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Summary Report

Forest Health Monitoring in the South, 1991

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Summary Report

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Abstract

The USDA Forest Service and the U.S. Environmental Protection Agency have launched a joint program to monitor the health of forests in the United States. The program is still in the initial phases of implementation, but several indicators of forest health are undergoing development and permanent plots have been established in 12 States. This report contains an initial summary of data gathered during 1991 in Alabama, Georgia, and Virginia. Simple percentage distributions of crown and damage data from the sample plots do not indicate any unusual or unexplained problems in these three States. About 99 percent of all trees sampled had crown ratings of average or better. A synopsis of supplemental forest pest data in the Southern Region shows that traditional pests continue to cause substantial damage.

Keywords: Forest health monitoring, forest damage assessment, visual crown rating.

Introduction

Forest Health Monitoring (FHM) is a national program jointly sponsored by the USDA Forest Service and the U.S. Environmental Protection Agency. A comprehensive description of the program is available in Palmer and others (1991). Authorized by the Forest Ecosystems and Atmospheric Pollution Research Act of 1988, and the Food, Agriculture, Conservation, and Trade Act of 1990 (Farm Bill), FHM has evolved in response to increasing concerns about the effect of various anthropogenic and natural stressors on forests of the United States.

The primary function of FHM is to gather and maintain an objective data base capable of supporting appraisals of forest health at the regional and national scales. Some of the intended program outputs include the evaluation of potential problems associated with anthropogenic stressors, the interaction of these stressors with natural pathogens, the recognition of developing problems before they reach crisis proportions, and the ability to judge the effectiveness of regulatory programs. FHM is a flexible, broad-based, long-term endeavor designed to accomplish these goals through:

- Identification and development of appropriate indicators of forest health (Hunsaker and Carpenter 1990)
- Establishment of baseline conditions with respect to the selected indicators
- Monitoring of indicators to detect unexpected deviations from established baselines
- Identification of causal relationships in the event of unexpected deviations
- Periodic statistical summaries and interpretive reports on trends in forest health

To address these goals efficiently, FHM is organized into three tiers. Detection monitoring is the first, whereby baselines are established and trends are monitored for unusual events. Detection monitoring is accomplished through a geographically based network of permanent plots coupled with supplemental off-frame ground and aerial surveys of forest pests. The supplemental surveys are termed "off-frame" because they are not directly linked to the network of permanent plots. The second tier, evaluation monitoring, is designed to probe the causal relationships associated with any potential problems uncovered by detection monitoring, to quantify the extent and severity of a problem, and to formulate research hypotheses. If a potential problem still defies explanation, the third tier–intensive research monitoring–is engaged to study the detailed processes associated with any event that triggers an alarm.

FHM field activities began in 1990 with the implementation of detection monitoring in six New England States. In 1991, three mid-Atlantic and three Southern States were added to the Program. The first part of this report summarizes the plot data gathered in the three Southern States–Alabama, Georgia, and Virginia. The second part is a synopsis of forest insect and disease information collected from a variety of off-frame surveys in all Southern States. A similar report has been prepared for the Northeastern States (Eagar and others 1992).

The application of confidence limits to all estimates of indicator status is a critical program goal, but not all statistical details have been finalized at this writing. The numbers reported here represent simple counts and percentages of sample observations. No statements of statistical significance are implied in this summary report. A comprehensive report covering all 12 States, with more rigorous statistical treatment of the data, is now being prepared (U.S. Environmental Protection Agency, in review). The items highlighted in the discussion of the summary data presented here have been judged noteworthy by the authors of this report.

All aspects of FHM are still evolving. At present, three indicators have undergone implementation as part of detection monitoring: forest mensuration/site classification, visual crown rating (VCR), and tree damage evaluation. VCR and damage data are scheduled for collection annually. Forest mensuration/site classification data (stand structure, growth, and mortality) are scheduled for collection on a 4-year cycle. Since only the first year of data are available for the South, this report focuses on baseline conditions existing in 1991. Reports on trends will be issued in future years. The baseline conditions treated here consist primarily of VCR and damage data, since it will take at least one complete 4-year measurement cycle to obtain growth data.

On-Frame Activities

Plot Design

Plot locations are linked to a systematic grid designed to ensure a statistically valid sample of all land categories within a region (Overton and others 1990). Each plot consists of a cluster of four 1/24-acre circular subplots spaced 120 feet apart in triangular formation (Conkling and Byers 1992). Forest plots are installed if any portion of the cluster occurs in forest. It is possible for a plot cluster to straddle more than one land use, so subplots and tally trees are mapped by "condition class." A condition class is defined by five variables: land use (forest, cropland, etc.), forest type, stand origin (planted or natural), stand size (sapling, poletimber, etc.), and past disturbance. Trees 5.0 or more inches in diameter at breast height (d.b.h.) are tallied if they occur within the 24-foot radius defining the perimeter of each subplot. Trees between 1.0 and 4.9 inches d.b.h. are tallied on a 6.8-foot radius (1/300 acre) microplot, which is offset 12 feet from each subplot center.

Tree-Level Variables

Besides condition class, standard mensurational data recorded for all trees 1.0 inch d.b.h. and larger on FHM plots include species, d.b.h., distance and azimuth from subplot or microplot center, and crown class (dominant, codominant, etc.). In addition, several variables associated with the damage and VCR indicators were also recorded. A brief description of the variables linked to these two indicators follows. Further details about all variables associated with the implemented indicators, as well as indicators still in the testing phase, are provided by Conkling and Byers (1992). More background concerning the development of VCR is available in Anderson and Belanger (1987), Belanger and Anderson (1989), Belanger and others (1991), and Millers and others (1991, 1992).

No more than three damages were tallied for trees 5.0 inches d.b.h. or larger, and only the single most severe damage observed for each tree is included in the tabular data presented in this report. In addition to type of damage, the cause of damage and its location on the tree were also noted.

Six variables are included in the VCR system: live crown ratio, crown diameter, crown density, crown dieback, foliage transparency, and crown vigor. Efforts are currently underway to consolidate some or all of these into a single estimate of crown condition. In the absence of a composite estimator, the latter four measurements are presented individually in this report: crown density, foliage transparency, and crown dieback for trees 5.0 inches d.b.h. and larger; and crown vigor for trees between 1.0 and 4.9 inches d.b.h. To aid interpretation, some of the VCR data have been partitioned into discrete categories ranging from "good" to "poor." These thresholds were imposed on the data only to provide general guidelines across all species. As the development of a composite VCR indicator proceeds, it will be necessary to adjust for differences among species, and some of the thresholds may change.

Crown ratio is the percentage of total tree height supporting live green foliage that is effectively contributing to tree growth. It is the ratio of crown length to total tree height.

Crown diameter is an average of two measurements–the width of a tree crown at its widest point, and the width of the crown 90 degrees from its widest point.

Crown density is a measure of the percentage of skylight obstructed by the foliage, seeds, and branches of sampled trees. Dead branches, gaps, and holes in tree crowns result in lower estimates of density. Positive correlations between crown density and diameter growth have been established for several tree species (Belanger and others 1991). In general, a density greater than 50 percent is considered good by the indicator experts; less than 20 percent is poor.

Crown dieback is recent branch mortality in the upper canopy. Starting at the terminal portions of branches, it then spreads toward the trunk. Dead branches in the middle and lower portions of crowns are usually the result of competition and are not counted as dieback. Dieback of less than 5 percent is considered normal; 6-20 percent, light; 21-50 percent, moderate; and greater than 50 percent, severe.

Foliage transparency is the amount of skylight visible through the living portions of tree crowns. It differs from crown density in that density applies to the crown as a whole, whereas transparency is confined to the living, normally foliated portions of tree crowns. Foliage transparency less than 30 percent is normal. Transparency greater than 50 percent is poor, and is indicative of a tree under stress.

Crown vigor applies to seedlings and saplings only. It is the only VCR descriptor collected for trees less than 5.0 inches d.b.h. in 1991. The objective of the vigor rating system is to separate plants in obviously good condition from plants in very poor condition. For a tree to be classified "good," at least one-third of its length must be in foliage; there can be no dieback in the upper half of the crown; and 80 percent of the foliage must be undamaged. A tree with 20 percent or less of its crown in normal foliage is in poor condition. Everything else is considered average.

Results

In all, 602 plots were visited in three Southern States (table 1). Forest plots were installed at 386 locations. Most of the remaining plots were either nonforest, or access was denied by landowners. On the 386 plots that were at least partially forested and accessible,

Table 1--Numbers of plots, forest acres, and trees measured by State, Southern Region, 1991

State	Plots sampled	Forest area[a]	Trees sampled: 1.0-4.9 in. d.b.h.	5.0+ in. d.b.h. understory	5.0+ in. d.b.h. overstory	Total trees
	Number	Acres	Number of stems			
Alabama	208	21.28	898	890	1,747	3,535
Georgia	234	23.05	861	552	2,194	3,607
Virginia	160	15.49	737	883	1,565	3,185
Total	602	15.83	2,496	2,325	5,506	10,327

[a] Forest area is the combined plot area located and measured in an accessible forest land use; i.e., 59.83 acres of forest were sampled in the South.

