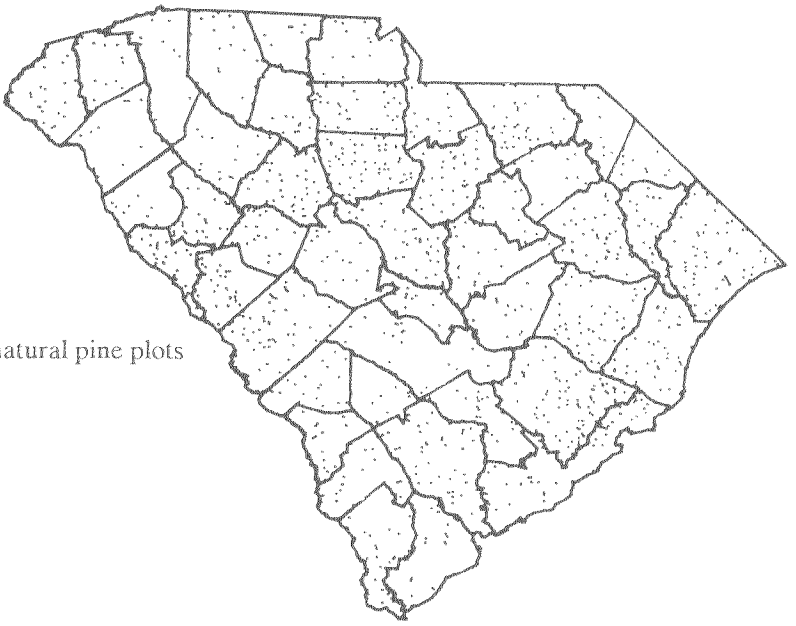

Figure 2 – Distribution of natural pine plots in South Carolina, 1986.

Figure 3 – Distribution of oak-pine plots in South Carolina, 1986.

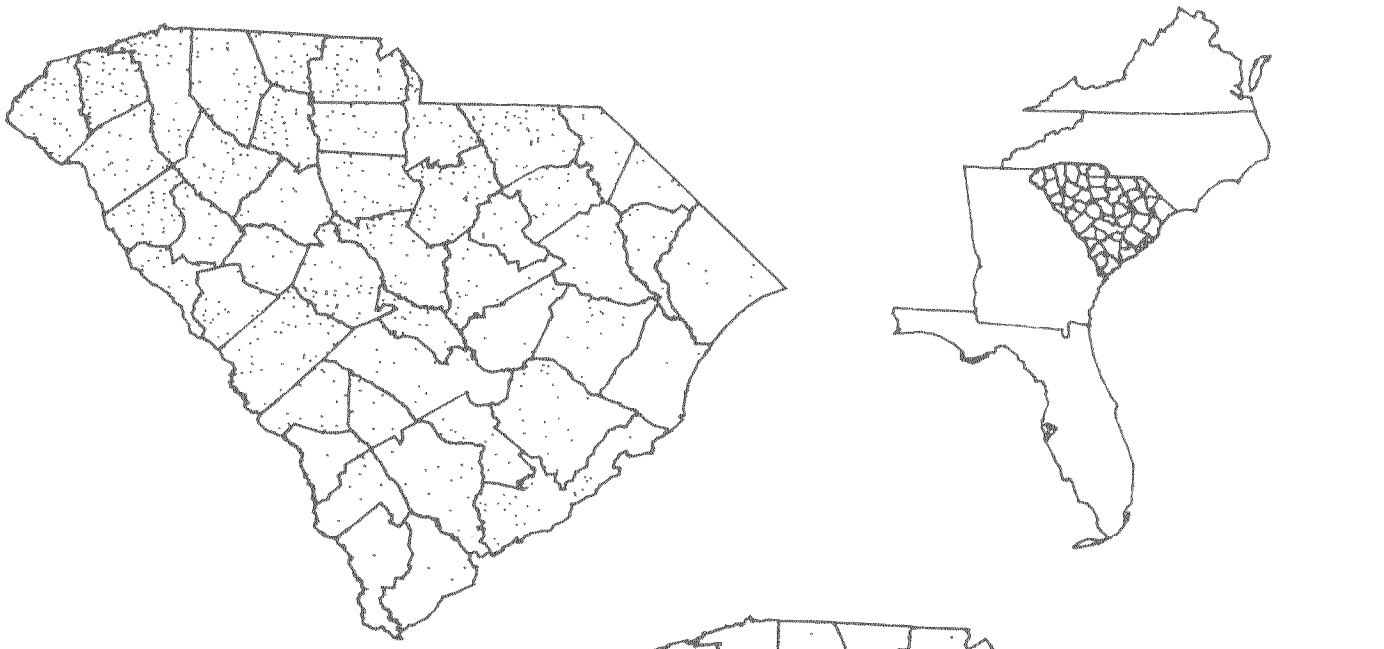

Figure 4—Distribution of upland hardwood in South Carolina, 1986.

Figure 5—Distribution of bottomland hardwoods in South Carolina, 1986.

Figure 6—Distribution of plots with 10 percent or greater fusiform rust in South Carolina, 1986.

