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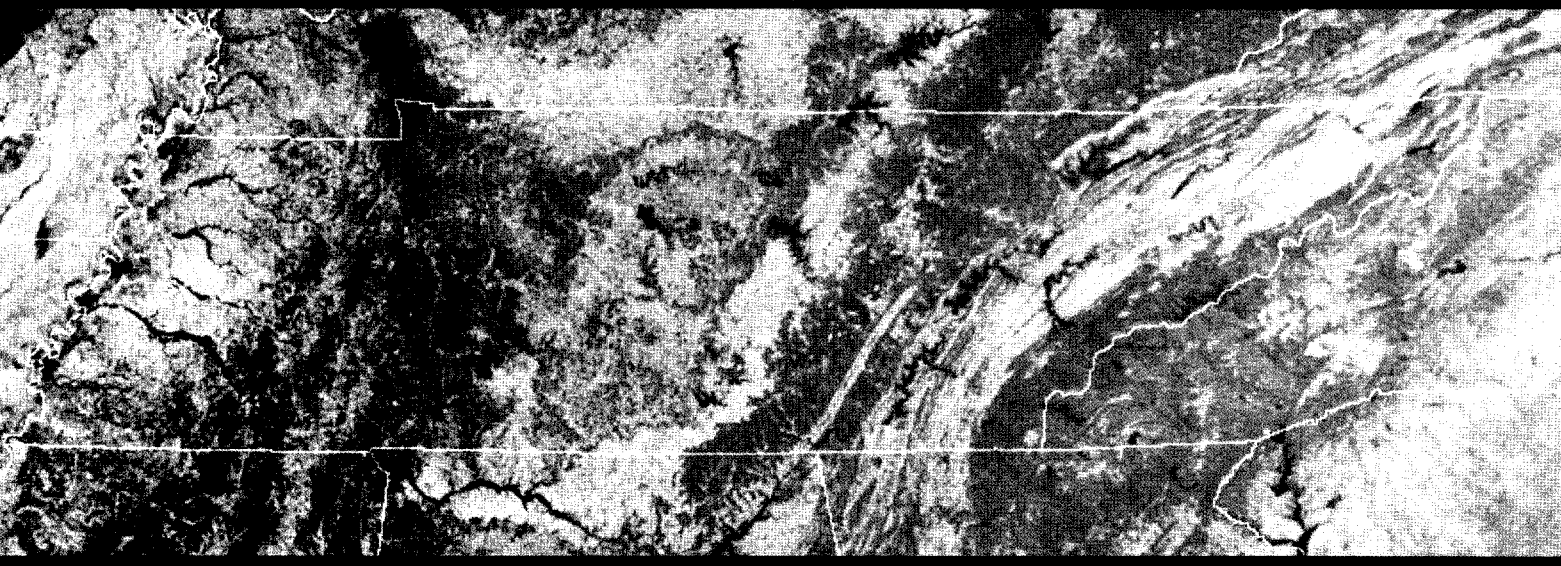
Forest Resources of Tennessee

Dennis M. May



Front cover: Advanced Very High Resolution Radiometer (AVHRR) image of Tennessee produced from data collected by the NOAA-11 satellite of the National Oceanic and Atmospheric Administration on September 25, 1990. In general, forest land is dark red; nonforest land is light red and blue; water is dark blue.

July 1991

CONTENTS

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HIGHLIGHTS

Some important findings of the 1989 Tennessee forest survey are presented below. Some of the findings report changes that have occurred since the 1980 forest survey.

- After years of settlement and development, timberland still covers half the State.
- Hardwood forests dominate the landscape, occupying three-quarters of all timberland.
- The pine resource of the State is slowly shifting from natural to planted stands.
- A diverse group of private owners controls 9 out of every 10 acres of timberland.
- The area of sawtimber-size stands is increasing as the State's timberland matures.
- Timberland trees are fewer in number, but larger in size.
- Growing-stock volume of both softwood and hardwood has increased, and much of the increase is concentrated in sawtimber-size trees.
- Four-fifths of the growing-stock volume is hardwood.
- As the pine resource shifts from natural to planted stands, loblolly pine volume is increasing and shortleaf pine volume is decreasing.
- The proportion of live-tree volume made up of trees too rough or rotten to be classified as growing stock has declined. As a result, growing-stock volume now comprises 9 out of every 10 cubic feet of live-tree volume.
- Hardwood quality has declined as growth has been concentrated in lower grade trees and volume drain has been concentrated in higher grade trees.
- A more optimal stocking of growing-stock trees of preferred species has resulted in increased gross growth.
- Mortality has doubled, countering much of the increase in gross growth.
- Hardwood removals have declined slightly; softwood removals have increased.
- Net growth exceeds removals by three to one for hardwoods and two to one for softwoods, accounting for the increasing inventory of growing-stock volume in the State.
- Timber harvesting, primarily partial harvesting, has affected one-fifth of all timberland.
- Nevertheless, because of the maturing nature of the resource, half of all timberland offers further treatment opportunities, primarily for final harvests.
- The main forest products cut from Tennessee's timberland are sawlogs, pulpwood, and firewood.
- Today's forest products industry is smaller and more efficient, with higher roundwood harvests supplying fewer mills.

INTRODUCTION

Since the 1930's, the Southern Forest Experiment Station of the USDA Forest Service (FS) has been conducting continuous surveys of the forest resources in seven midsouth States. The first survey of Tennessee was completed in 1950 (Sternitzke 1955). Subsequent surveys have followed at approximately 10-year intervals to the present (Sternitzke 1962, Murphy 1972, Birdsey 1983). Results from these surveys and supplemental surveys of Tennessee's forest industries (Bertelson 1971, Rudis 1981) form the basis for assessing long-term trends. The most recent survey was completed in 1989. The significant findings from that survey pertaining to the status and trends of the State's timber resources are summarized in this report. Information about the regional timber resources of the State is provided in previous reports (May and Vissage 1988, May and Vissage 1989a-d). In upcoming reports, nontimber resources of the State, Tennessee's timberland owners, and other topics of special interest or concern will be examined.

FOREST AREA

Forest Land

Tennessee's first settlers, moving west from North Carolina and Virginia in the late 1700's, encountered a seemingly endless forest that stretched from the spruce-clad peaks of the eastern mountains to the hardwood bottoms along the Mississippi River and its

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tributaries. This vast and diverse forest then covered about 92 percent of the State (Allred and others 1939). During the next 100 years, continued settlement and establishment of an agricultural economy reduced the forested area to about 50 percent of the State (Young 1979).

As agricultural development spread, it was influenced by the varied physical characteristics of the land (fig. 1). (Boundaries of these physiographic regions would later form the basis for defining the forest survey regions of the State [fig. 2]). Areas of more gentle terrain and fertile soils served as focal points for agriculture. Consequently, much of the early agricultural economy was based in the valleys and coves of the East survey region, the basin of the Central survey region, and the fertile bottomlands of the West survey region. Conversely, much of the State's forest land was concentrated in areas of rougher terrain and poorer fertility, such as the Highland Rim, Plateau, and mountain physiographic regions of the State. Even so, small subsistence-type farms could still be found scattered throughout these regions.

The establishment of an agricultural economy essentially fixed the extent and distribution of the State's forest land. Forest land still covered about half the State at the time of the first forest survey in 1950, and its distribution reflected past agricultural development patterns. Since the first survey, the area of forest land has fluctuated slightly in response to changing agricultural economies and demographics (fig. 3). Strong agricultural economies have favored the clearing of forests for agricultural uses, while weak agricultural economies have favored the abandonment of marginal farm lands and their reversion back to forest.

At the same time, the continuing transition of the State's populace from rural-agricultural to urban-industrial has also caused abandonment and reversion of marginal farm lands back to forests, as rural people dropped agricultural lifestyles in favor of jobs in the manufacturing and urban centers of the State (fig. 4). In later years, this increasing urbanization had the opposite effect as forests were cleared to support the infrastructure of the growing urban and industrial centers.

Timberland

Since the first forest survey, a small portion of the State's forests have been reserved from commercial timber production by written statute (fig. 5). Much of this reserved acreage is contained in the Great Smoky Mountains National Park and the wilderness areas of the Cherokee National Forest. The remaining forest