Note: Data may not add to totals because of rounding.

59.8 acres of forest land were sampled, and field crews measured 10,327 trees. Of the total trees tallied, 2,496 were between 1.0 and 4.9 inches d.b.h. and occurred on the 1/300-acre microplots. The rest were larger than 4.9 inches d.b.h. and tallied on the 1/24-acre subplots. Of the 7,831 trees tallied on subplots, 5,506 were classified as "overstory" (open grown, dominant, or codominant). Overstory trees are highlighted in most of the tabular information that follows because data from their crowns are less likely to be confounded by symptoms of suppression caused by competition for light in the understory.

Table 2 shows the distributions of sampled acreage by forest-type group. These groups correspond to the 10 eastern-type groups recognized by the Society of American Foresters (SAF) (Eyre 1980). SAF-type groups for which only traces were encountered (white/red/jack pine, spruce/fir, maple/beech/birch, and aspen/birch) are combined in the "Other Groups" category. The two southern pine-type groups, longleaf/slash and loblolly/shortleaf, have been further subdivided into local types of regional importance. Numbers of trees sampled across all type groups, by species group, tree size, and crown position are listed in table 3.

Almost 99 percent of all overstory trees 5.0 inches d.b.h. and larger received crown-density ratings of average or better (table 4). Slash (*Pinus elliottii* Engelm.) and Virginia pines (*Pinus virginiana* Mill.) had slightly higher proportions of trees with poor

Table 2--Number of forest acres measured by forest-type group and State, Southern Region, 1991

Forest-type group	Alabama	Georgia	Virginia	All States
	- - - - - - - -	Acres	- - - - - - - -	
Longleaf/slash				
Longleaf pine	0.83	1.08	0.00	1.92
Slash pine (natural)	0.12	1.71	0.00	1.83
Slash pine (planted)	0.00	1.85	0.00	1.85
Loblolly/shortleaf				
Loblolly pine (natural)	1.67	2.99	0.48	5.14
Loblolly pine (planted)	3.35	3.21	1.13	7.68
Shortleaf pine	0.17	0.42	0.02	0.60
Virginia pine	0.54	0.33	0.96	1.83
Other	0.12	0.00	0.21	0.33
Oak/pine	7.08	3.46	1.80	12.33
Oak/hickory	4.63	4.36	9.82	18.82
Oak/gum/cypress	2.20	3.31	0.06	5.57
Elm/ash/red maple	0.29	0.17	0.31	0.77
Other groups	0.27	0.16	0.70	1.13
All groups	21.28	23.05	15.49	59.83

Note: Data may not add to totals because of rounding.

Table 3--Number of trees sampled by selected species group, tree size, and crown position, Southern Region, 1991

Species group	1.0-4.9 in. d.b.h.	5.0+ in. d.b.h. Understory	5.0+ in. d.b.h. Overstory
	- - - - - - Number of stems - - - - - -		
Softwood			
Longleaf pine	9	18	101
Slash pine	33	46	409
Shortleaf pine	24	49	228
Loblolly pine	324	214	1,557
Virginia pine	28	106	346
Other softwoods	40	82	119
All softwoods	458	515	2,760
Hardwood			
White oaks	99	281	550
Red oaks	338	247	651
Maples	266	243	230
Sweetgum	283	207	342
Yellow-poplar	77	86	284
Blackgum	175	161	194
Hickories	117	150	189
Other hardwoods	683	435	306
All hardwoods	2,038	1,810	2,746
All Species	2,496	2,325	5,506

Table 4--Distribution of 5.0-inch d.b.h. and larger overstory trees by selected species group and crown-density class, Southern Region, 1991

Species group	Sample size	Crown-density class: Good (51+%)	Average (21-50%)	Poor (1-20%)
	Number	Percent trees sampled		
Softwood				
Longleaf pine	101	16.8	83.2	0.0
Slash pine	409	7.6	88.8	3.7
Shortleaf pine	228	14.9	84.6	0.4
Loblolly pine	1,557	26.3	73.0	0.8
Virginia pine	346	13.6	83.2	3.2
Other softwoods	119	31.9	66.4	1.7
All softwoods	2,760	20.9	77.6	1.5
Hardwood				
White oaks	550	35.1	64.4	0.6
Red oaks	651	37.0	62.2	0.8
Maples	230	42.2	57.4	0.4
Sweetgum	342	38.0	61.1	0.9
Yellow-poplar	284	52.1	47.9	0.0
Blackgum	194	23.2	75.3	1.6
Hickories	189	45.0	55.0	0.0
Other hardwoods	306	33.7	64.4	2.0
All hardwoods	2,746	37.9	61.3	0.8
All species	5,506	29.4	69.5	1.1

densities, but these proportions are still extremely low. A cross-comparison of crown densities with foliage-transparency ratings (table 5) for these two species shows that the higher proportion of poor density ratings is probably due to normal branching patterns for slash pine. The number of Virginia pines with poor ratings was slightly elevated in both the density and transparency categories.

By broad species group, more than 98 percent of all softwoods and 96 percent of all hardwoods were rated normal with respect to foliage transparency. At 92 percent, Virginia pine is the only softwood species with a noticeable percentage of trees outside the normal range. All hardwood species seem to be faring well, with yellow-poplar (*Liriodendron tulipifera* L.), sweetgum (*Liquidambar styraciflua* L.), blackgum (*Nyssa sylvatica* Marsh.), and hickories rating slightly better than oaks and maples.

Only 2 percent of all softwoods exhibited appreciable amounts of dieback (6 percent or more), compared with 15 percent of the hardwoods (table 6). Oaks and hickories had the highest proportions of dieback among the hardwoods, with red oaks being the most notably affected. Still, nearly all the hardwood dieback was comparatively light, even among the red oaks. Only 2 percent of all sampled hardwoods displayed signs of moderate to severe dieback (21 percent or more).

Almost one-fourth of all softwoods, and half of all hardwoods, exhibited some sign of damage (table 7).

Table 5--Distribution of 5.0-inch d.b.h. and larger overstory trees by selected species group and foliage-transparency class, Southern Region, 1991

Species group	Sample size	Foliage-transparency class Normal (0-30%)	Moderate (31-50%)	Severe (51+%)
	Number	Percent trees sampled		
Softwood				
Longleaf pine	101	99.0	1.0	0.0
Slash pine	409	99.5	0.2	0.2
Shortleaf pine	228	99.1	0.9	0.0
Loblolly pine	1,557	99.1	0.8	0.1
Virginia pine	346	91.9	4.3	3.8
Other softwoods	119	96.6	1.7	1.7
All softwoods	2,760	98.2	1.2	0.6
Hardwood				
White oaks	550	94.2	4.2	1.6
Red oaks	651	94.6	4.3	1.1
Maples	230	93.5	5.6	0.9
Sweetgum	342	100.0	0.0	0.0
Yellow-poplar	284	98.2	1.1	0.7
Blackgum	194	100.0	0.0	0.0
Hickories	189	98.4	1.1	0.5
Other hardwoods	306	94.8	5.2	0.0
All hardwoods	2,746	96.1	3.1	0.8
All species	5,506	97.2	2.2	0.7

Table 6--Distribution of 5.0-inch d.b.h. and larger overstory trees by selected species group and crown-dieback class, Southern Region, 1991

Species group	Sample size	Crown-dieback class None (0-5%)	Light (6-20%)	Moderate (21-50%)	Severe (50+%)
	Number	- - - -	Percent trees sampled		- - - -
Softwood					
Longleaf pine	101	96.0	4.0	0.0	0.0
Slash pine	409	99.0	0.7	0.2	0.0
Shortleaf pine	228	95.2	4.4	0.4	0.0
Loblolly pine	1,557	98.3	1.6	0.1	0.0
Virginia pine	346	94.8	4.9	0.3	0.0
Other softwoods	119	97.5	2.5	0.0	0.0
All softwoods	2,760	97.6	2.2	0.2	0.0
Hardwood					
White oaks	550	84.6	14.2	1.1	0.2
Red oaks	651	77.6	19.2	2.5	0.8
Maples	230	87.8	11.3	0.4	0.4
Sweetgum	342	88.3	9.7	1.8	0.3
Yellow-poplar	284	96.5	3.5	0.0	0.0
Blackgum	194	89.2	9.8	1.0	0.0
Hickories	189	85.2	14.3	0.5	0.0
Other hardwoods	306	83.7	13.7	1.3	1.3
All hardwoods	2,746	85.1	13.1	1.3	0.4
All species	5,506	91.4	7.7	0.7	0.2

Table 7--Distribution of 5.0-inch d.b.h. and larger overstory trees by selected species group and cause of damage, Southern Region, 1991