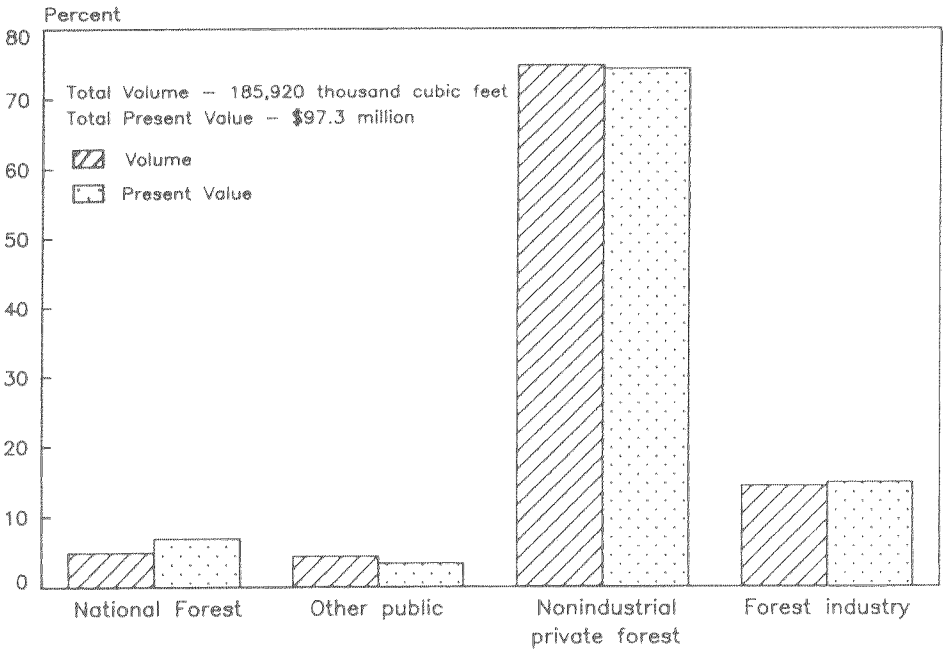

Figure 7—Percentage of total affected volume and present value of loss, by ownership, South Carolina, 1978-1986.

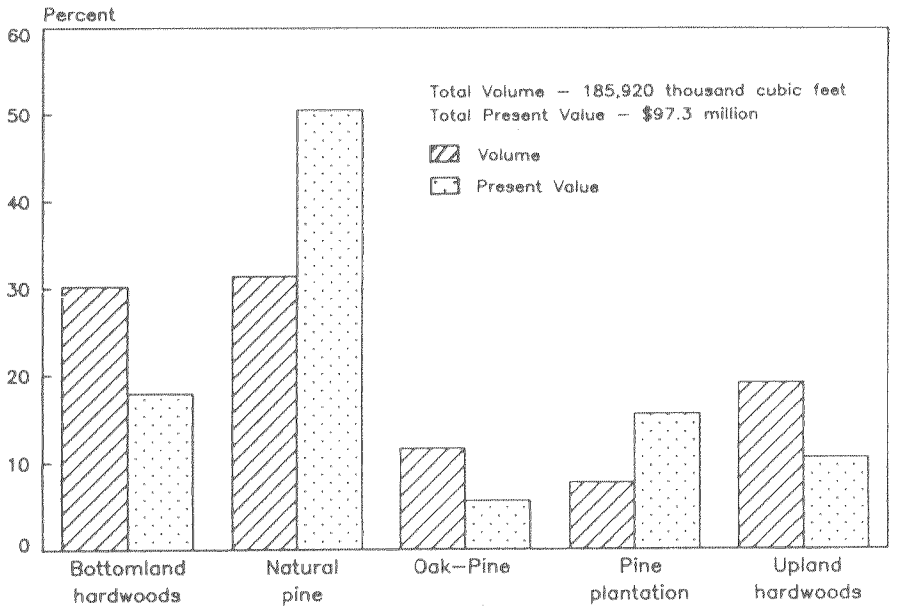

Figure 8—Percentage of total annual affected volume and present value of loss, by species, South Carolina, 1978-1986.

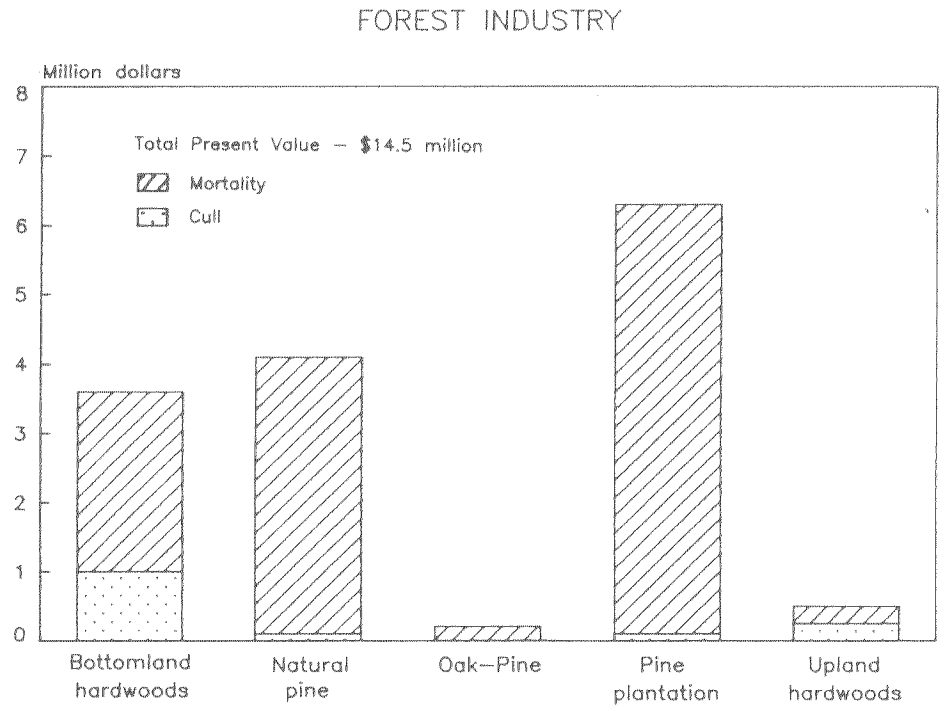

Figure 9—Present value of estimated average annual loss due to insect and disease, South Carolina, 1978-1986.