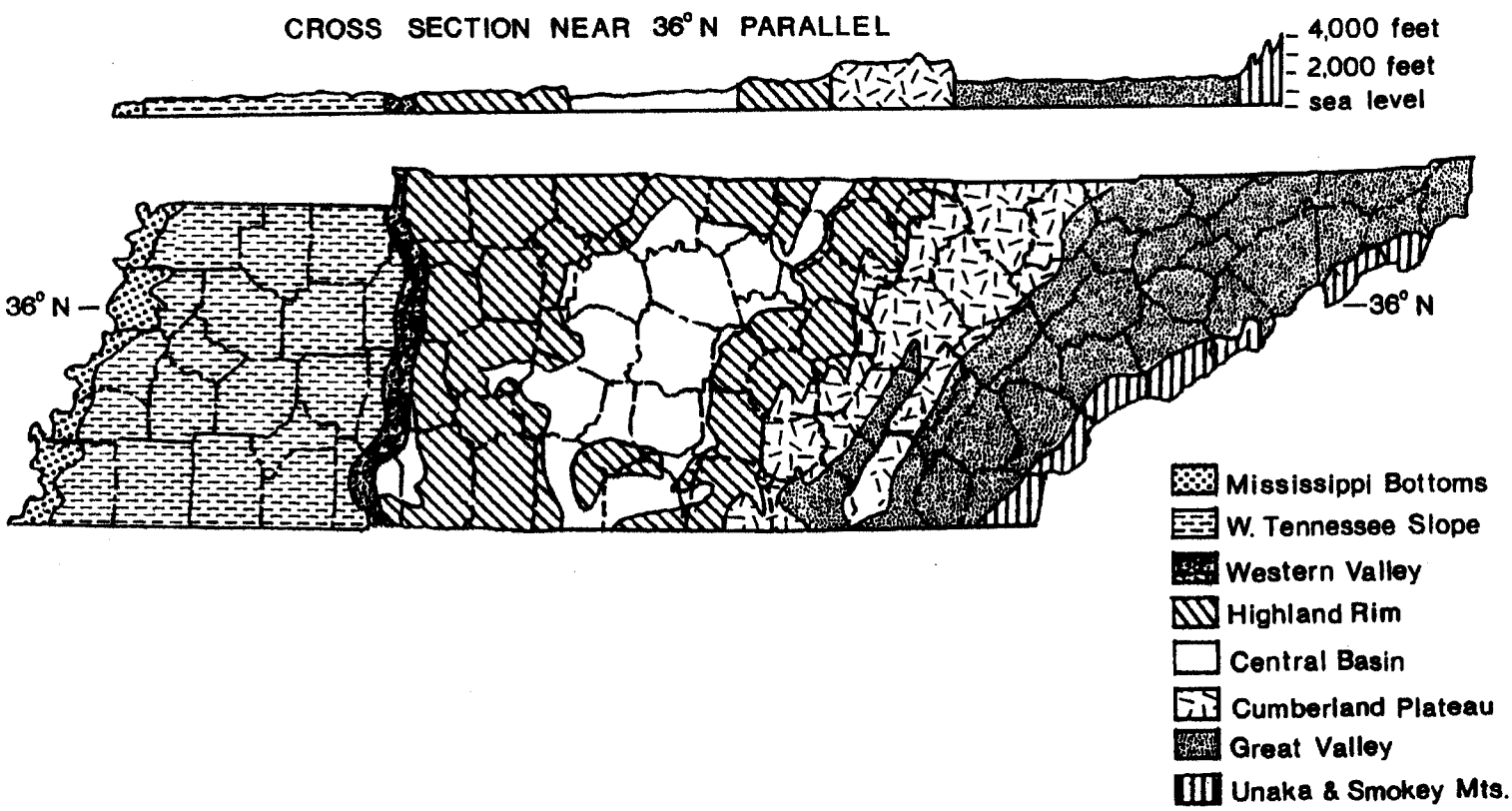


Figure 1.—*Physiographic regions of Tennessee. Source: Sternitzke, 1955.*

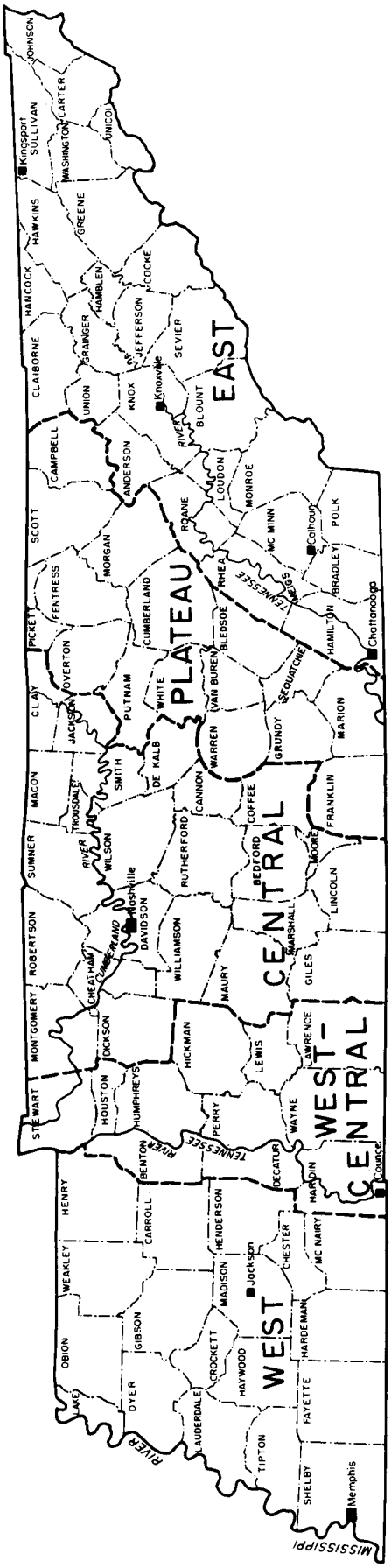


Figure 2.—*Forest survey regions in Tennessee.*

land is capable of commercial timber production and is classified as timberland. The current distribution of timberland has been dictated by past agricultural and urban development (fig. 6).

Since the last forest survey in 1980, timberland has increased only slightly (table I); however, changes within individual counties and regions have been more dynamic (fig. 7). Additions to timberland have been concentrated in the center of the State and have come predominantly from abandoned pastures and cropland. Losses, on the other hand, have been concentrated at both ends of the State and were due primarily to agricultural diversions in the west and wilderness designations and urban sprawl in the east.

General Forest Types.—Tennessee's varied physiography and climate create growing conditions that favor certain tree species over others. As a result, Tennessee's timberland is made up of a variety of forest types that are not evenly distributed across the State (fig. 8). Generally, upland hardwood forests (oak-hickory and maple-beech-birch forest types) are the most common and widely dispersed. Bottomland hardwood forests (oak-gum-cypress and elm-ash-cottonwood forest types) are concentrated in the western end of the State, along the Mississippi River and its tributaries, on lands least suited to agriculture. A scattering of bottomland hardwood forests is also evident along portions of the Tennessee River not inundated by water impoundments. Pine forests (loblolly-shortleaf [yellow pine] and white pine-hemlock forest types) are concentrated in the eastern end of the State, but the yellow pine types are also prevalent in the Highland Rim physiographic region to the west. The mixed oak-pine forests are distributed along a pattern similar to the pine forests. Redcedar and redcedar-hardwood forests are generally clustered within the Central Basin. These general distribution patterns have held true in the past as well, although the magnitude of each forest type has fluctuated over time (fig. 9) because of the influences of normal successional development patterns and man-caused disturbances.

Although the area of pine forests is currently smaller than in 1950, pine forests have been slowly increasing since 1971. Since 1980, all of the increase has been in planted pine stands; the area in natural pine stands has remained relatively stable. Consequently, species composition of the State's pine forests is changing as natural pine forests, made up mainly of shortleaf and Virginia pines, are being replaced by planted loblolly pine forests. These trends can be traced to the startup of the southern pine pulping industry and its expansion into the State in the 1950's.

The pulping industry was initially drawn to the mature pine resources of the State, a product of natural regeneration on abandoned farmlands and reforestation efforts of numerous conservation agencies in the first half of this century. As the mature pine resources

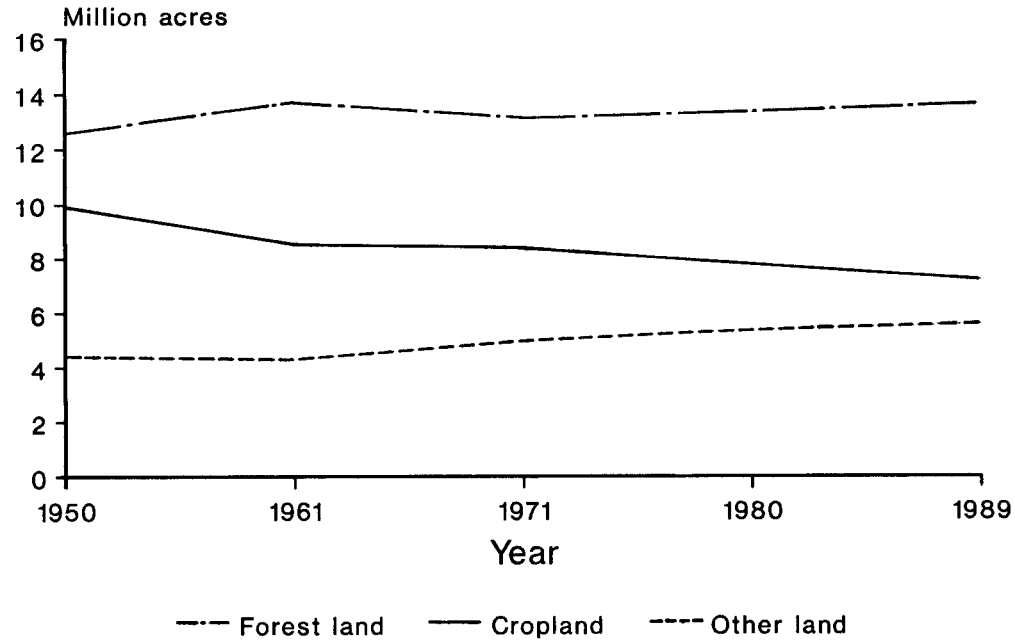


Figure 3.—*Area by land class, 1950–89.*

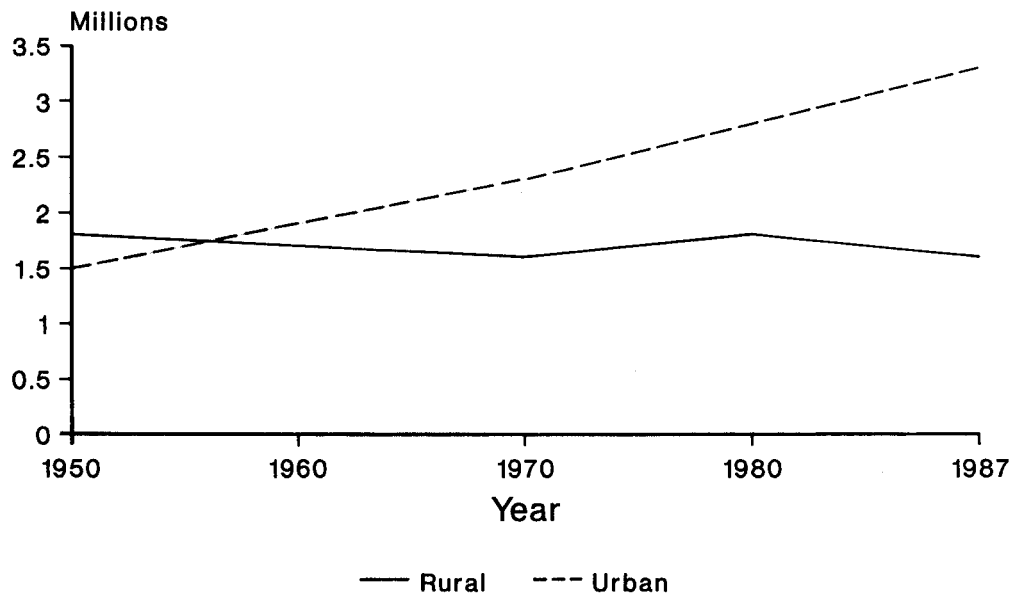


Figure 4.—*Tennessee population trends, 1950–87. Source: U.S. Bureau of the Census.*

were utilized, the pulp and paper industry started intensive pine management to ensure itself an adequate raw material supply in the future. Concurrently, the industry itself created markets for pine roundwood and provided incentive for pine management to Tennessee's other timberland owners. Because loblolly pine was the species of choice in intensified pine management, its presence increased as plantations became established.

Similar trends in species composition and stand establishment are occurring in the State's mixed oak-pine forests, many of which have been planted but are classified as oak-pine because of their stage of development and level of management. Overall, more than half a million acres of plantations currently exist in the State, about 150,000 of which were established after the last survey. It is not surprising that most of these plantations are composed of loblolly pine and are clustered within the procurement zones of the region's pine-using pulpmills (fig. 10).