Species group	Sample size	None visible	Insects	Disease	Fire	Animal	Weather	Suppression	Logging and related	Other	Unknown
	Number	- - - -				Percent trees sampled					- - - -
Softwood											
Longleaf pine	101	80.2	1.0	0.0	1.0	5.0	1.0	1.0	4.0	0.0	6.9
Slash pine	409	81.9	0.5	9.8	0.2	0.0	0.7	0.0	2.9	1.5	2.4
Shortleaf pine	228	76.8	0.4	3.5	0.4	0.0	3.5	0.9	4.0	0.4	10.1
Loblolly pine	1,557	80.2	0.8	7.4	1.3	0.2	2.5	1.0	1.9	1.7	3.2
Virginia pine	346	63.9	0.9	15.9	0.0	0.3	10.7	1.4	1.7	0.3	4.9
Other softwoods	119	69.8	0.8	2.5	0.0	0.8	10.9	2.5	3.4	1.7	7.6
All softwoods	2,760	77.6	0.8	8.0	0.8	0.4	3.7	0.9	2.3	1.3	4.2
Hardwood											
White oaks	550	36.7	18.7	7.3	0.2	0.4	17.3	4.0	4.4	0.0	11.1
Red oaks	651	49.8	6.9	11.2	0.9	1.5	7.5	4.6	6.3	0.3	10.9
Maples	230	49.6	4.4	6.5	0.4	0.4	14.8	4.4	5.2	0.0	14.4
Sweetgum	342	50.6	0.9	1.8	2.9	3.8	8.8	2.0	12.3	0.3	16.7
Yellow-poplar	284	54.6	2.8	2.5	1.1	0.7	17.3	3.5	3.2	0.0	14.4
Blackgum	194	54.1	1.0	2.6	0.0	4.1	6.2	1.6	5.2	0.0	25.3
Hickories	189	49.2	10.1	7.4	1.1	2.1	7.4	4.2	7.9	0.0	10.6
Other hardwoods	306	47.7	4.6	5.2	1.6	2.0	13.1	4.9	7.8	0.7	12.4
All hardwoods	2,746	47.8	7.4	6.4	1.0	1.7	11.8	3.8	6.4	0.2	13.5
All species	5,506	62.8	4.1	7.2	0.9	1.0	7.7	2.4	4.4	0.7	8.8

Virginia pines showed a higher incidence of damage than any other softwood species. Disease and weather account for most of the damage to Virginia pine. White oaks were the most severely affected hardwood species, with insects being the primary causal factor. Across all species, weather and disease caused the greatest damage. Weather damage was spread over several species, while the incidence of disease was particularly high for Virginia pine, red oaks, and slash pine. Diseases with the highest impact on these species were most likely eastern gall rust (*Cronartium quercuum* (Berk.) Miy. ex Shirai), oak decline, and fusiform rust (*Cronartium quercuum* (Berk.) Miy. ex Shirai f. sp. *fusiforme*), respectively. Insects, probably gypsy moth (*Lymantria dispar* L.) and oakworms (*Anisota* spp.), also had a notable impact on white oaks, hickories, and red oaks.

As far as understory saplings are concerned, 90 percent had vigor-class ratings of average or better (table 8). Virginia pine is the only species with a substantial percentage of trees in poor condition. However, the sample size for Virginia pine saplings is relatively small.

Table 8--Distribution of trees 1.0-4.9 inches d.b.h. by selected species group and crown-vigor class, Southern Region, 1991

Species group	Sample size	Crown-vigor class: Good	Average	Poor
	Number	Percent trees sampled		
Softwood				
Longleaf pine	9	55.6	44.4	0.0
Slash pine	33	51.5	42.4	6.1
Shortleaf pine	24	54.2	45.8	0.0
Loblolly pine	324	56.8	32.7	10.5
Virginia pine	28	32.1	46.4	21.4
Other softwoods	40	60.0	30.0	10.0
All softwoods	458	55.0	34.9	10.0
Hardwood				
White oaks	99	41.4	46.5	12.1
Red oaks	338	48.5	44.7	6.8
Maples	266	32.0	56.4	11.6
Sweetgum	283	50.9	40.6	8.5
Yellow-poplar	77	42.9	50.7	6.5
Blackgum	175	29.1	61.1	9.7
Hickories	117	23.1	65.8	11.1
Other hardwoods	683	36.0	54.0	10.0
All hardwoods	2,038	33.8	51.7	9.5
All species	2,496	41.8	48.6	9.6

Discussion

Of all trees sampled, 99 percent had crown-density ratings of average or better, 99 percent had transparency ratings of average or better, and 99 percent had dieback ranging from none to light (0 to 20 percent). The vast majority of all tree crowns sampled appear to be normal. On the other hand, damage was recorded for a considerable number of trees–37 percent. Since trend data are not available, it is not known whether this amount of damage is unusual or beyond the range considered normal. Field crews were instructed to record visible damage if they thought present or future tree vigor was in jeopardy, but definitive correlations between objective measures of tree vigor (such as growth) and the damages listed here have yet to be established. All things considered, the simple percentage distributions of VCR and damage data presented in this analysis do not indicate any widespread problems in 1991. There are, however, a few patterns worth mentioning.

More than 90 percent of all overstory Virginia pines received average or better crown ratings in all categories, but more Virginia pines were rated "poor" in all categories than any other softwood species. Virginia pine also had more incidence of damage and more understory trees in poor condition than any other softwood species. Several factors are probably contributing to this pattern. Virginia pines normally grow in dense stands where crowns are thinned by competition. They also tend to occupy relatively poor sites, having been displaced by eastern white (*Pinus strobus* L.) and loblolly (*Pinus taeda* L.) pines on the better sites. Virginia pine is susceptible to eastern gall rust, and its wood is relatively brittle (predisposing it to damage from wind and ice), which explains the high proportions of damage from disease and weather. It is also subject to periodic attacks from pine sawflies, although no major outbreaks were observed in 1991.

As with the softwoods, hardwoods generally seem to be in good condition. Among oaks and hickories there were slightly elevated numbers of trees with poor foliage transparencies and crown dieback, but proportions of these species with serious problems are still low. Damages noted on oaks and hickories indicate that insects and disease–probably gypsy moth and oak decline–are the primary causal agents.

The regional patterns described above also hold for the individual States contributing to this analysis (app. tables 11-28). Based on their crown ratings, only small percentages of trees in each State are in poor condition. Of those few trees that are experiencing problems, however, there does seem to be a spatial trend. Proportions of Virginia pines, oaks, and hickories with poor VCR ratings are generally highest in Virginia and lowest in Alabama. Damage incidence follows the same pattern–49 percent of all overstory trees tallied in Virginia had some type of damage. The corresponding figures for Georgia and Alabama are 34 and 31 percent, respectively.

Off-Frame Pest Surveys

This portion of the report focuses on several off-frame surveys of six major pests in the Southern Region: fusiform rust, southern pine beetle (*Dendroctonus frontalis* Zimmermann), dogwood anthracnose (*Discula destructiva* sp. Nov.), oak decline, littleleaf disease, and gypsy moth. Also included is a consolidated briefing on lesser pests. This information was compiled from a variety of sources such as State forestry agency reports, Forest Inventory and Analysis data, and Forest Pest Management data bases such as Southern Pine Beetle Information System.