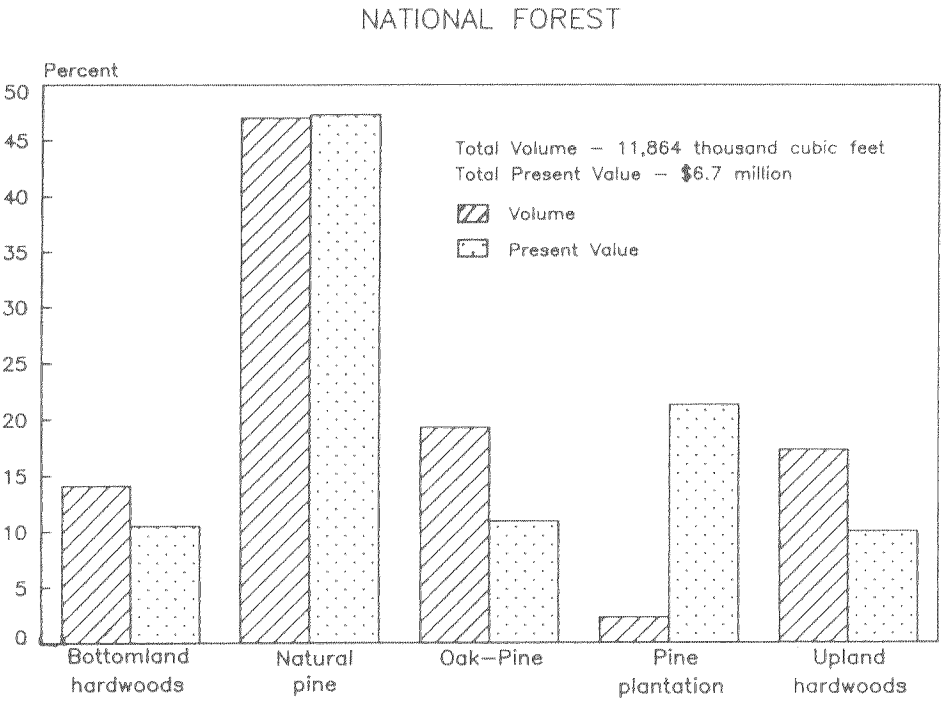

Figure 10—Percentage of annual affected volume and present value of loss, by ownership, South Carolina, 1978-1986.

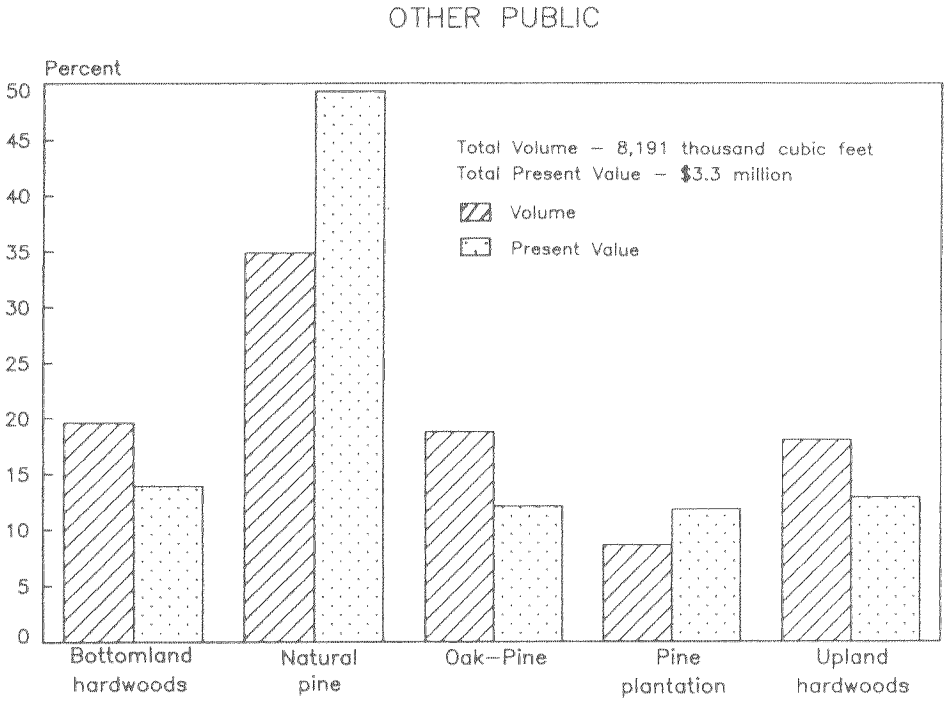

Figure 11 – Percentage of annual affected volume and present value of loss, by ownership, South Carolina, 1978-1986.