The State's redcedar forests have gone through several cycles of maturation and utilization, while fluctu-

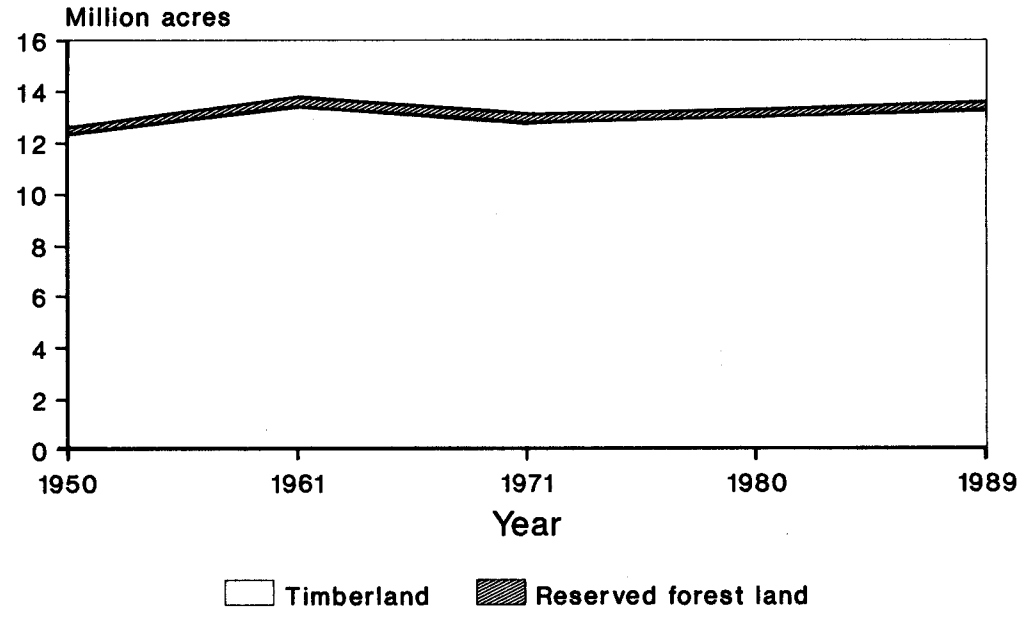


Figure 5.—*Area by forest land class, Tennessee, 1950–89.*

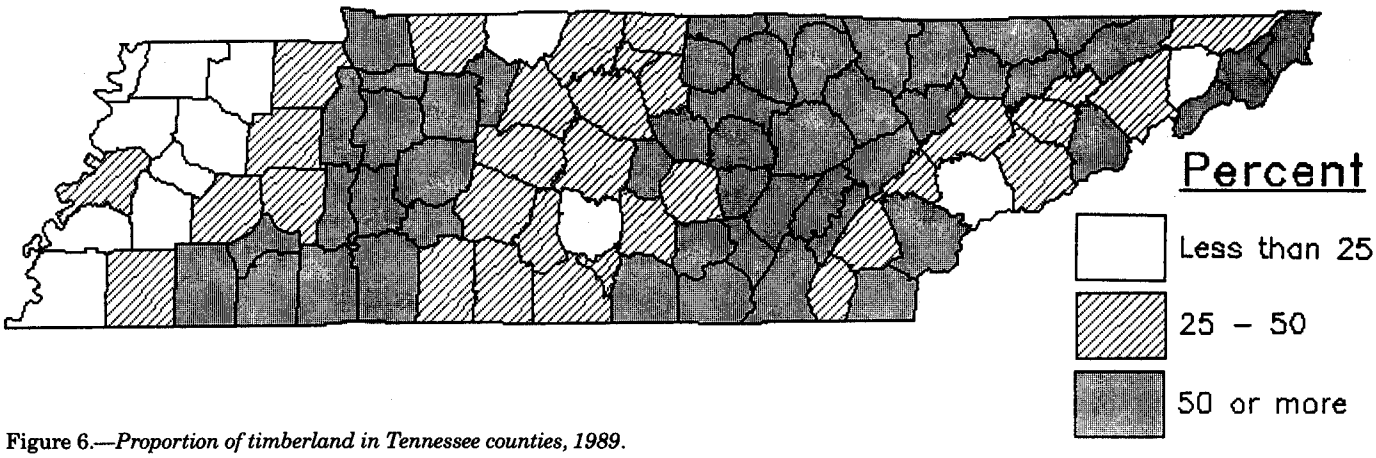


Figure 6.—*Proportion of timberland in Tennessee counties, 1989.*

Table I.—*Changes in timberland by survey region, Tennessee, 1980–89**

Survey region	All land†	Timberland	Net change	Additions from:			Diversions to:		
				Total	Agriculture	Other‡	Total	Agriculture	Other‡
	Thousand acres								
West	6,007.0	1,963.0	−189.9	30.8	21.6	9.2	220.7	189.2	31.5
West-Central	3,287.6	2,333.7	148.1	155.2	105.8	49.4	7.1	5.8	1.2
Central	6,163.2	2,461.3	298.9	344.7	268.1	76.6	45.8	16.7	29.1
Plateau	4,394.9	3,064.8	86.8	150.9	90.5	60.4	64.1	19.8	44.3
East	6,486.4	3,442.3	−38.1	143.0	88.8	54.2	181.1	51.7	129.4
All regions	26,339.1	13,265.1	305.8	824.6	574.8	249.8	518.8	283.3	235.5

* Columns may not sum to totals due to rounding.
† Department of Commerce, Bureau of the Census, Land and Water Area of the United States, 1980.
‡ Includes urban, industrial, highway, noncommercial forest, water, rights-of-way, and other land uses.

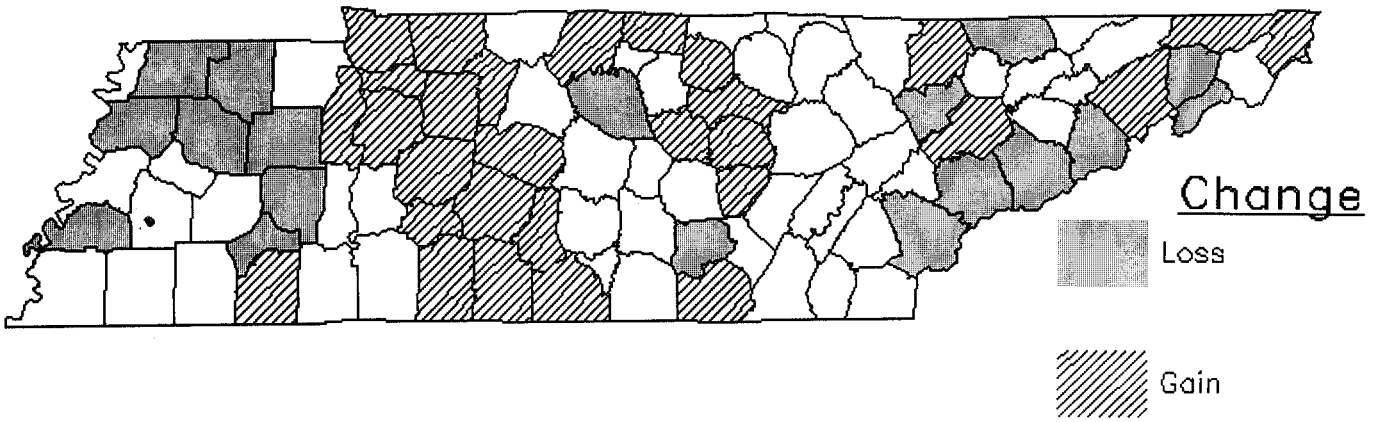


Figure 7.—*Change in timberland for Tennessee counties, 1980–89; gain or loss of at least 10,000 acres, 1980–89.*

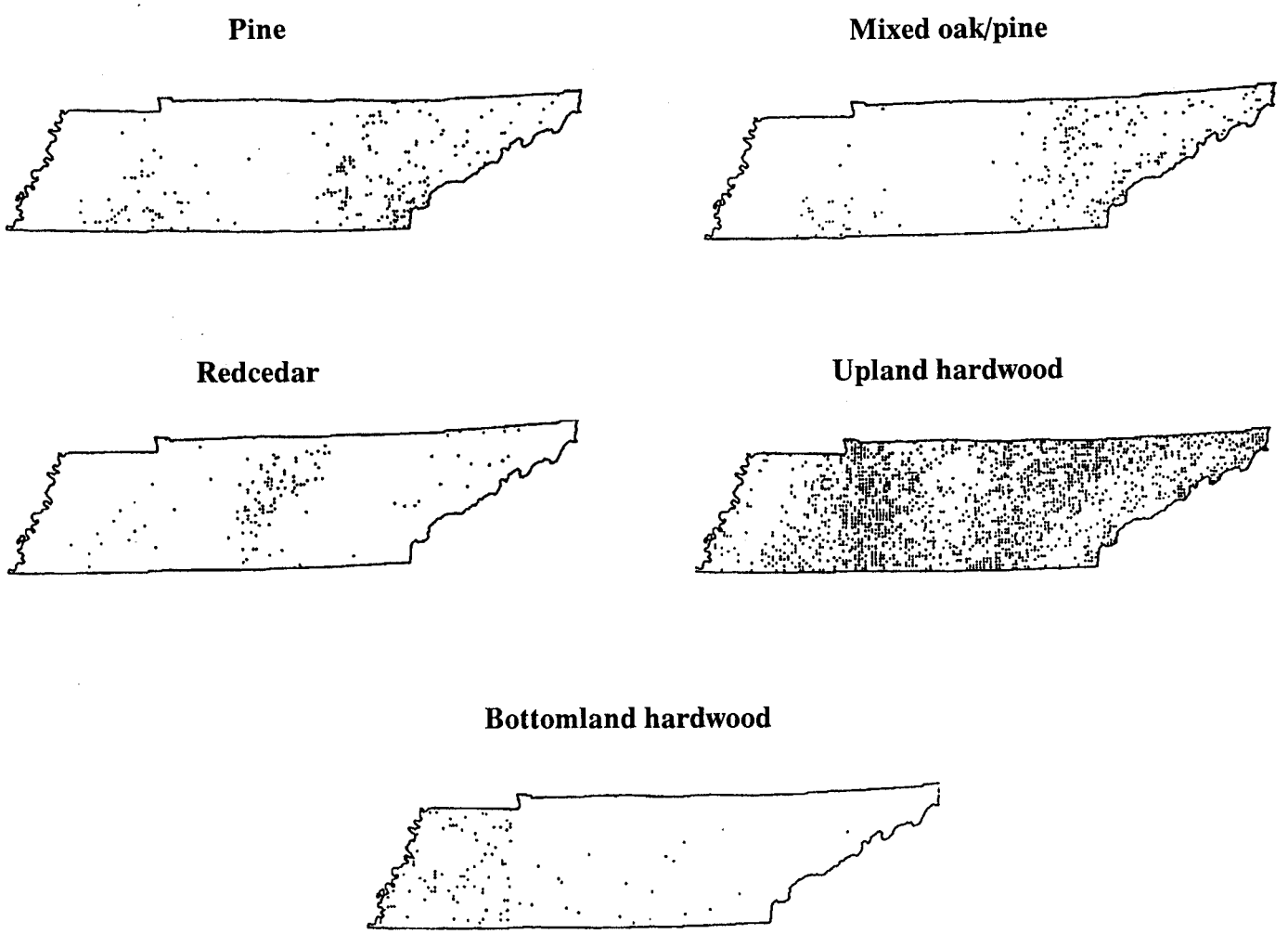


Figure 8.—*Distribution of forest plots by general forest type, Tennessee, 1989.*