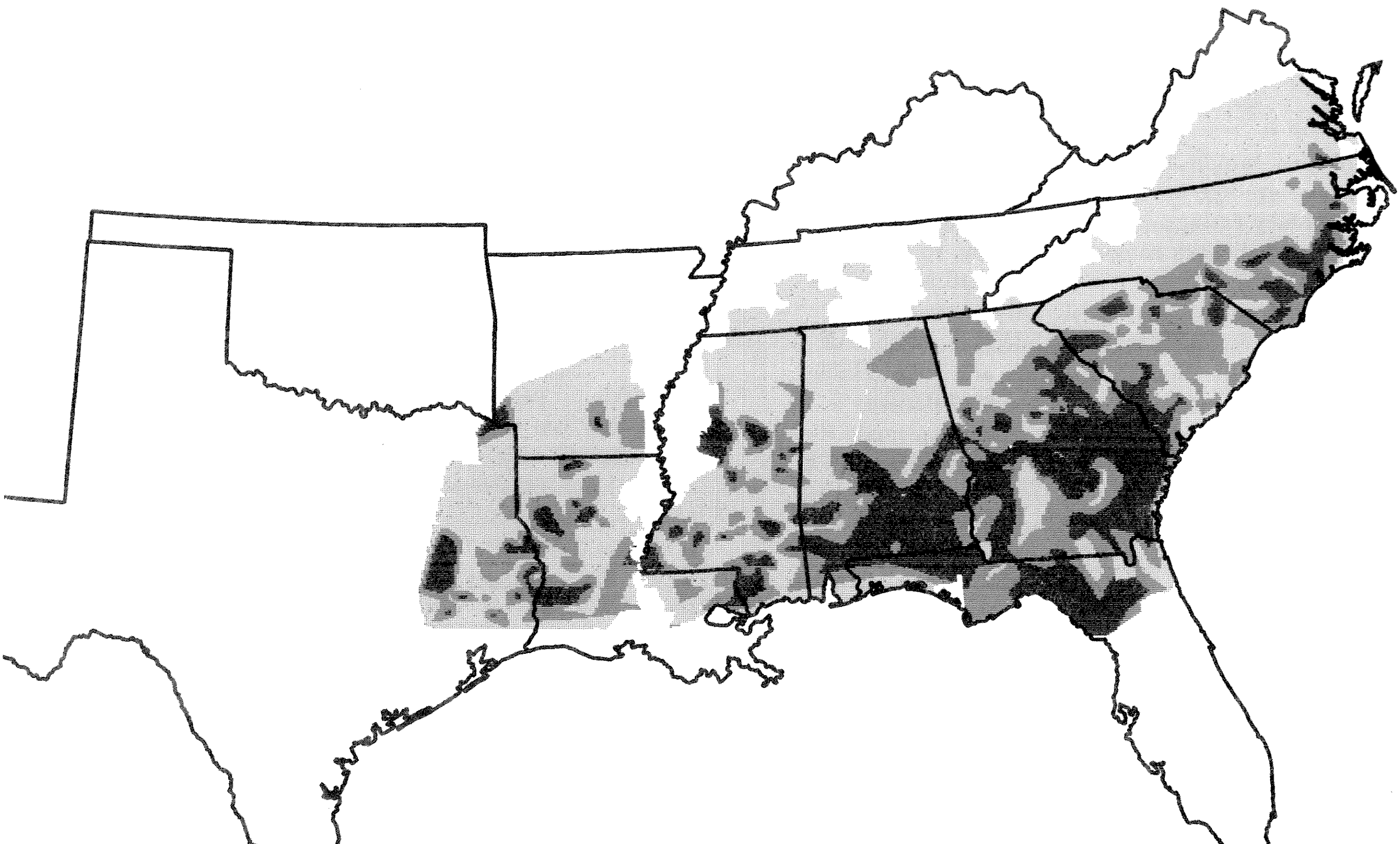

Figure 1–Fusiform-rust hazard for loblolly pine.

Fusiform Rust

Fusiform rust continues to be the most prevalent disease of loblolly and slash pines. It is relatively common throughout the ranges of these two species (figs. 1 and 2). A third of the acreage in loblolly and slash pine forest types has 10 percent or more of the trees infected with potentially lethal cankers (table 9). At 5 million acres, Georgia is the most heavily infected State, accounting for 30 percent of all infected lands. Alabama and Mississippi each have more than 2 million infected acres. Together, these three States account for nearly 60 percent of all infected acreage.

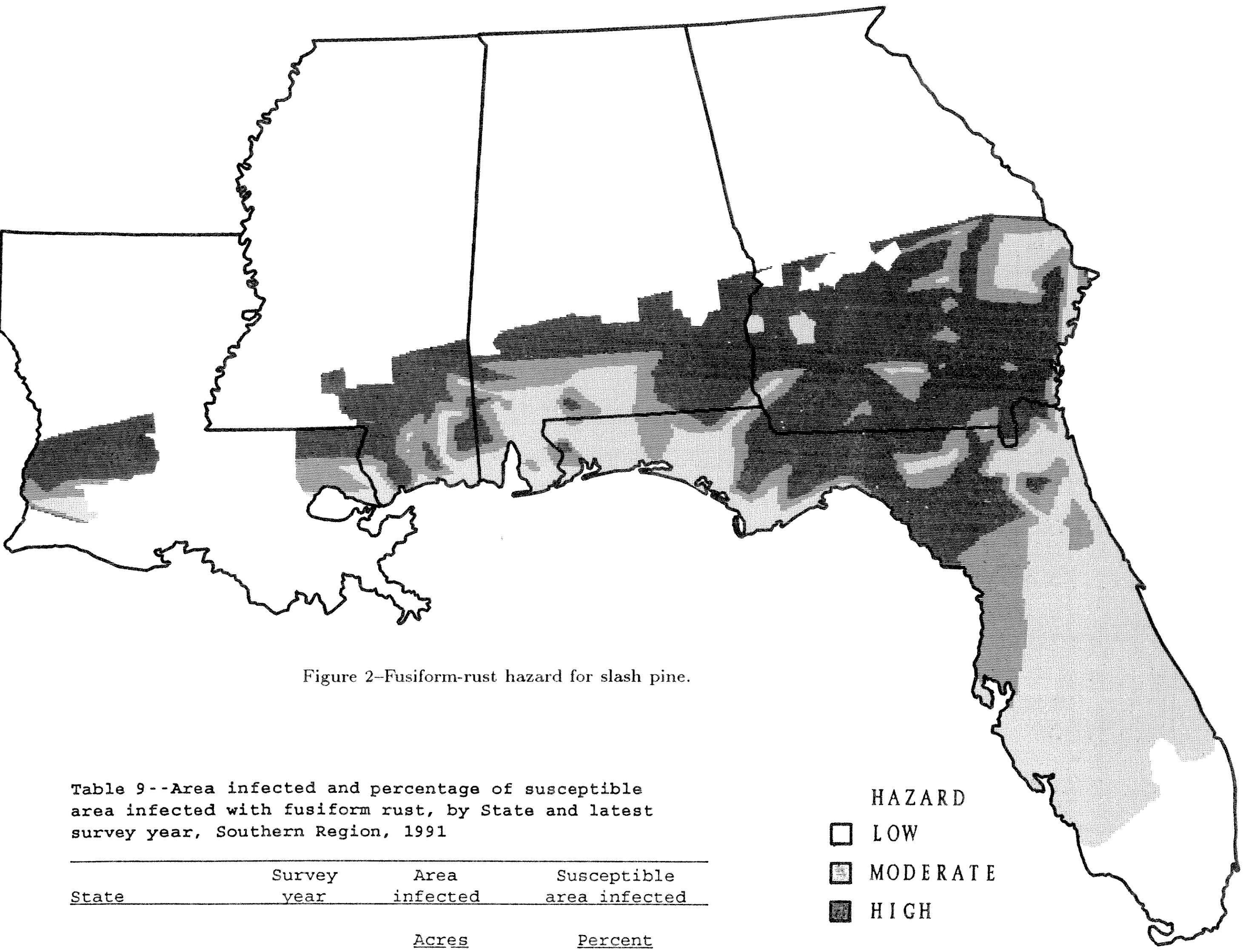

Figure 2–Fusiform-rust hazard for slash pine.

Table 9--Area infected and percentage of susceptible area infected with fusiform rust, by State and latest survey year, Southern Region, 1991

State	Survey year	Area infected	Susceptible area infected
		Acres	Percent
Alabama	1982	2,621,271	34
Arkansas	1988	307,378	8
Florida	1987	1,332,314	23
Georgia	1989	4,981,954	53
Louisiana	1984	1,784,550	30
Mississippi	1987	2,018,505	32
North Carolina	1990	1,116,555	29
Oklahoma	1996	22,525	6
South Carolina	1986	1,840,545	40
Tennessee		--	--
Texas	1986	624,814	12
Virginia	1986	70,534	4
Total		16,720,945	30

Southern Pine Beetle

Southern pine beetles infested nearly 10 million acres in 1991–a 133-percent increase over the previous year (fig. 3). The heaviest activity shifted eastward from the Western Gulf States. Alabama currently accounts for 40 percent of all outbreak acreage. An outbreak is declared if at least 0.1 percent of susceptible host trees in a county are infested (fig. 4). An outbreak in the Appalachian Mountains has recently collapsed, but populations have expanded dramatically in the Piedmont of Georgia, South Carolina, and North Carolina. Arkansas, Florida, Kentucky, Oklahoma, and Tennessee have not experienced an outbreak in the past 2 years.

Despite a 77-percent decrease in affected acreage in Texas, pine beetle populations there are still troublesome, especially in wilderness areas containing old-growth pines. These old trees are prime habitat for the endangered red-cockaded woodpecker. Unfortunately, the same trees are highly susceptible to southern pine beetle infestation.