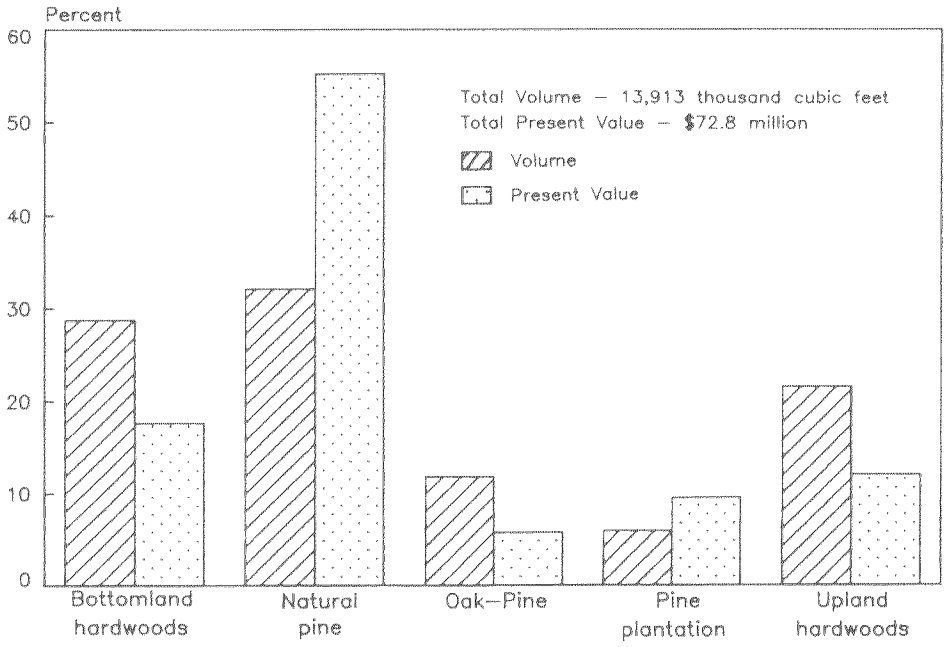

Figure 12 – Percentage of annual affected volume and present value of loss, by ownership, South Carolina, 1978-1986.

Table 1--Distribution of timberland, by broad management class and forest type, South Carolina, 1978 and 1986

Broad management class and forest type	1986	1978
	Acres	Acres
Planted pine		
Loblolly	1,635,752	867,514
Longleaf	51,326	61,131
Shortleaf	6,044	0
Slash	304,579	424,130
Virginia	4,116	0
Eastern white	2,951	8,742
Other planted pine	4,815	0
All planted pine	2,009,583	1,361,517
Natural pine		
Loblolly	2,234,714	2,536,204
Longleaf	345,145	409,981
Shortleaf	361,193	655,877
Slash	68,504	88,007
Pitch	7,942	4,633
Spruce pine	2,195	7,735
Pond	196,335	301,549
Virginia	187,143	178,021
White pine-hemlock	7,734	4,632
Redcedar	16,616	22,764
All natural pine	3,427,521	4,209,403
Oak-pine		
All oak-pine	1,543,693	1,718,544
Upland hardwoods		
Oak-hickory	2,432,922	2,694,392
Chestnut oak	15,157	4,405
Southern scrub oak	196,159	246,457
All upland hardwoods	2,644,238	2,945,254
Bottomland hardwoods		
Oak-gum-cypress	2,298,116	1,990,754
Elm-ash-cottonwood	252,810	277,434
Palm	2,795	0
All bottomland hardwoods	2,553,721	2,268,188
Total	12,178,756	12,502,906

Table 2--Percentage of susceptible all-live trees damaged and volume of associated cull, by broad management class and tree size, South Carolina, 1978 and 1986

Management class	Total population		Trees damaged			Volume of associated cull	
	1986	1978	Saplings 1986	Poletimber 1986	Sawtimber 1986	Poletimber 1986	Sawtimber 1986
	Thousands of trees		Percent			Thousand cubic feet	
Planted pine	1,148,364	805,363	14	24	32	444	2,208
Natural pine	2,444,103	3,384,078	16	21	23	3,302	12,434
Oak-pine	1,104,081	1,432,757	17	25	27	3,085	17,499
Upland hardwood	1,760,073	2,183,900	19	25	27	9,600	50,152
Bottomland hardwood	1,921,897	1,980,109	15	25	30	20,562	181,281
Total	8,378,518	9,786,207	16	24	27	36,993	263,574

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Planted pine			
Loblolly			
Terminal shoot & stem borers	3	0	0
Fusiform rust	11	18	23
Longleaf			
Fusiform rust	2	18	22
Weather	3	2	1
Logging & related	3	1	2
Shortleaf			
Other insects	0	0	5
Other diseases	0	8	0
Weather	9	0	0
Logging & related	0	12	7
Slash			
Fusiform rust	15	34	34
Weather	1	3	3
Total softwoods			
Terminal shoot & stem borers	3	0	0
Fusiform rust	10	21	25
Total hardwoods			
Basal defects	0	0	27
Fire	3	6	0
Weather	1	0	10
Logging & related	1	1	10
Natural pine			
Loblolly			
Fusiform rust	9	14	15
Weather	2	2	2
Logging & related	2	2	3
Longleaf			
Fusiform rust	0	2	2
Fire	1	2	2
Sapsucker	0	0	3
Weather	4	2	2
Logging & related	3	4	5