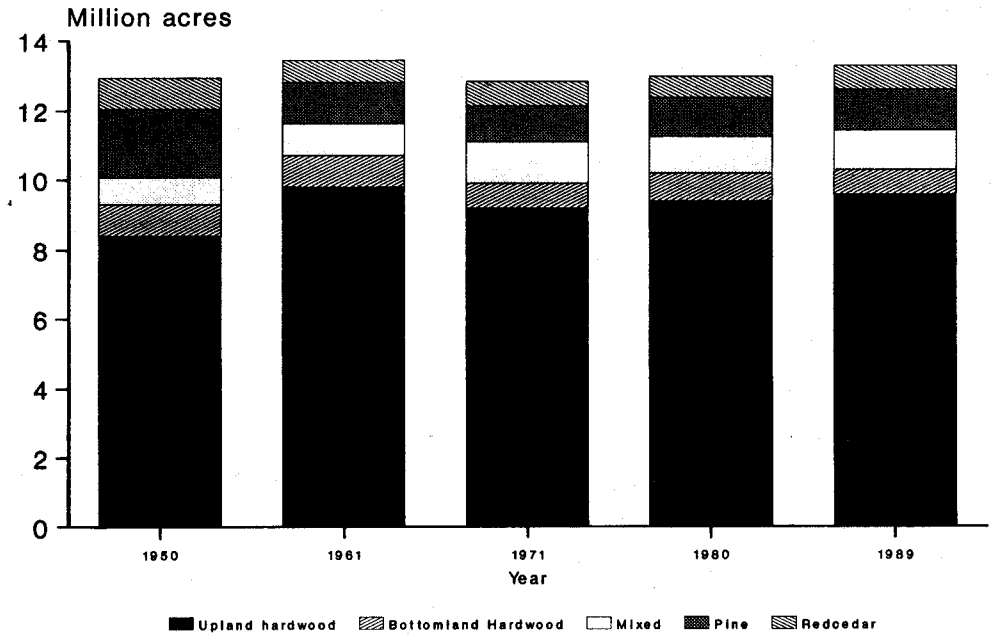


Figure 9.—*Area of timberland by general forest type, Tennessee, 1950–89.*

Figure 10.—*Distribution of planted forest plots, Tennessee, 1989.*

ating with the agricultural economy of the Central Basin. The last cycle of intense harvesting occurred in the 1950's and 1960's. Since then, the redcedar forests have been recovering. With the downturn in the agricultural economy since the last survey, reversions of abandoned farmland (primarily pastures in the Central survey region of the State) have increased the size of the State's redcedar forest (fig. 9). These reversions and selective harvesting in mature redcedar stands have resulted in most of the increase being in the redcedar-hardwood forest type.

Much of the State's bottomland hardwood forest was cleared for agriculture or inundated by water impoundments before the first survey. Since the first survey, the area of bottomland hardwoods has generally been declining, a trend that has continued from 1980 to the present (fig. 9). In contrast, the State's upland hardwood forest has always dominated the landscape, occupying nearly 3 out of every 4 acres of timberland, and has been steadily increasing in area since 1971.

Ownership.—Private owners have always controlled most of Tennessee's timberland, with public ownership limited to about 10 percent of the total area (fig. 11). Much of this public timberland is concentrated in the eastern portions of the State (fig. 12). Although the area in public ownership is not large, it provides timber as well as nontimber amenities to Tennessee's increasingly urban population. For this reason, the steady increase in public timberland over time and the increase in public ownership of the declining bottomland hardwood forest type since 1980 should be well received.

Within the private sector, the forest industry holds the smallest amount of timberland (fig. 11). Of that timberland, most is concentrated in the pine forest regions of the State, although a small amount is located in the State's western bottomland hardwood areas (fig. 12). Over the years, forest-industry ownership of timberland has steadily increased as the industry attempted to ensure itself a continuing raw material supply. Since the last survey, this trend has been reversed, probably because of the economic recession of the early 1980's. That recession had a great impact on the forest products industry, forcing some companies that were in the process of streamlining for efficiency to rethink their land-ownership and -management policies. The acreage remaining under forest industry control has a higher proportion of pine types and plan-

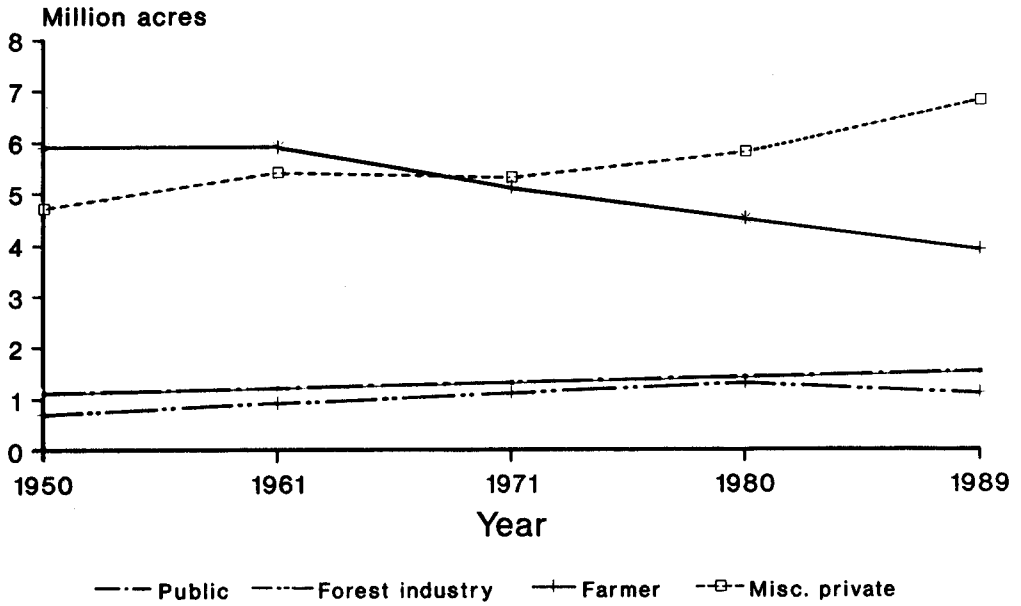


Figure 11.—*Area of timberland by ownership class, Tennessee, 1950–89.*

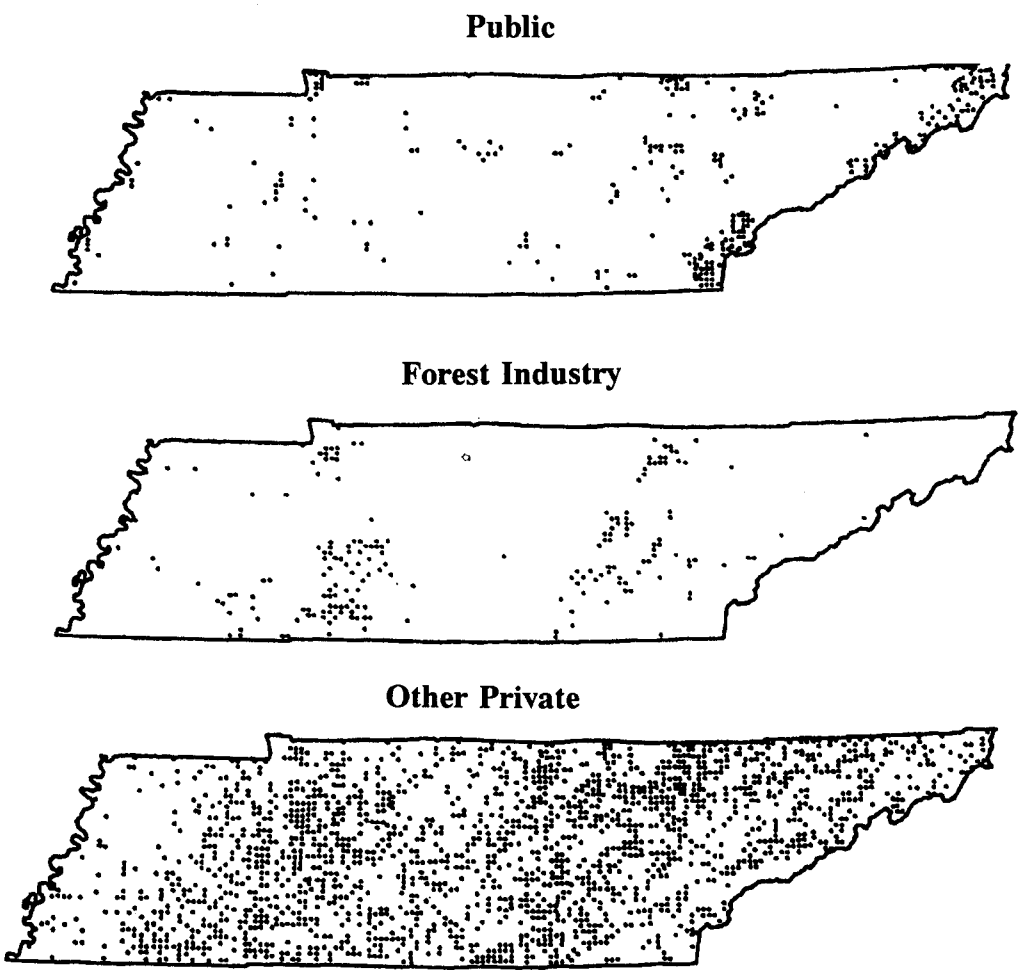


Figure 12.—*Distribution of forest plots by ownership class, Tennessee, 1989.*

tations, reflecting the continued emphasis on pine management as hardwood forests are either being converted to pine or sold.

In the State's earlier history, when its economy was agriculturally based, farmers were the major owners of Tennessee's timberland. It was still so in 1950 (fig. 11), even though the State's economy was shifting from agriculture to industry, and its populace from rural to urban. Since 1950, farmer ownership has declined as changes in agricultural economies and demographics have continued to affect farming lifestyles and the land-use status of marginal farmlands. As this decline continued, a new ownership class, miscellaneous private, emerged as the largest class of timberland owners in the State. This class is made up of nonfarming individuals and nonforest-industry corporations.

This history of land ownership has had an impact on the State's timberland. Out of economic necessity, farmers generally were obligated to make the land "pay its way." Consequently, farm woodlots were viewed as sources of exploitable resources that could provide fuelwood and building materials for personal use, forage and shade for livestock, and supplemental income from sales of timber products (Sternitzke 1955). By altering stand stocking, regeneration, species composition, and quality over the years, the consumptive uses had lasting and sometimes detrimental effects on the condition of the State's timberland.

With the shifting of the resource into miscellaneous private control, much of the economically driven emphasis on consumptive uses waned. Many of these owners no longer depended on the land as a sole source of income, or were "distanced" from the land and held timberland for nonconsumptive reasons (Wiggins 1977). The general diversification of ownership created a variety of ownership goals, of which timber production was one of many and not necessarily the primary one. As a result, concerns have been raised about the willingness of these landowners to sell timber and the resulting impact on timber supplies (Wells 1977). In total, these other private timberland owners (farmer and miscellaneous private sectors) control four-fifths of the State's timberland. What they do or do not do on these lands will greatly influence the condition of Tennessee's future forest resource.

Stand Size.—Over the years, Tennessee's timberland has evolved under opposing influences: normal successional development, which tends to move forests toward maturation; and both natural and man-caused disturbances, which generally set the maturation process back to a more juvenile stage. The current state of Tennessee's timberland can be gauged by trends in its stand-size class distribution. Since 1980, the shift has been toward sawtimber-size stands and away from smaller size stands (fig. 13). As a result, nearly half of the State's timberland is currently of sawtimber size, evidence that normal stand development is outstripping the rejuvenating effects of disturbances. Consequently, the State's timberlands are generally maturing.