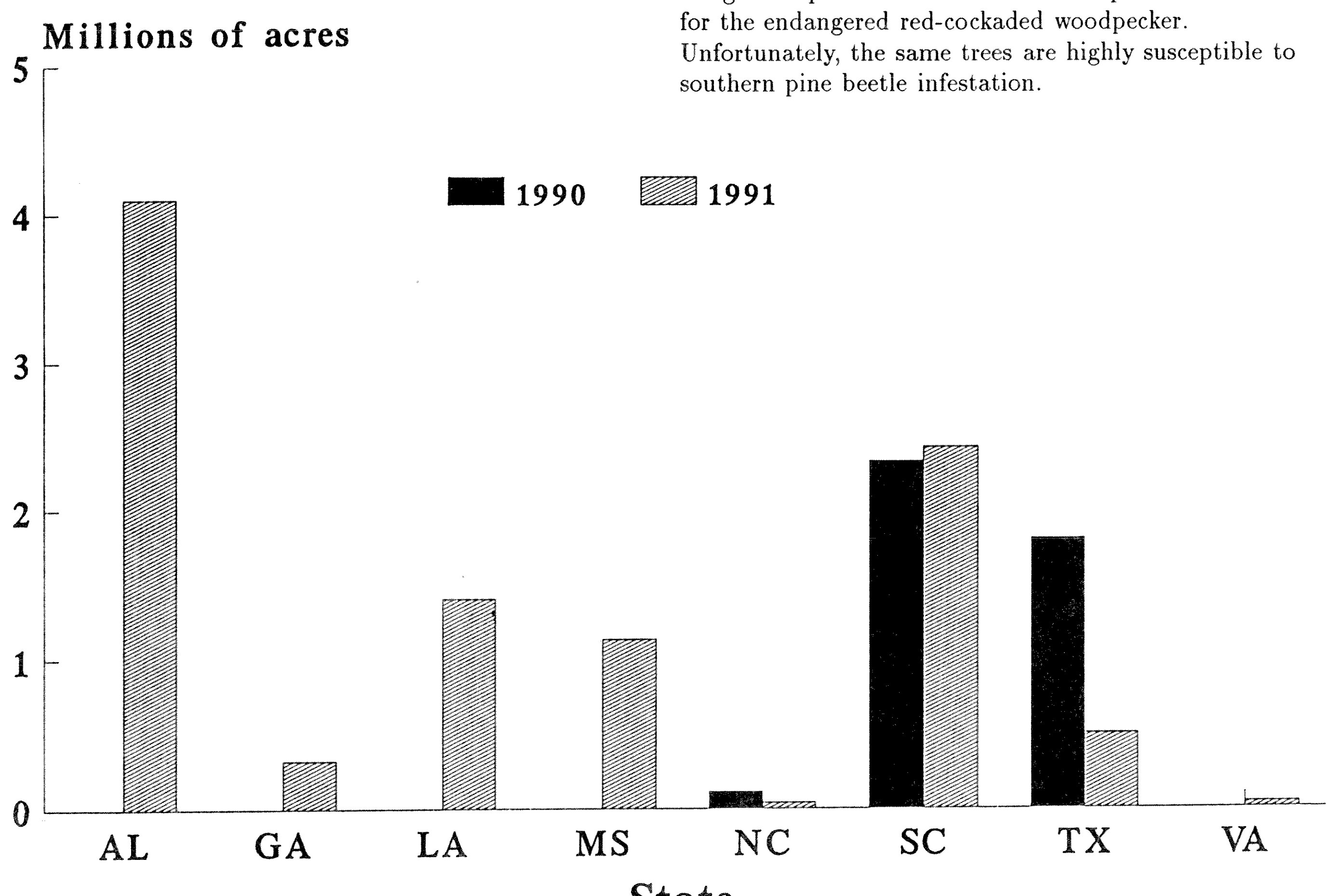

Figure 3–Southern pine beetle outbreak acres, 1990 and 1991.

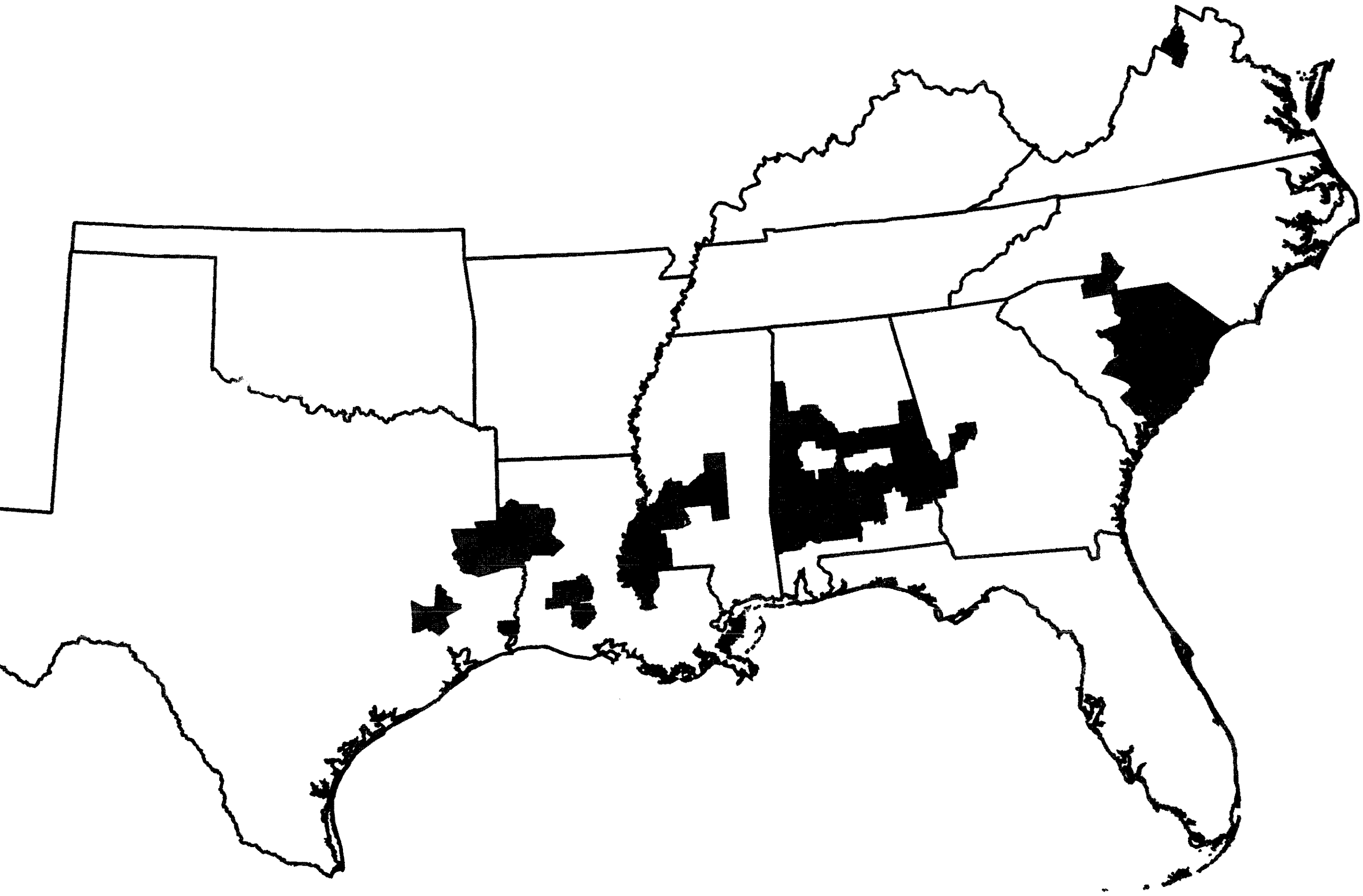

Figure 4–Southern pine beetle outbreak counties, 1991.

Dogwood Anthracnose

Since first discovered in northern Georgia in 1987, dogwood anthracnose has expanded rapidly throughout the southern range of the flowering dogwood (*Cornus florida* L.). So far, 120 counties in 7 Southeastern States have confirmed infections (fig. 5). The disease is most prevalent on moist, cool sites such as north-facing slopes, and beneath dense overstories. The cumulative acreage infected has increased year by year since first quantified in 1988 (fig. 6).