Continued

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986--Continued

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Shortleaf			
Littleleaf disease	1	4	4
Weather	2	1	1
Slash			
Bark beetles	0	0	2
Fusiform rust	13	17	16
Fire	5	0	1
Weather	10	2	1
Logging & related	4	0	2
Pond			
Gall rust	4	12	19
Fire	5	2	1
Weather	1	3	1
Total softwoods			
Gall rust	6	9	11
Logging & related	2	2	3
Total hardwoods			
Basal defects	1	2	8
Fire	2	3	1
Sapsucker	0	1	5
Weather	3	4	4
Logging & related	2	3	2
Oak-pine			
Loblolly			
Fusiform rust	12	14	12
Sapsucker	0	0	4
Weather	2	4	1
Logging & related	2	6	4
Slash			
Fusiform rust	17	20	22
Pitch canker	0	0	5
Weather	0	0	8
Logging & related	0	0	3

Continued

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986--Continued

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Shortleaf			
Terminal shoot & stem borers	5	0	0
Weather	4	3	1
Logging & related	0	7	4
Longleaf			
Fusiform rust	2	5	0
Fire	0	3	2
Sapsucker	0	0	11
Total softwoods			
Rusts	7	9	8
Sapsucker	0	0	4
Weather	3	4	1
Logging & related	2	5	4
Total hardwoods			
Hardwood borers	2	4	4
Basal defects	0	2	10
Dieback	1	2	2
Weather	2	4	4
Logging & related	3	5	2
Upland hardwoods			
Maple			
Hardwood borers	14	8	5
Other diseases	0	3	0
Hardwood cankers	0	0	4
Basal defects	0	7	12
Sapsucker	0	2	5
Weather	3	5	7
Logging & related	6	5	2
Sweetgum			
Basal defects	0	2	5
Dieback	0	2	3
Weather	4	5	5
Logging & related	8	7	1
Red oaks			
Hardwood borers	2	6	4
Basal defects	0	1	7

Continued

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986--Continued

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Weather	2	3	4
Logging & related	3	3	1
White oaks			
Hardwood borers	2	5	2
Basal defects	0	1	6
Sapsucker	0	1	3
Weather	3	4	3
Logging & related	2	3	2
Hickory			
Hardwood borers	3	1	0
Terminal shoot & stem borers	23	13	2
Basal defects	0	1	7
Sapsucker	0	7	9
Weather	5	4	4
Logging & related	5	3	0
Yellow-poplar			
Hardwood borers	2	1	9
Basal defects	0	2	5
Weather	2	5	5
Logging & related	2	2	1
Total softwoods			
Other diseases	1	2	2
Rusts	2	5	4
Sapsucker	0	0	8
Weather	3	3	3
Logging & related	5	5	3
Total hardwoods			
Hardwood borers	3	3	4
Basal defects	0	2	7
Weather	3	5	4
Logging & related	5	4	1
Bottomland hardwoods			
Water tupelo			
Basal defects	0	2	12
Weather	4	3	6

Continued

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986--Continued

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Blackgum			
Branch stubs	0	0	3
Basal defects	0	7	15
Dieback	1	4	3
Weather	2	3	5
Logging & related	4	2	7
Cypress			
Basal defects	1	4	7
Fire	2	4	0
Red oaks			
Hardwood borers	4	4	6
Basal defects	0	2	8
Dieback	1	2	3
Weather	2	4	4
Logging & related	4	3	6
White oaks			
Hardwood borers	0	4	2
Other diseases	0	3	2
Dieback	2	5	12
Sapsucker	0	0	8
Weather	1	5	4
Logging & related	4	1	1
Ash			
Branch stubs	0	0	6
Basal defects	0	5	11
Dieback	0	4	3
Sapsucker	0	3	9
Weather	2	5	16
Logging & related	1	3	3
Sweetgum			
Other insects	1	2	2
Basal defects	0	2	6
Dieback	1	3	4
Sapsucker	0	0	3
Weather	3	4	9
Logging & related	4	6	11

Continued

Table 3--Incidence of damage, by broad management class, host species, and type of damage, South Carolina, 1986--Continued

Broad management class, host species, and damage type	Trees damaged		
	Sapling	Pole	Sawtimber
	Percent		
Maple			
Hardwood borers	6	7	6
Other diseases	0	1	3
Branch stubs	0	1	7
Basal defects	0	3	18
Dieback	0	2	5
Weather	3	6	13
Logging & related	3	5	11
Total softwoods			
Gall rust	6	18	8
Fire	1	4	1
Sapsucker	0	0	4
Logging & related	4	6	8
Total hardwoods			
Branch stubs	0	1	3
Basal defects	0	3	11
Dieback	1	2	3
Weather	2	4	7
Logging & related	2	3	6

Table 4--Number of trees, total volume, and cull volume in South Carolina, by broad management class and species, 1986