Exceptions to this overall maturation of the forest exist, however. The loblolly pine forests of the State are more heavily concentrated in the smaller size classes because of intensive plantation management practiced primarily on forest-industry lands. This size-class distribution also points to the recent buildup and future potential of this species within the State. The other exception is the redcedar forest, which has a preponderance of seedling/sapling-size stands because of the large area of reversions in the Central survey region since the last survey.

INVENTORY

Growing Stock

Tennessee's first forest survey in 1950 depicted a forest depleted by years of extractive uses. First among these was the broad-scale clearing of Tennessee's forests to establish an agricultural economy and, later, the repeated high grading of the State's remaining timberland to establish and supply the State's forest products industry. These repeated high gradings, which harvested only the best species, grades, and sizes of trees, resulted in a deteriorated forest composed of smaller and poorer quality trees of inferior timber species. These conditions were aggravated by the annual burning of thousands of acres of timberland to provide forage and access for livestock. In combination, fires and grazing worked to further reduce the stocking, quality, and regeneration of the State's timberland.

The first survey conducted was late enough to reflect some of the gains made by numerous State and Federal conservation agencies in eliminating abusive practices and revitalizing neglected timberland. These gains were accomplished through educational efforts, legislative actions, timberland purchases, and demonstrations of sound forest-management techniques, all of which slowly resulted in better forest-fire control and prevention, elimination of open range, acceptance of scientific forest management, and reforestation of denuded and neglected lands. Since the first survey, the continuance of these conservation efforts, plus the natural development of the State's timberland, has caused the State's volume of growing stock to continually climb to present-day levels (fig. 14).

This threefold increase in growing-stock volume since 1950 has been accompanied by an increasing proportion of volume in sawtimber-size trees, especially in the more recent surveys (fig. 15). A concurrent reduction has occurred in the total number of growing-stock trees, all associated with the sapling component of the inventory. The number of timber-size

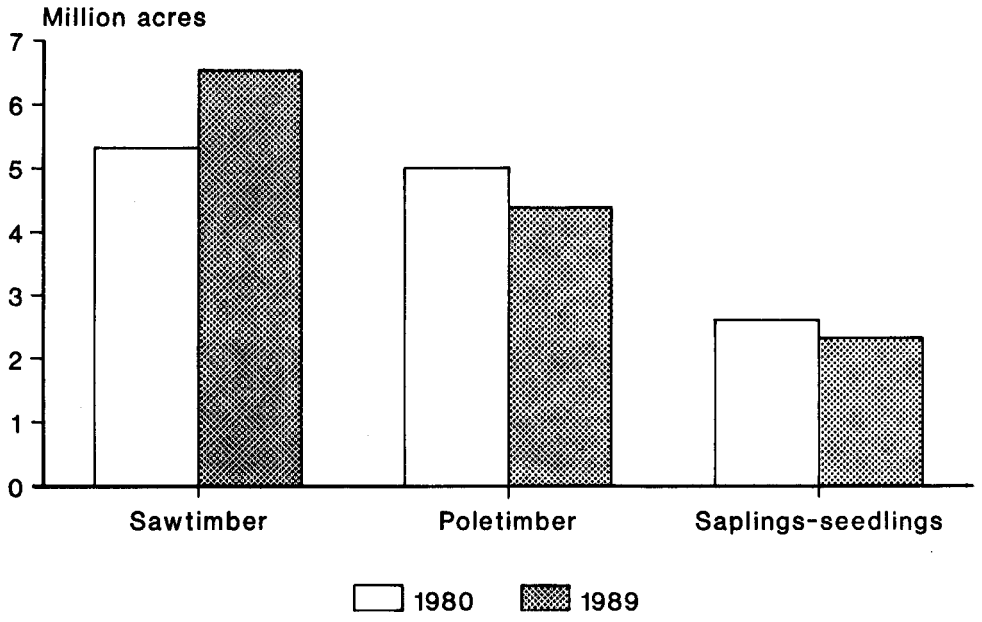


Figure 13.—*Area of timberland by stand-size class, Tennessee, 1980 and 1989.*

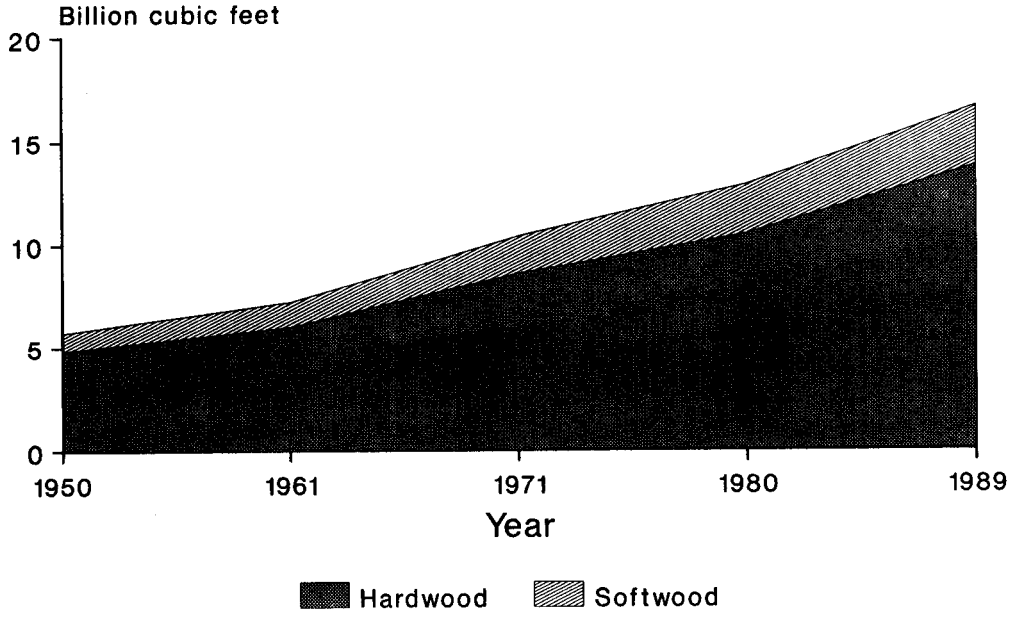


Figure 14.—*Volume of growing stock by species group, Tennessee, 1950–89.*

trees, especially those of sawtimber size, has increased (fig. 16). This shift to fewer but larger trees of increasing volume is another indication of the maturing nature and improving condition of Tennessee's timber resource since 1950.

Hardwood.—Today, as in the past, Tennessee's timber resource is essentially a hardwood resource, with hardwood species comprising four-fifths of the State's inventory volume. Most of this hardwood inventory (91 percent) is contained within the State's blanket of hardwood-forest types, and its distribution closely follows the distribution pattern of these forest types. However, the distribution of individual hardwood species is influenced by the State's varied physiography, climate, and resulting growing conditions (fig. 17).

Since 1980, the hardwood resource has continued the characteristic development of a maturing resource. Its increase in growing-stock volume (fig. 18) has been

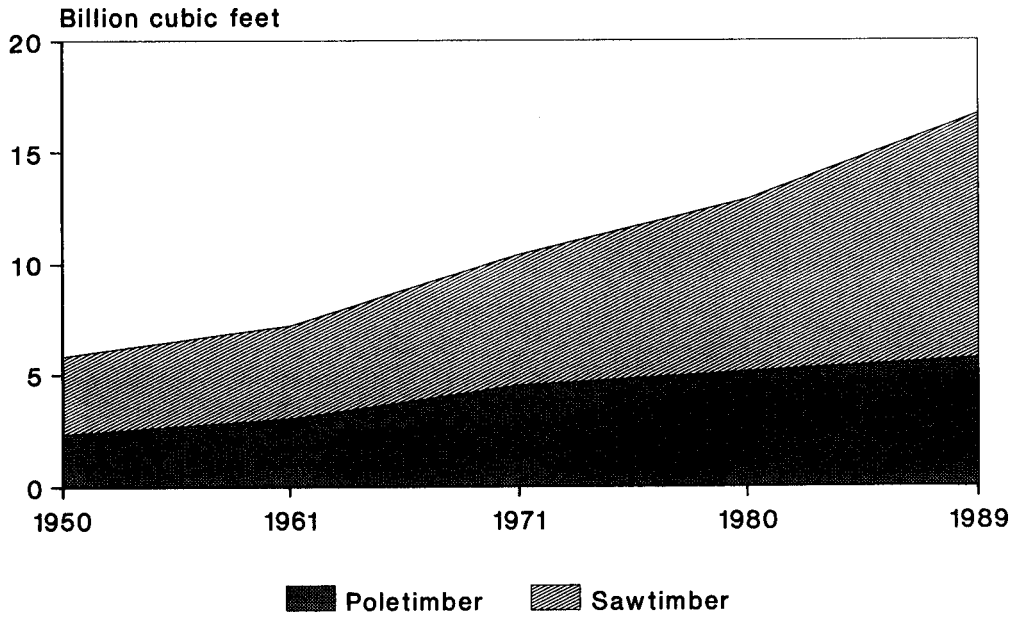


Figure 15.—*Volume of growing stock by tree-size class, Tennessee, 1950–89.*

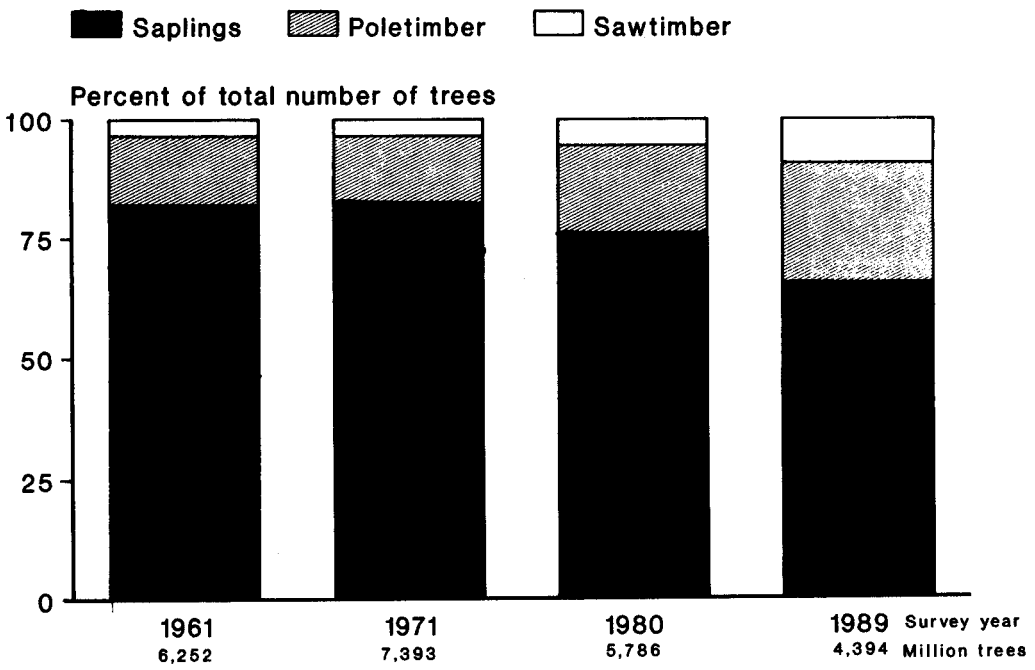
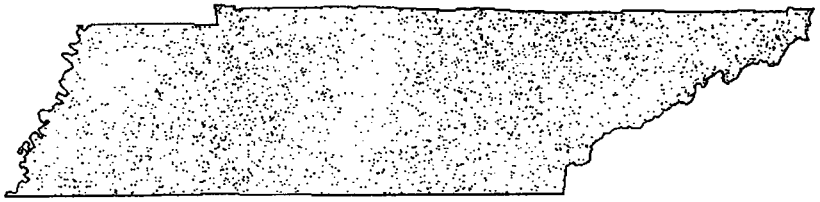


Figure 16.—*Proportion of growing-stock trees by tree-size class, Tennessee, 1961–89.*

concentrated in larger diameter classes (fig. 19), while its loss in tree numbers has occurred in diameter classes smaller than 8 inches (fig. 20). As might be expected of a maturing resource, the sawtimber inventory volume has increased appreciably since 1980 as well (fig. 21). Generally, all species of hardwoods have shared in the volume increase since 1980. Yellow poplar posted the largest volume gain and moved ahead of hickory as the State's third most voluminous species (fig. 17).