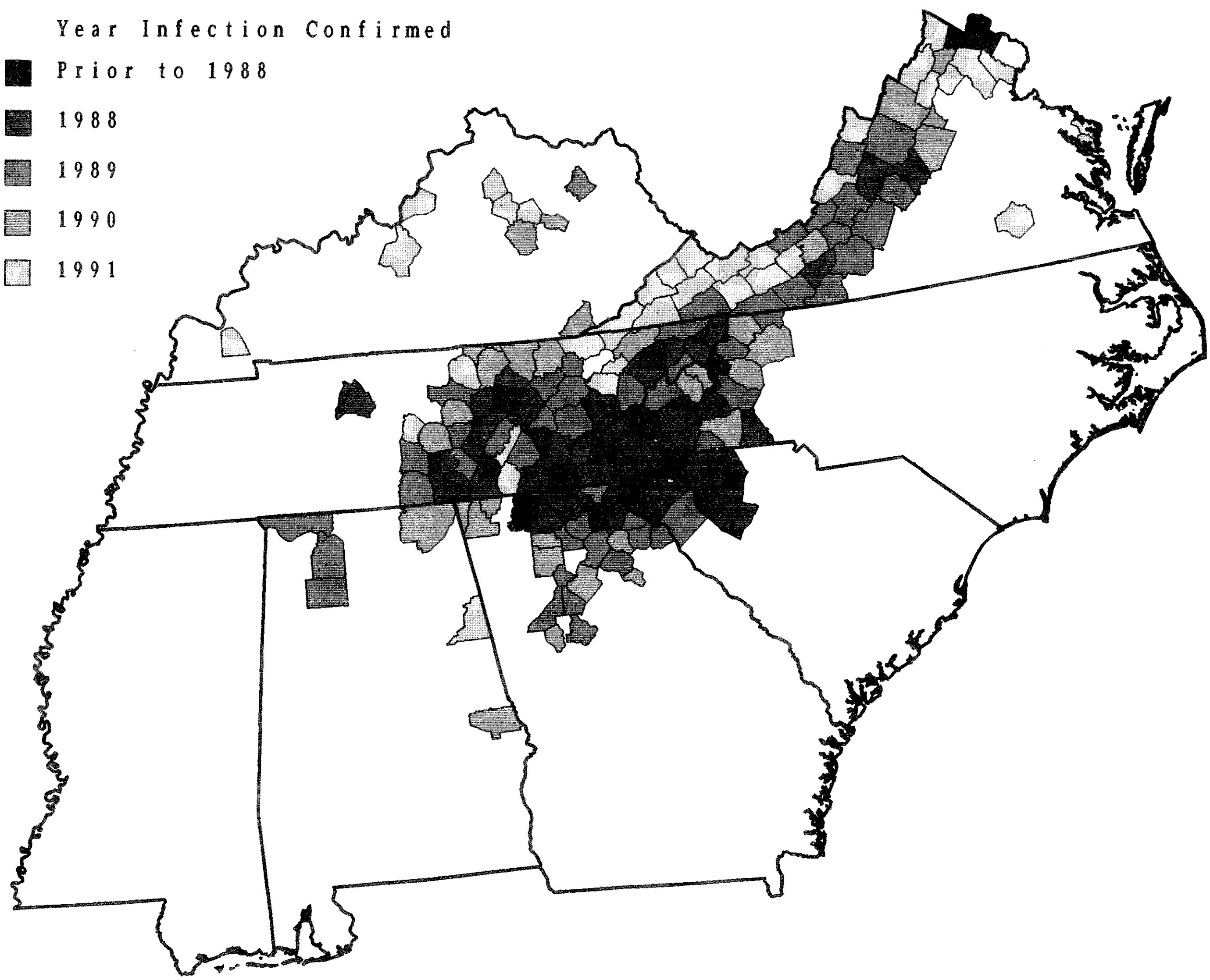

Figure 5–Dogwood anthracnose occurrence in the Southern Region, 1991.

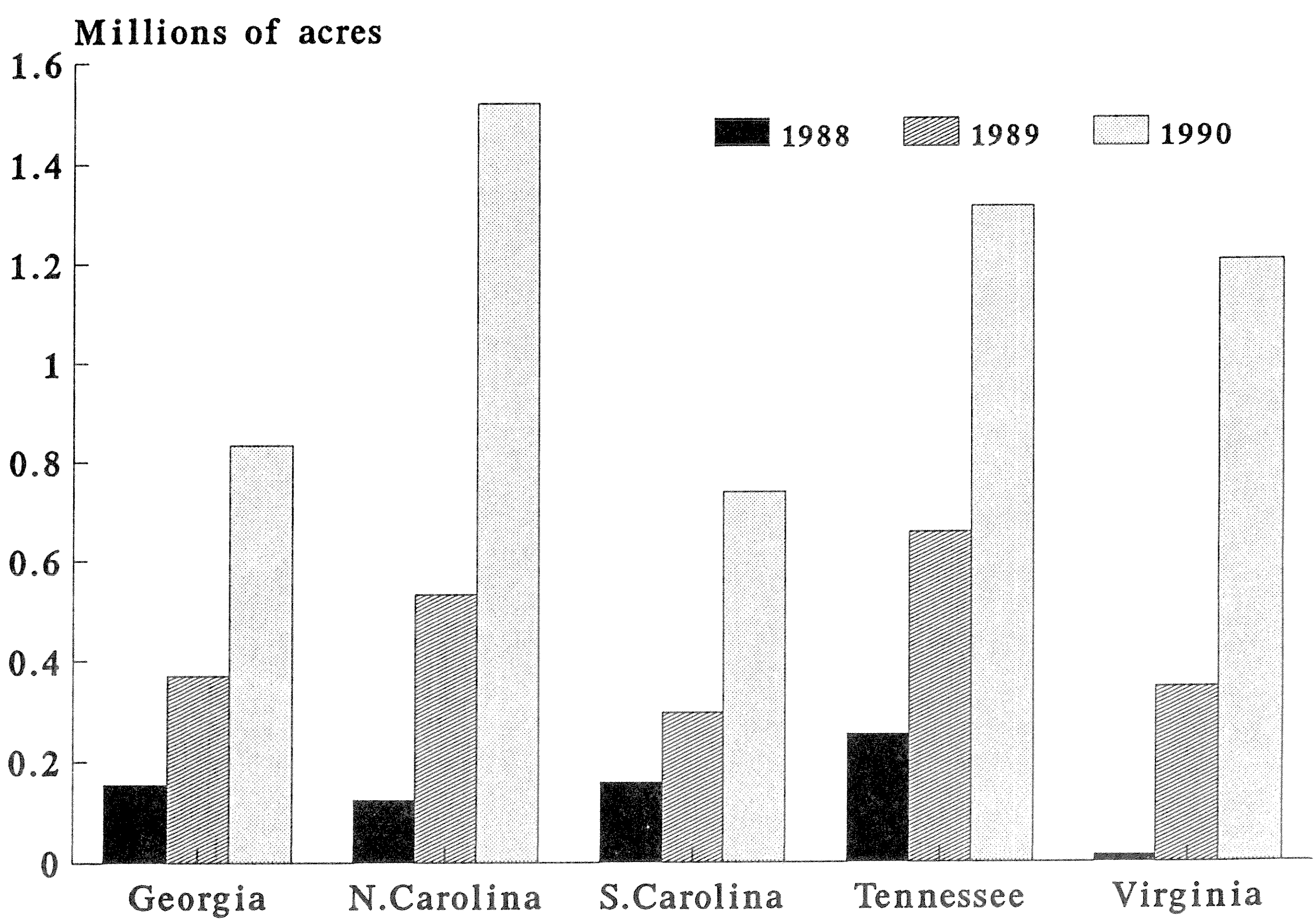

Figure 6–Estimated acreage affected by dogwood anthracnose, 1980-1990. (No data available for Kentucky or Alabama.)

Figure 7–Bottomland oak plots with signs of oak decline in the Southern Region.

Oak Decline

Oak decline is a complex, slow-acting syndrome involving interactions among predisposing factors such as climate, site quality, and tree age; an inciting stress such as drought or insect defoliation; and contributing organisms of secondary action such as armillaria root disease (*Armillaria mellea* Vahl.) and the twolined chestnut borer (*Agrilus bilineatus* Weber). Decline is characterized by a gradual but progressive dieback of the crown. Susceptible trees often die, but only after several years of progressive dieback. Mature overstory trees are most often affected. Oak decline, which has a long history, is widely distributed over the eastern half of the United States (figs. 7 and 8). Episodes of damage have been noted for more than 130 years. Since the turn of the century, at least 26 episodes have been recorded.

Forest Inventory and Analysis (FIA) data from 12 Southern States have been compiled to assess the relative severity of oak decline in the South (table 10). Comparisons of oak mortality on plots with and without symptoms of crown dieback yield an indirect estimate of the impact of oak decline.