Broad management class and host species	Number of trees	Total volume	Cull volume	
			Poletimber	Sawtimber
	Thousand	- - - - - Thousand cubic feet - - - - -		
Planted pine				
Loblolly	541,197	1,300,411	46	257
Longleaf	25,461	50,035	72	0
Shortleaf	9,582	11,010	0	0
Slash	86,276	357,663	226	40
Total softwoods	684,712	1,731,061	344	297
Total hardwoods	463,652	49,204	100	1,911
Natural pine				
Loblolly	694,246	3,415,553	76	2,201
Longleaf	64,706	528,409	0	118
Shortleaf	188,841	489,660	21	74
Slash	18,191	102,629	0	16
Pond	50,897	288,125	14	431
Total softwoods	1,184,523	5,137,929	124	3,267
Total hardwoods	1,259,580	713,568	3,178	9,167
Oak-pine				
Loblolly	105,474	591,293	14	888
Slash	3,743	28,095	0	21
Shortleaf	32,851	129,078	0	103
Longleaf	11,412	57,492	0	0
Total softwoods	208,832	974,923	70	2,387
Total hardwoods	895,249	927,243	3,015	15,112
Upland hardwoods				
Maple	147,752	155,323	1,412	4,347
Sweetgum	218,972	484,416	2,368	5,647
Red oaks	228,520	835,046	1,563	9,655
White oaks	145,553	683,399	378	11,231
Hickory	133,823	252,043	404	3,775
Yellow-poplar	52,218	387,047	223	5,717
Total softwoods	123,418	338,309	0	448
Total hardwoods	1,636,655	3,190,168	9,600	49,704

Continued

Table 4--Number of trees, total volume, and cull volume in South Carolina, by broad management class and species, 1986--Continued

Broad management class and host species	Number of trees	Total volume	Cull volume	
			Poletimber	Sawtimber
	Thousand	Thousand cubic feet		
Bottomland hardwoods				
Water tupelo	80,243	563,664	373	30,637
Blackgum	253,816	1,096,755	6,270	47,090
Cypress	55,732	508,626	501	14,141
Red oaks	204,000	943,228	1,537	24,449
White oaks	29,437	208,450	334	4,025
Ash	204,880	300,169	2,020	5,817
Sweetgum	258,024	967,766	3,107	10,744
Maple	338,076	569,117	3,588	26,798
Total softwoods	24,694	239,172	14	258
Total hardwoods	1,897,203	5,896,083	20,548	181,023

Table 5--Annual poletimber and sawtimber removals and mortality, by broad management type and tree species, South Carolina, 1978 and 1986

(In hundred cubic-feet)

Broad management type and species	Removals				Mortality			
	Poletimber		Sawtimber		Poletimber		Sawtimber	
	1986	1978	1986	1978	1986	1978	1986	1978
Planted pine								
Loblolly	216,891	138,435	167,158	19,894	64,773	14,059	21,253	0
Longleaf	2,342	10,094	7,086	6,828	1,030	3,186	1,094	0
Shortleaf	2,941	2,247	9,195	783	1,835	1,363	0	0
Slash	203,486	164,287	109,278	29,610	38,968	40,977	10,640	0
All pines	428,417	315,063	295,425	57,115	106,606	59,585	32,987	0
All hardwoods	10,834	2,251	3,777	1,661	536	5,486	859	1,030
Natural pine								
Loblolly	635,128	510,664	1,629,384	993,194	153,387	157,220	155,423	108,575
Longleaf	77,811	111,362	179,842	238,167	6,105	9,857	11,991	15,168
Pond	80,485	43,344	146,983	139,419	10,993	27,791	17,437	18,343
Shortleaf	161,685	167,990	194,544	146,717	74,566	76,285	31,762	55,045
Slash	23,051	19,437	54,345	11,507	9,395	8,139	11,507	1,476
Virginia	31,720	27,091	36,284	20,882	13,527	11,336	7,968	3,155
Redcedar	7,897	7,332	2,498	955	7,375	5,347	1,303	5,075
Black cherry	4,200	396	0	0	622	2,357	0	0
Blackgum (bottomland)	5,845	5,614	3,666	8,034	1,381	765	1,726	0
Elm	5,365	2,426	2,834	1,183	3,230	0	2,785	580
Red maple	8,450	2,323	3,154	928	3,787	2,061	1,976	661
Sweetgum	44,548	8,843	28,055	17,638	4,842	8,581	0	14,181
Yellow-poplar	3,247	6,761	19,022	947	1,160	2,463	0	1,635
Cherrybark oak	275	1,293	5,568	946	0	1,030	5,547	0
Post oak	1,238	5,413	3,170	2,634	831	853	1,734	0
Northern red oak	2,866	853	1,938	2,285	0	0	0	1,312
Southern red oak	14,104	8,060	6,711	7,629	3,435	4,766	5,065	0
Water oak	30,331	10,662	4,131	4,432	5,882	4,296	0	5,886
White oak	5,964	2,193	2,999	6,130	770	1,519	0	0
Willow oak	9,526	8,629	10,873	3,425	1,558	3,621	0	2,655
Scrub oak	895	1,012	0	0	3,381	1,783	723	410
All pines	1,020,394	895,228	2,257,375	1,563,631	278,140	296,467	238,977	207,471
All hardwoods	152,955	73,633	118,346	68,890	34,800	40,800	21,637	28,419

Continued

Table 5--Annual poletimber and sawtimber removals and mortality, by broad management type and tree species, South Carolina, 1978 and 1986--Continued

(In hundred cubic-feet)