Softwood.—The State's inventory of softwood growing stock is made up mainly of yellow pine, which accounts for three-quarters of the total volume. Thus, the distribution of the softwood volume within the State mirrors that of the pine and mixed oak-pine forests, which contain about three-quarters of the entire softwood inventory. As with hardwoods, the distribution of individual species of softwood varies with the State's physiography, climate, and resulting growing conditions (fig. 22).

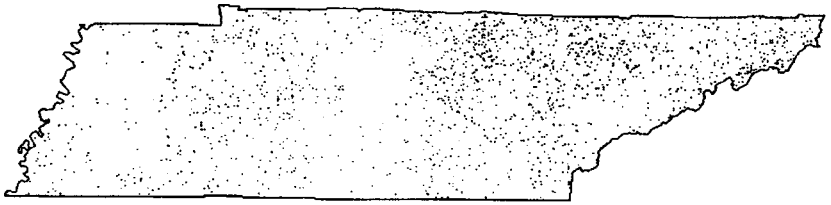
Hardwood growing-stock volume
1 dot = 5 million cubic feet



White oaks
1 dot = 1 million cubic feet
1

Red oaks
1 dot = 1 million cubic feet
2

Yellow poplar
1 dot = 1 million cubic feet
3



Sweetgum
1 dot = 1 million cubic feet
6

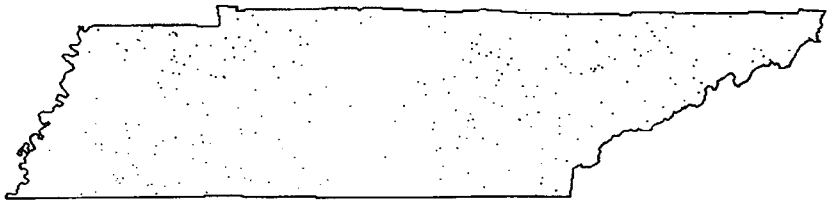
Hard maple
1 dot = 1 million cubic feet
7

Ash
1 dot = 1 million cubic feet
8

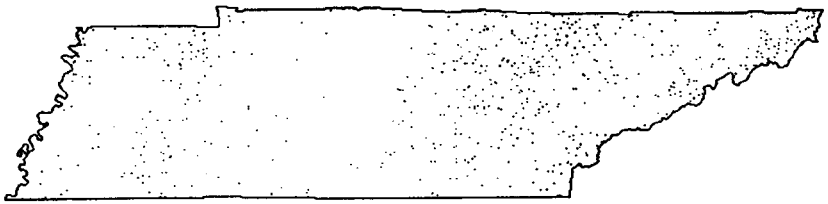
Beech
1 dot = 1 million cubic feet
9

Hickory
1 dot = 1 million cubic feet
4

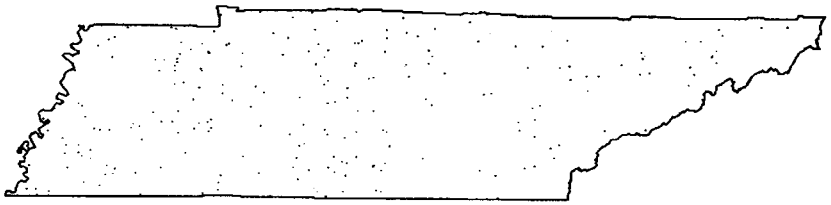
Blackgum
1 dot = 1 million cubic feet
10



Soft maple
1 dot = 1 million cubic feet
5



Elm
1 dot = 1 million cubic feet
11



Other hardwoods
1 dot = 1 million cubic feet
12

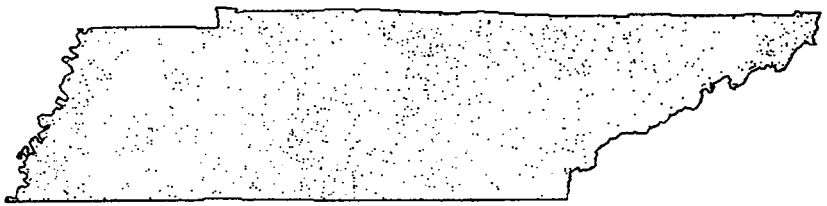


Figure 17.—*Distribution of hardwood growing-stock volume by species grouping and volume ranking of named species, Tennessee, 1989.*

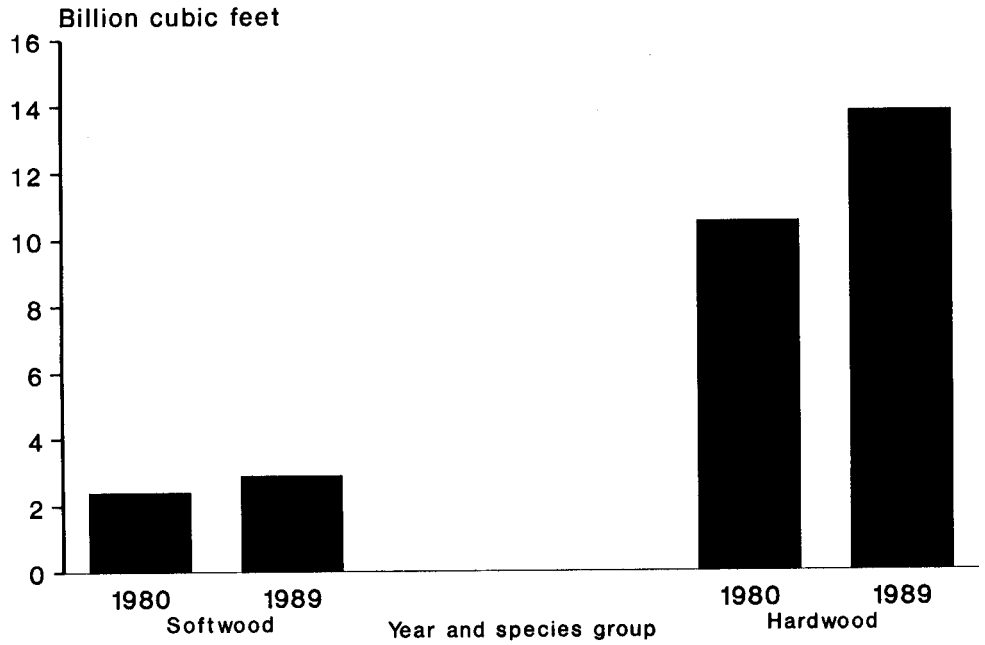


Figure 18.—*Volume of growing stock by species group, Tennessee, 1980 and 1989.*

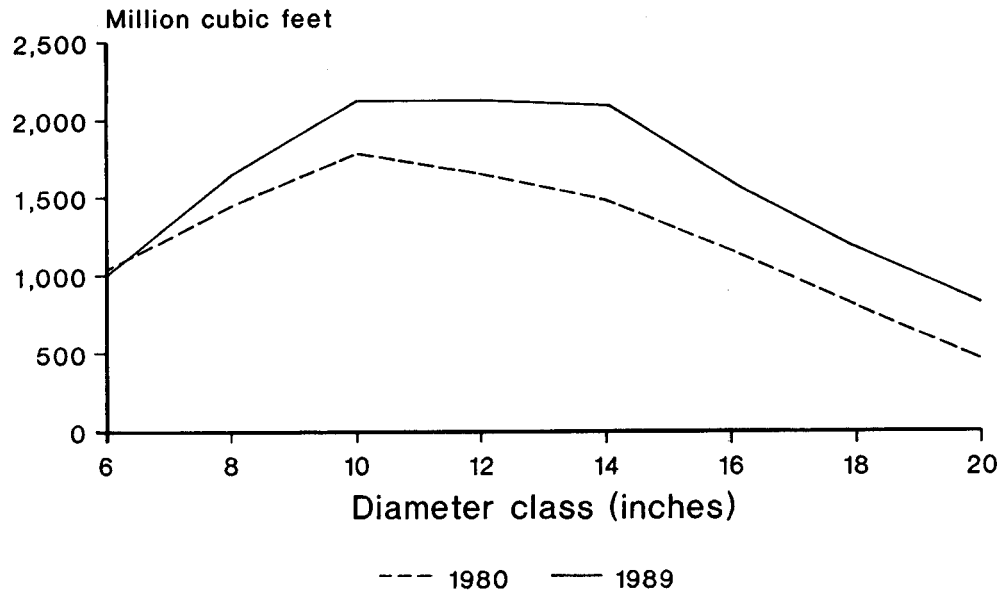


Figure 19.—*Volume of hardwood growing stock by diameter class, Tennessee, 1980 and 1989.*

In contrast to the general maturation of the hardwood resource, structural changes within the softwood resource have been more dynamic. Overall, softwood growing-stock volume has increased (fig. 18), mostly in the larger diameter classes (fig. 23). However, increments in loblolly pine volume have been concentrated in pole-size trees, and shortleaf pine volume has actually declined since 1980. The decline in shortleaf pine volume can be attributed to the loss of trees below the 14-inch class. Although 10-inch and smaller Virginia pines experienced a similar loss their volume did not decline. As a result, Virginia pine has surpassed shortleaf pine as the most voluminous softwood species in the State. The losses in trees associated with the maturing components of the softwood resource have been offset by an increase in naturally regenerated white pine, redcedar, and hemlock and by planted loblolly pines, resulting in a stable number of softwood growing-stock trees since 1980 (fig. 24).

Because of the maturing components of the softwood resource, sawtimber volume has also increased since 1980 (fig. 21). Specific trends in the sawtimber inventory are similar to those of the growing-stock inventory, generally because of the maturation and utilization of the natural pine resource and its gradual replacement by planted loblolly pine.