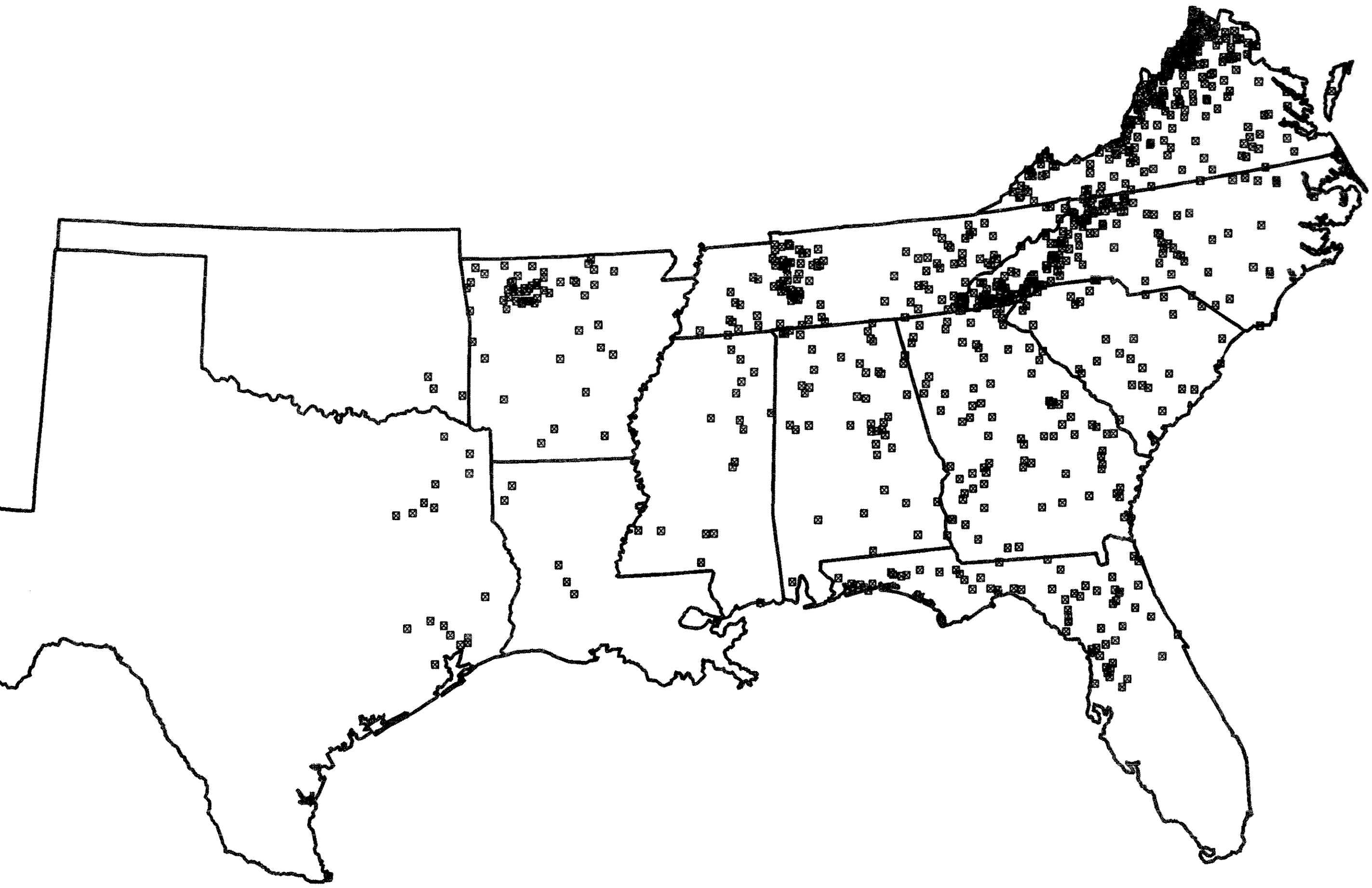

Figure 8–Upland oak plots with signs of oak decline in the Southern Region.

Table 10--Area affected, and percentage of susceptible area affected with oak decline, and mortality volume in affected and unaffected stands, by State, Southern Region, 1991

State	Area affected	Susceptible area affected	Annual mortality[a] Affected	Annual mortality[a] Unaffected
	Acres	Percent		
Alabama	265,688	6.87	1.08	1.00
Arkansas	377,821	6.38	1.22	0.97
Florida	165,716	18.65	2.43	1.90
Georgia	274,526	7.82	1.36	1.02
Louisiana	28,120	2.32	1.90	1.09
Mississippi	112,960	3.48	0.88	0.78
North Carolina	713,466	19.63	1.30	1.00
Oklahoma	18,278	0.92	2.00	1.35
South Carolina	86,016	5.49	2.49	1.26
Tennessee	677,807	12.02	1.71	1.15
Texas	110,539	4.43	2.20	1.55
Virginia	1,087,889	19.13	1.53	0.86
Total	3,918,826	9.88	1.49	1.04

[a] Annual oak mortality per acre expressed as a percentage of initial inventory volume.

Littleleaf Disease

Historically, the range of littleleaf disease, a complex of factors characterized by infection with *Phytophthora cinnamomi* Rands, includes 165 counties and covers 48.5 million acres of forest from Mississippi to Virginia (fig. 9). Eighty-six of these counties, encompassing 25.3 million acres, contain moderate- to high-risk soils, but only 10 counties (3.6 million acres) also have high volumes of shortleaf (*Pinus echinata* Mill.) and loblolly pines. Counties with the highest vulnerability are located in Alabama, Georgia, and South Carolina. Vulnerability is low in 130 counties within the historical littleleaf range due to low percentages of susceptible soils and/or low volumes of loblolly and shortleaf. The area presently identified as highly vulnerable to littleleaf has declined moderately when compared with that reported 30 years ago.

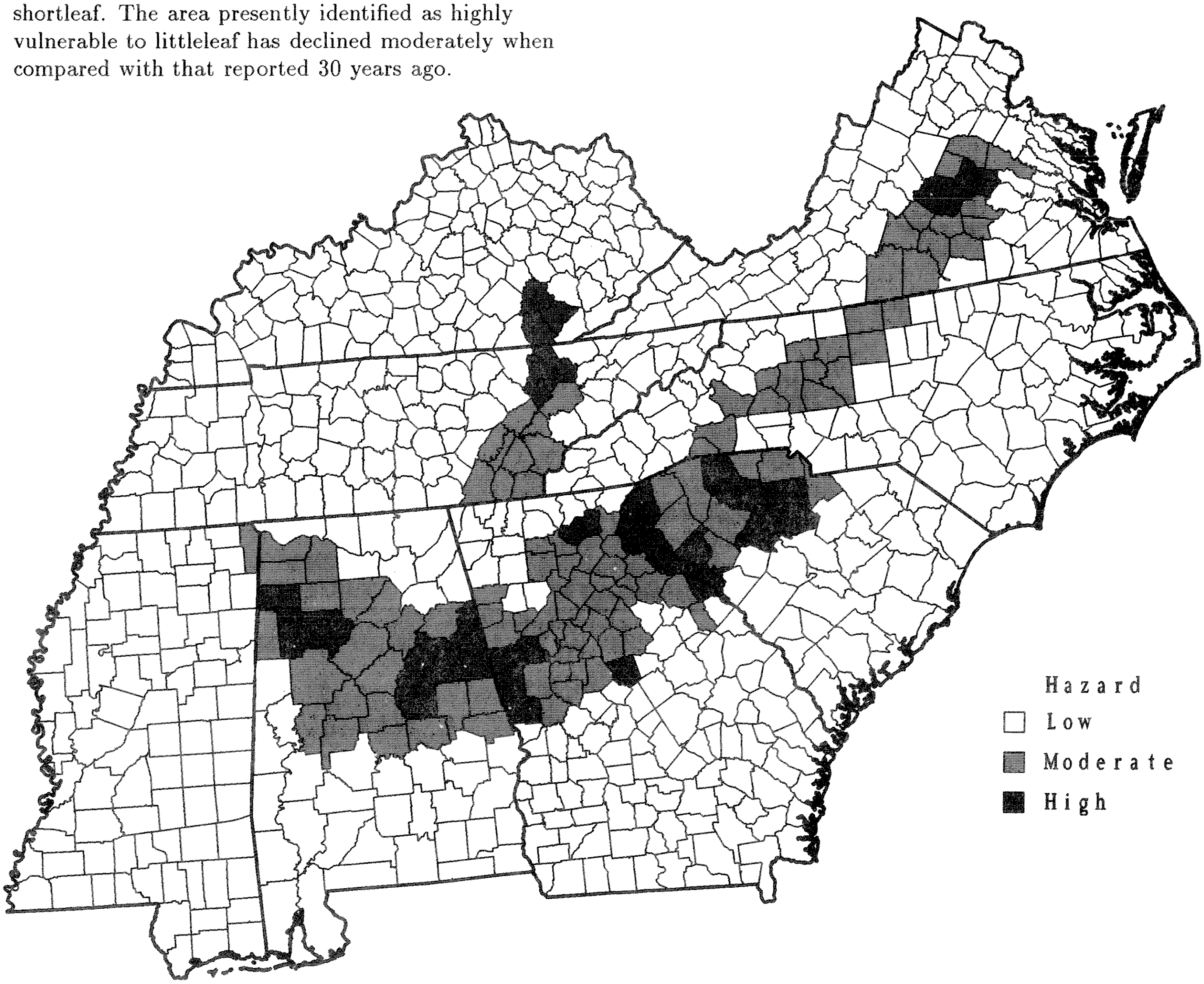

Figure 9–Littleleaf disease hazard in the Southern Region.