Broad management type and species	Removals				Mortality			
	Poletimber		Sawtimber		Poletimber		Sawtimber	
	1986	1978	1986	1978	1986	1978	1986	1978
Oak-pine								
Loblolly pine	33,190	72,888	242,453	286,189	15,338	19,938	28,336	29,937
Longleaf pine	11,017	3,320	23,089	14,438	802	2,526	1,795	2,926
Pond pine	4,127	8,704	41,654	15,500	3,544	2,571	6,417	2,811
Shortleaf pine	12,554	24,438	29,926	43,910	22,819	26,782	20,198	19,439
Slash pine	4,966	621	6,328	6,968	2,457	16,749	1,682	0
Virginia pine	0	677	4,919	2,642	5,381	3,777	9,446	1,813
Redcedar	2,995	2,399	1,681	1,188	4,019	1,602	866	0
Black cherry	2,655	858	0	0	2,397	1,975	0	0
Blackgum (bottomland)	1,442	10,853	2,721	22,075	1,350	1,498	2,329	2,873
Red maple	3,536	5,167	941	5,509	407	3,204	4,937	2,848
Sweetgum	27,793	36,080	30,136	21,578	4,257	5,972	774	4,547
Willow	0	1,185	0	0	1,203	772	0	4,669
Yellow-poplar	4,833	0	11,340	12,030	0	2,259	2,519	0
Hickory	879	6,564	3,985	5,783	0	0	2,350	382
Black oak	3,935	3,675	0	2,577	3,604	1,739	5,376	0
Post oak	3,889	4,529	2,208	9,349	3,821	0	0	0
Northern red oak	0	0	0	0	0	0	3,139	1,256
Scarlet oak	7,548	0	6,803	974	3,426	957	1,803	1,750
Southern red oak	11,116	3,235	8,915	10,498	5,718	937	1,793	1,134
Water oak	14,349	5,164	2,349	7,661	11,335	7,173	7,515	2,985
White oak	5,299	5,655	8,048	8,404	1,221	0	0	1,433
Willow oak	1,202	3,651	5,174	17,168	1,600	4,056	3,557	2,422
Scrub oak	6,823	1,730	0	755	3,024	1,525	0	0
All pines	69,765	114,803	354,192	389,591	54,360	73,945	68,740	56,926
All hardwoods	109,533	96,311	93,096	142,025	45,091	39,469	38,110	39,005
Upland hardwoods								
Loblolly pine	10,543	35,054	51,194	132,986	3,178	8,177	11,556	10,760
Longleaf pine	3,787	5,827	4,719	18,953	0	776	2,772	4,661
Pond pine	2,253	663	1,455	4,552	0	4,415	2,963	3,269
Shortleaf pine	13,310	19,005	14,026	23,229	11,570	10,430	19,077	4,793

Continued

Table 5--Annual poletimber and sawtimber removals and mortality, by broad management type and tree species, South Carolina, 1978 and 1986--Continued

(In hundred cubic-feet)

Broad management type and species	Removals				Mortality			
	Poletimber		Sawtimber		Poletimber		Sawtimber	
	1986	1978	1986	1978	1986	1978	1986	1978
Redcedar	1,644	1,958	0	1,012	672	0	1,801	2,800
Eastern white pine	0	0	0	1,917	0	0	2,669	0
Black cherry	4,468	2,687	0	0	3,634	1,076	0	0
Blackgum	3,150	5,384	10,786	4,423	0	478	2,496	5,949
Elm	3,554	4,199	819	7,213	3,666	4,044	6,901	5,787
Red maple	7,461	4,611	10,766	7,923	8,050	7,199	3,435	8,205
Sweetgum	40,245	42,549	72,205	47,335	12,461	9,401	15,633	16,435
Sycamore	0	0	2,891	1,096	1,582	0	0	1,540
Willow	0	406	0	644	1,560	3,301	1,384	0
Yellow-poplar	6,487	11,256	43,464	44,740	9,249	3,462	6,825	2,239
Ash	2,428	3,262	2,716	2,646	3,294	1,087	0	921
Beech	0	1,943	0	14,642	0	0	4,669	0
Birch (except yellow)	1,472	722	4,450	551	1,557	498	976	1,340
Black locust	1,059	0	0	0	1,711	649	1,430	0
Black walnut	2,645	0	0	0	1,503	0	0	0
Dogwood	1,735	401	0	0	2,193	645	0	0
Hickory	17,541	12,354	20,550	23,889	2,423	1,665	8,865	3,117
Persimmon	0	1,821	1,697	0	2,712	0	0	0
Black oak	7,702	3,840	6,062	15,473	2,983	4,304	7,382	5,659
Chestnut oak	1,378	5,293	2,530	12,481	0	900	1,447	2,004
Laurel oak	3,123	11,229	6,581	5,802	1,100	5,686	4,193	2,310
Post oak	8,487	5,231	8,524	11,178	3,787	4,843	8,471	5,848
Northern red oak	14,437	7,015	9,669	12,002	5,568	2,736	3,469	0
Scarlet oak	15,006	5,929	18,309	24,531	12,533	1,892	8,351	2,279
Southern red oak	27,570	17,028	24,951	14,602	17,185	7,722	6,888	3,132
Water oak	25,871	28,510	32,022	26,933	12,981	11,927	24,005	13,873
White oak	30,033	29,784	41,918	59,814	4,623	4,744	9,785	3,984
Willow oak	17,293	14,016	20,631	29,539	6,164	4,626	3,374	4,315
Scrub oak	3,691	3,741	1,259	0	3,539	2,589	0	0
All pines	31,537	63,275	72,121	191,459	15,420	28,686	41,635	26,283
All hardwoods	261,219	238,861	360,922	401,598	139,569	95,683	137,029	96,326

Continued

Table 5--Annual poletimber and sawtimber removals and mortality, by broad management type and tree species, South Carolina, 1978 and 1986--Continued

(In hundred cubic-feet)