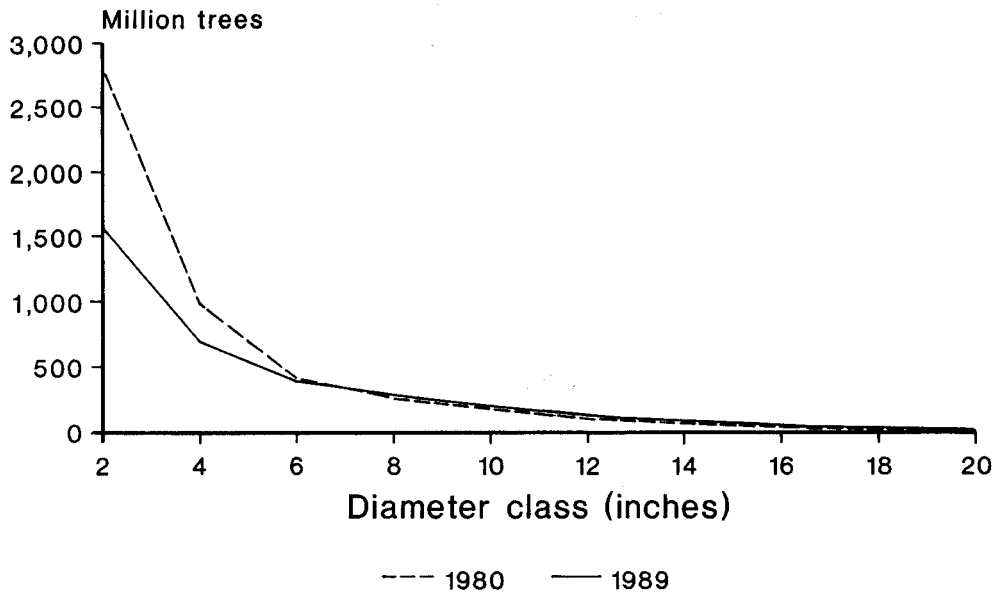


Figure 20.—*Number of hardwood growing-stock trees by diameter class, Tennessee, 1980 and 1989.*

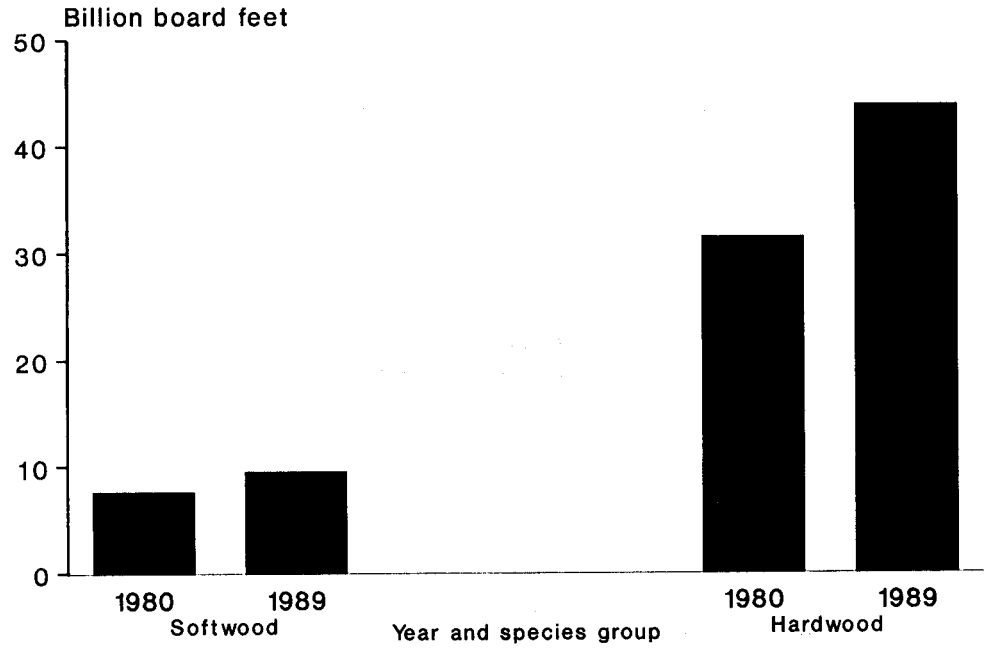


Figure 21.—*Volume of sawtimber by species group, Tennessee, 1980 and 1989.*

Ownership Trends.—Current development of both the hardwood and softwood inventories can be better understood by assessing the stand dynamics in each ownership class. In the public sector, the increasing volumes of both the softwood and hardwood inventories since 1980 (fig. 25) are due to their general maturation, during which volume gains were concentrated in the larger diameter trees and tree number losses were concentrated in the smaller diameter classes (fig. 26). However, the softwood resource has an increased number of small sapling-size trees, positioning the resource for future growth into the pole-size volume classes. Overall, because of the general maturation and volume buildup of these inventories, the public ownership class has the highest concentration of volume per acre of any ownership class.

A far different story is evident on forest-industry timberland. Emphasis on intensive pine management has been shifting the softwood resource from a natural to a plantation-based resource, resulting in a two-

Softwood growing-stock volume
1 dot = 5 million cubic feet

Yellow pine
1 dot = 1 million cubic feet
 # 1

White pine - Hemlock
1 dot = 1 million cubic feet
 # 2

Redcedar
1 dot = 1 million cubic feet
 # 3

Cypress
1 dot = 1 million cubic feet
 # 4

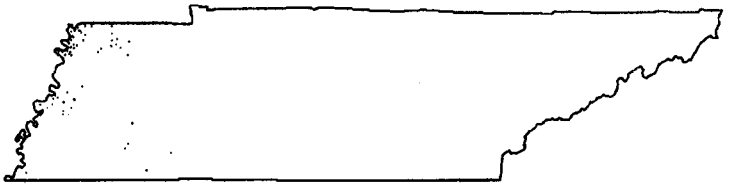


Figure 22.—*Distribution of softwood growing-stock volume by species grouping and volume ranking of named species, Tennessee, 1989.*

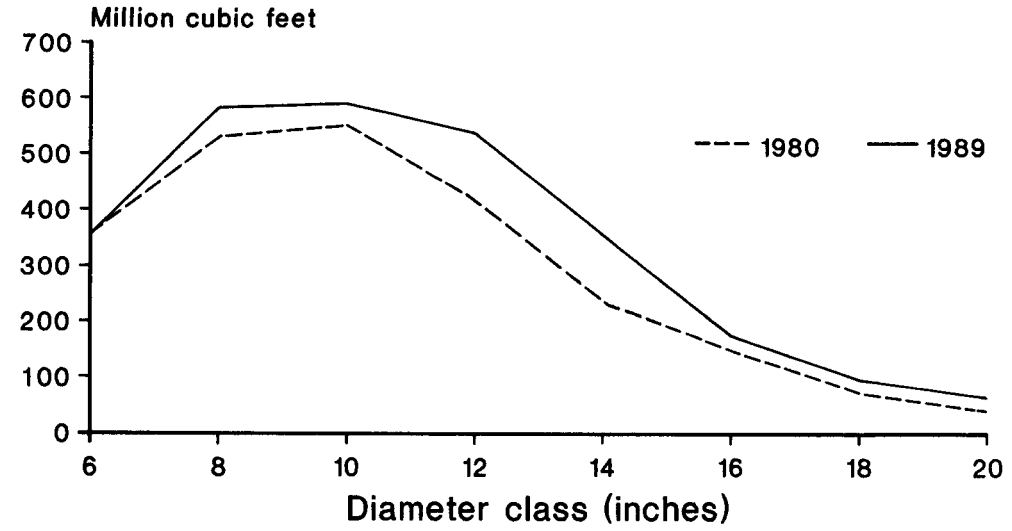


Figure 23.—*Volume of softwood growing stock by diameter class, Tennessee, 1980 and 1989.*

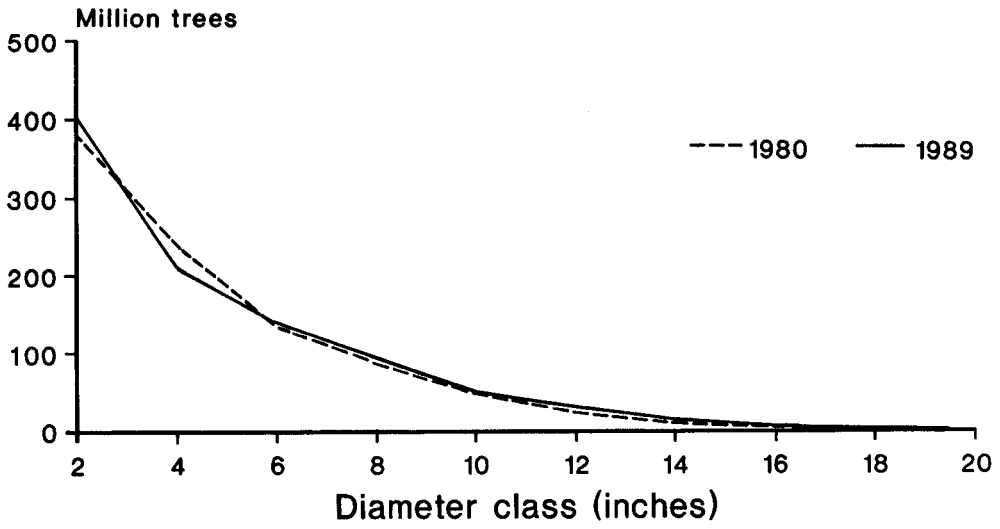


Figure 24.—*Number of softwood growing-stock trees by diameter class, Tennessee, 1980 and 1989.*

thirds increase in planted pine volume and a decrease in natural pine volume on forest-industry timberlands since 1980. This conversion of mature natural pine stands into young loblolly pine plantations has swelled the inventory of pole-size trees and decreased the inventory of sawtimber-size trees (fig. 27). Overall, the net result has been a slight increase in softwood volume since 1980. The conversion has also caused a buildup of sapling-size trees that will eventually grow across the 5-inch growing-stock volume threshold and ensure loblolly pine's increasing presence on forest-industry timberland in the future. This intensive pine management has also resulted in declining inventories of both hardwood growing-stock volume and hardwood regeneration, which will likely continue as pines are favored in management and hardwood stands are either converted to pine or sold.

Other private owners control most of the State's timberland and hence most of the growing-stock inventory as well (fig. 25). As a result, inventory trends in this ownership mirror those of the State totals. Generally, the inventory has followed the characteristic development of a maturing resource, with increasing volumes on fewer but larger trees (fig. 28). This development pattern in the softwood resource has caused a decline in both pole-timber volume and sapling numbers, the stock for future growth into pole timber. The failure of softwood regeneration, either through natural or artificial means, to keep pace with the maturation and utilization of the resource raises concern for the future. Overall, however, the general maturation of the resource holds some promise for increasing the concentration of volume per acre on other private holdings, currently the lowest of any ownership class.