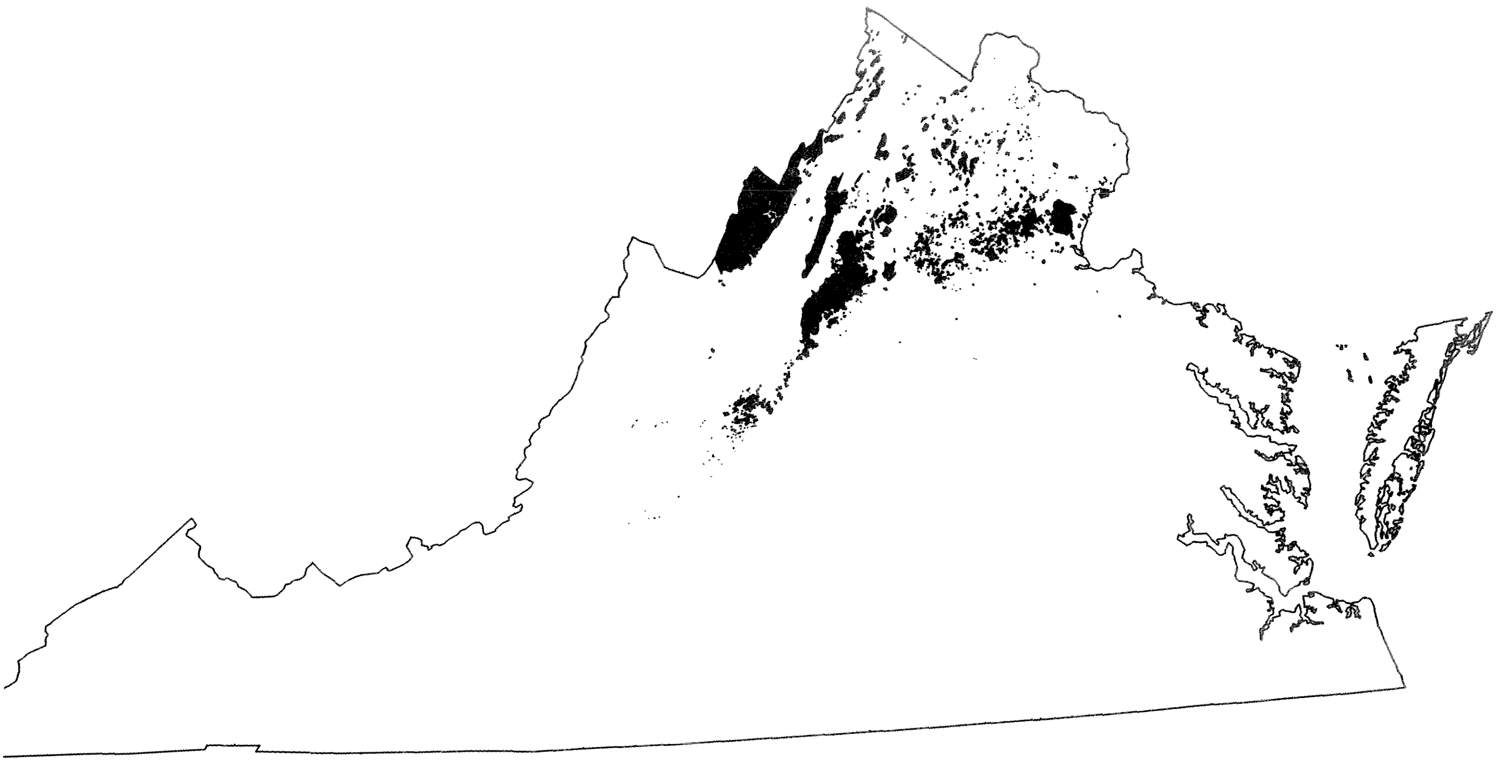

Figure 10–Gypsy moth defoliation in Virginia, 1991.

Gypsy Moth

The gypsy moth continues its westward and southward spread. In 1991 an estimated 616,300 acres of forest were defoliated in Virginia (fig. 10). Most of the defoliation occurred in the northern mountain region, with the George Washington National Forest accounting for about half of the State's defoliated acreage. Significant defoliation also occurred in the Jefferson National Forest and Shenandoah National Park. In all, 60 percent of the defoliation in Virginia took place on heavily wooded Federal land.

Accurate estimates of gypsy-moth-induced tree mortality are not available on State and private land in Virginia, but 22,500 acres of Federal land were defoliated severely enough to cause heavy mortality (greater than 50 percent).

Other Pests

Several relatively new or cyclic pests were also noteworthy in 1991. Perhaps chief among them is the hemlock woolly adelgid (*Adelges tsugae* Annand). Since first noticed in eastern Virginia about 1960, this aphidlike insect has spread west and south in a manner reminiscent of the gypsy moth. Heavy activity has been reported in the Peaks of Otter area along the Blue Ridge Parkway. This insect almost always kills its host, and some ecologists fear for the survival of the tree species. Since eastern hemlocks (*Tsuga canadensis* (L.) Carr.) favor cool, moist sites in the mountains, they play an important role in shading streams and wet areas. Widespread hemlock mortality could trigger significant changes in high-elevation wetland ecosystems.

Variable oakleaf caterpillars (*Heterocampa manteo* Doubleday) defoliated more than a million acres in northeast Texas in 1991. Damage is more spectacular than serious, however, since affected trees normally recover.

The Florida Department of Agriculture has reported thousands of cabbage-palm (*Sabal palmetto* (Walt.) Lodd. ex J.A. & J.H. Schult.) along the Gulf Coast dying of an unknown cause. The afflicted area is approximately 34 miles long and about 2 miles wide between Crystal River and Cedar Key. Palms of all ages are affected, but the older ones seem to be more susceptible. Trees have been killed on coastal islands as well as along the mainland.

Blackgum disease, the cause of which is unknown, has intensified in the Southern Appalachian Mountains. This condition appears to have great potential significance. Its frequent occurrence in association with dogwood anthracnose suggests that the two might have a similar etiology.

Because of an unusually wet spring, anthracnose, caused by various species of fungi, has been especially prevalent this year in the Appalachian Mountains. Maples were perhaps most conspicuously affected, but other hardwoods were also damaged.

Conclusions

This report is the first attempt to quantify forest health at a regional scale in the South. The intent is to provide an uncomplicated initial summary of on-frame and off-frame data. It is the first step in establishing a baseline from which to measure trends–a process that will take several to many years. More comprehensive and statistically rigorous analyses will follow as the program develops.

Concerning the plot data, simple percentage distributions of the VCR and damage data gathered in Virginia, Georgia, and Alabama do not indicate any unusual or unexplained problems. However, this conclusion is hedged with the caveats that the data have not yet been analyzed statistically, that analytical methods associated with these two indicators are still being developed, and that there is no compatible trend information. Data regarding growth and mortality, two other important indicators, will not be forthcoming until at least one 4-year measurement cycle is completed.

From the off-frame data, it is evident that traditional pests (southern pine beetle, fusiform rust, and littleleaf disease) continue to cause substantial damage in the South. There is some evidence that relatively new, or heretofore less significant, problems may be increasing in importance. Dogwood anthracnose is spreading at an alarming rate, as is the hemlock woolly adelgid. Oak decline has intensified in reponse to aging hardwood stands and recurrent episodes of drought. Gypsy moth continues to spread west and south, with much of Virginia heavily infested. Data concerning these and other pests will be archived, analyzed, and cross-referenced with data from the permanent plot network.

Finally, a word about interpreting "forest health." Even after a rigorous monitoring system is in place and fully operational, simple interpretations will always be elusive because the concept is extremely relative and multifaceted. A healthy stand may or may not include unhealthy trees, but a healthy forest must include some unhealthy stands because pest organisms are components of the ecosystem that require niches not present in healthy stands (Shafer 1990). It is certainly realistic to define and evaluate specific elements of forest health, but viewing these elements holistically requires a fair degree of value judgment.

Acknowledgments

The Forest Health Monitoring Program is founded upon the cooperative efforts of several public agencies. In addition to the Forest Service and the Environmental Protection Agency, the States of Alabama, Georgia, and Virginia provided field personnel and technical assistance, as did the Soil Conservation Service and the Tennessee Valley Authority. Other Federal and State agencies have assisted in other regions of the country. The supplemental off-frame pest data presented in this report were compiled with assistance from Wes Nettleton, Dale Starkey, Steve Oak, and Denny Ward of USDA Forest Service, Region 8, Forest Pest Management. Sincere gratitude is expressed to all participants.

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Appendix

The tables in this appendix are companions to text tables 3-8. Whereas tables 3-8 have been compiled for the Southern Region as a whole, appendix tables 11-28 contain the same VCR and damage data by individual State.

Table 11--Number of trees sampled by selected species group, tree size, and crown position, Alabama, 1991

Species group	1.0-4.9 in. d.b.h.	5.0+ in. d.b.h. Understory	5.0+ in. d.b.h. Overstory
	Number of stems		
Softwood			
Longleaf pine	7	13	47
Slash pine	0	1	6
Shortleaf pine	5	25	56
Loblolly pine	102	111	637
Virginia pine	7	17	65
Other softwoods	5	27	32
All softwoods	126	194	843
Hardwood			
White oaks	42	91	108
Red oaks	132	106	242
Maples	85	56	47
Sweetgum	108	118	144
Yellow-poplar	18	14	64
Blackgum	60	84	78
Hickories	47	50	97
Other hardwoods	280	177	124
All hardwoods	772	696	904
All species	898	890	1,747