Broad management type and species	Removals				Mortality			
	Poletimber		Sawtimber		Poletimber		Sawtimber	
	1986	1978	1986	1978	1986	1978	1986	1978
Bottomland hardwoods								
Loblolly pine	9,026	3,115	65,464	50,456	4,389	9,286	12,815	12,917
Longleaf pine	0	0	0	1,318	0	0	1,670	1,028
Pond pine	0	4,308	2,133	9,913	1,433	0	2,552	0
Slash pine	0	0	1,381	1,664	0	0	1,034	0
Baldcypress	5,589	0	47,176	36,769	2,728	3,971	9,056	1,106
Pondcypress	1,337	432	4,347	3,528	3,444	3,613	3,025	1,236
Blackgum	23,328	21,727	77,073	97,609	24,257	10,041	42,548	26,332
Boxelder	1,714	3,658	754	0	2,706	507	0	0
Cottonwood	2,619	2,361	3,431	4,292	7,859	8,072	19,740	4,399
Elm	8,515	3,114	25,226	14,707	8,861	7,699	17,536	10,582
Hackberry	933	645	7,072	5,692	0	3,767	2,006	6,742
Red maple	37,422	13,408	35,276	31,744	25,711	22,698	45,643	39,811
Sweetgum	64,653	29,734	193,230	87,899	24,631	15,753	48,918	15,540
Sycamore	0	0	8,327	0	764	1,873	1,739	2,195
Water tupelo	8,424	2,519	17,853	14,323	6,867	3,614	8,962	7,895
Willow	0	406	0	594	20,722	7,465	2,402	2,933
Yellow-poplar	7,600	834	37,554	16,244	2,911	6,731	3,639	6,236
Ash	13,260	4,169	45,287	16,577	17,986	21,436	14,885	20,422
Birch	3,291	7,757	12,890	584	4,637	4,067	1,864	7,233
Hickory	1,253	1,554	15,413	12,796	3,467	1,241	7,972	4,155
Persimmon	0	0	0	792	1,642	1,317	0	719
Cherrybark oak	1,666	1,895	4,002	9,655	868	0	3,972	0
Live oak	454	1,502	1,346	0	0	0	3,043	0
Overcup oak	0	0	7,702	13,198	1,810	1,417	6,342	3,143
Swamp chestnut oak	658	705	8,323	5,877	1,138	0	1,014	0
Water oak	23,650	6,248	24,723	14,352	12,708	8,405	22,490	10,225
Willow oak	2,412	4,530	21,749	11,172	8,971	946	4,395	4,783
All pines	17,094	7,855	123,999	118,941	12,837	19,712	30,152	19,304
All hardwoods	215,588	120,526	632,000	424,373	209,999	142,226	326,935	210,240

Table 6--Volume and value of timber damaged or killed annually, by ownership and broad management class, South Carolina, 1978-1986

Ownership and management class	Average annual volume affected	Average annual present value		
		Mortality	Cull	Total
	Thousand cubic feet	- - - - - - - - Dollars - - - - - - - -		
National forest				
Pine planted	269	1,417,666	5,753	1,423,419
Natural pine	5,581	3,129,754	30,044	3,159,798
Oak-pine	2,292	710,593	16,578	727,171
Upland hardwoods	2,049	651,463	16,317	667,780
Bottomland hardwoods	1,673	593,391	106,776	700,166
Total	11,864	6,502,867	175,468	6,678,334
Other public				
Pine planted	701	381,798	6,203	388,002
Natural pine	2,857	1,574,335	43,655	1,617,990
Oak-pine	1,539	31,174	366,710	397,884
Upland hardwoods	1,486	332,543	91,793	424,336
Bottomland hardwood	1,608	431,200	25,425	456,625
Total	8,191	2,751,050	533,786	3,284,837
Nonindustrial private				
Pine planted	8,244	6,618,324	315,096	6,933,420
Natural pine	44,583	39,303,671	888,889	40,192,561
Oak-pine	16,474	3,740,154	409,908	4,150,062
Upland hardwoods	29,957	7,708,980	1,017,894	8,726,874
Bottomland hardwoods	39,874	10,168,495	2,622,283	12,790,779
Total	139,132	67,539,645	5,254,070	72,793,696
Forest industry				
Pine planted	5,185	6,149,490	132,567	6,282,056
Natural pine	5,334	3,972,312	143,389	4,115,701
Oak-pine	1,190	166,808	6,143	172,951
Upland hardwoods	1,989	240,392	166,998	407,390
Bottomland hardwoods	13,035	2,566,067	953,092	3,519,159
Total	26,733	13,095,069	1,402,189	14,497,257
All ownerships				
Pine planted	14,398	14,567,279	459,619	15,026,897
Natural pine	58,355	47,980,072	1,105,978	49,086,050
Oak-pine	21,495	4,648,730	799,338	5,448,068
Upland hardwoods	35,481	8,933,378	1,292,001	10,226,380
Bottomland hardwoods	56,191	13,759,153	3,707,576	17,466,729
Total	185,920	89,888,612	7,364,512	97,254,124

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Incidence and impact of 21 damage types and mortality trends to the forest resources of South Carolina in 1986 are described. Acres affected, volume losses, geographic distribution, and economic impact are discussed. About 186 million cubic feet are lost per year from 1978 to 1986, with an estimated annual dollar loss of $97.3 million.

Keywords: Insect damage, disease damage, fusiform rust, bark beetles, forest insects, forest diseases.

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The Forest Service, U.S. Department of Agriculture, 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.