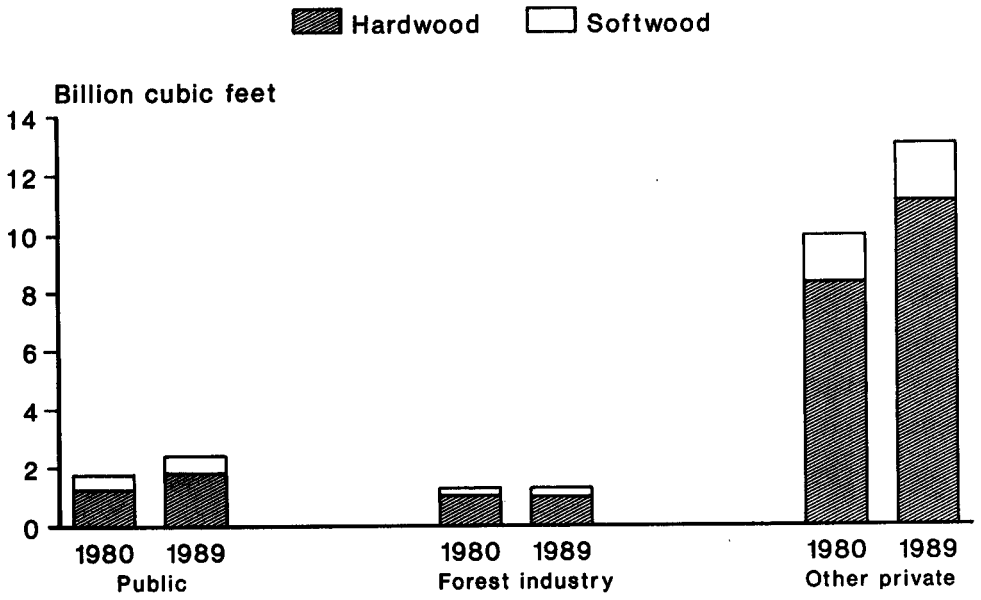


Figure 25.—*Volume of growing stock by ownership class and species group, Tennessee, 1980 and 1989.*

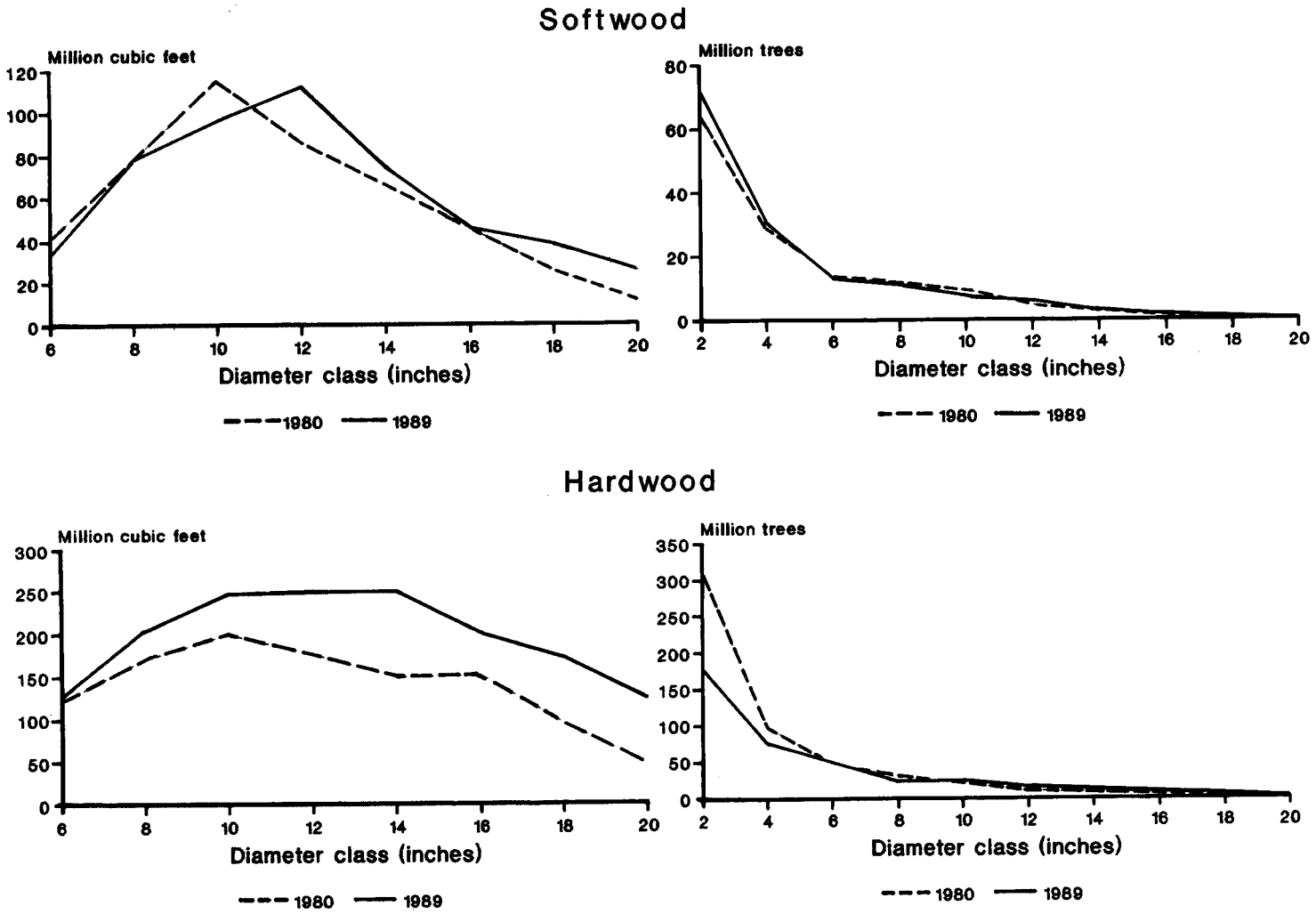


Figure 26.—*Volume and number of growing-stock trees on public timberland by diameter class and species group, Tennessee, 1980 and 1989.*

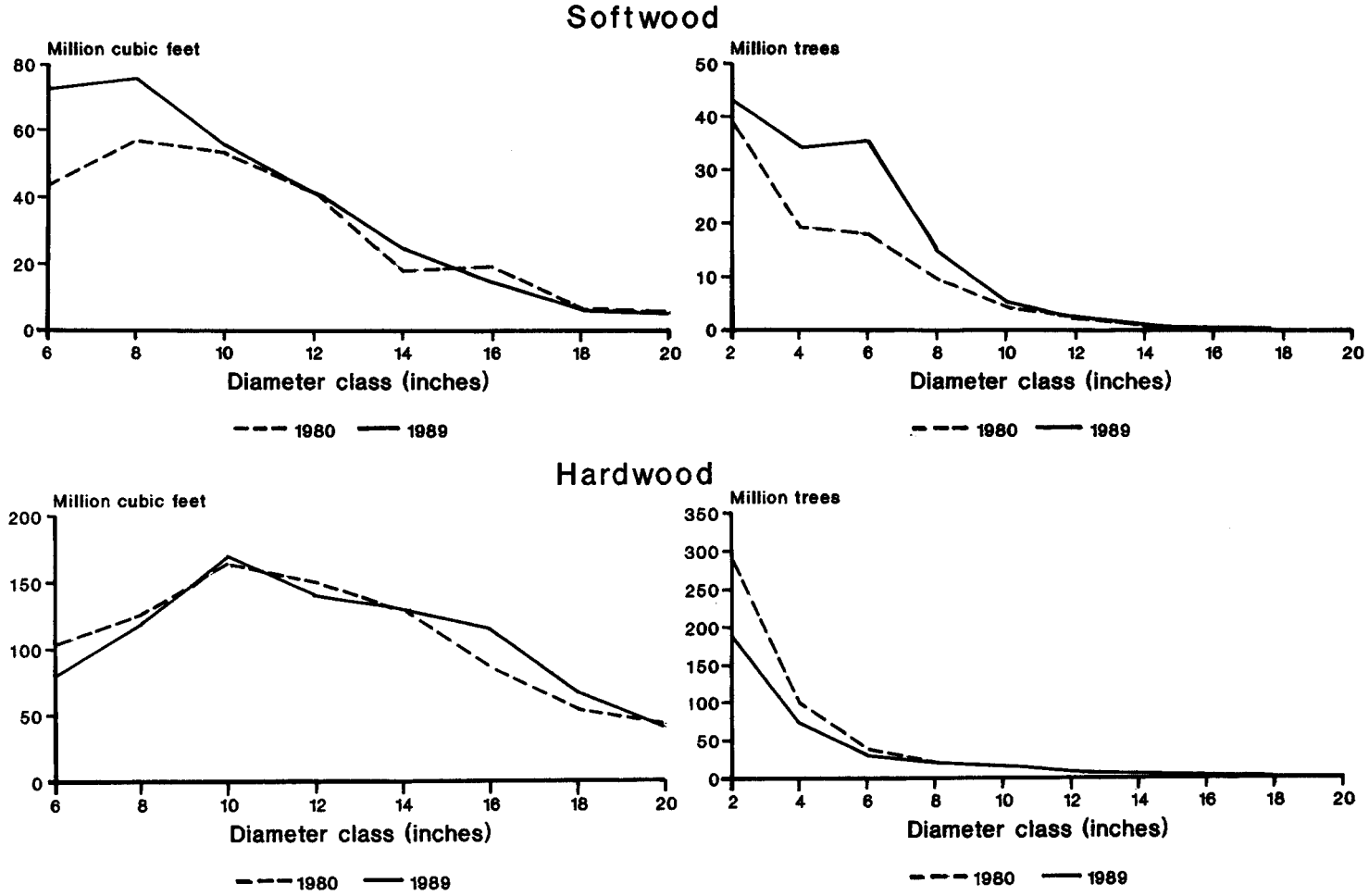


Figure 27.—*Volume and number of growing-stock trees on forest-industry timberland by diameter class and species group, Tennessee, 1980 and 1989.*

Live-Tree Volume

Growing-stock volume constitutes nine-tenths of the entire cubic-foot volume in live trees with 5-inch d.b.h. and larger (fig. 29). The remaining one-tenth of live-tree volume is made up of trees too rough or rotten to be classified as growing stock, including trees classified as rough because of their noncommercial status. Most of this cull volume is contained in hardwood species, most of which are classified as rough culls.

Since the first survey, the proportion of live-tree volume made up of cull trees has generally declined. This trend has continued since 1980, exemplifying the improving condition of the State's timber resource. Although considered cull, these trees contribute to the State's overall forest resource by providing increased fiber potential, mast, and wildlife cavities. Although these trees do not meet the growing-stock log requirements, many contain a short log of 8 to 11 feet. The volume in these short logs supplements the total sawlog supply in the State for mills that accepts logs of this size (table II).

Table II.—*Volume of short logs by species group and cull class, Tennessee, 1989*

Species group	Cull class		
	Rough cull	Rotten cull	Total cull
	*Million board feet**		
Softwood	94.8	1.8	96.6
Hardwood	1,197.5	159.8	1,357.3
Total	1,292.3	161.6	1,453.9

* International ¼-inch rule.

Biomass

Additional fiber potential exists in the crowns and limbs of Tennessee's timber trees as well as in its sapling-size trees themselves. These additional sources of fiber increase the biomass inventory of the State (fig. 30) by half. Nine-tenths of this additional biomass is contained within the hardwood portion of the resource, with the crowns and limbs of timber trees containing twice the biomass inventory of the sapling-size trees.

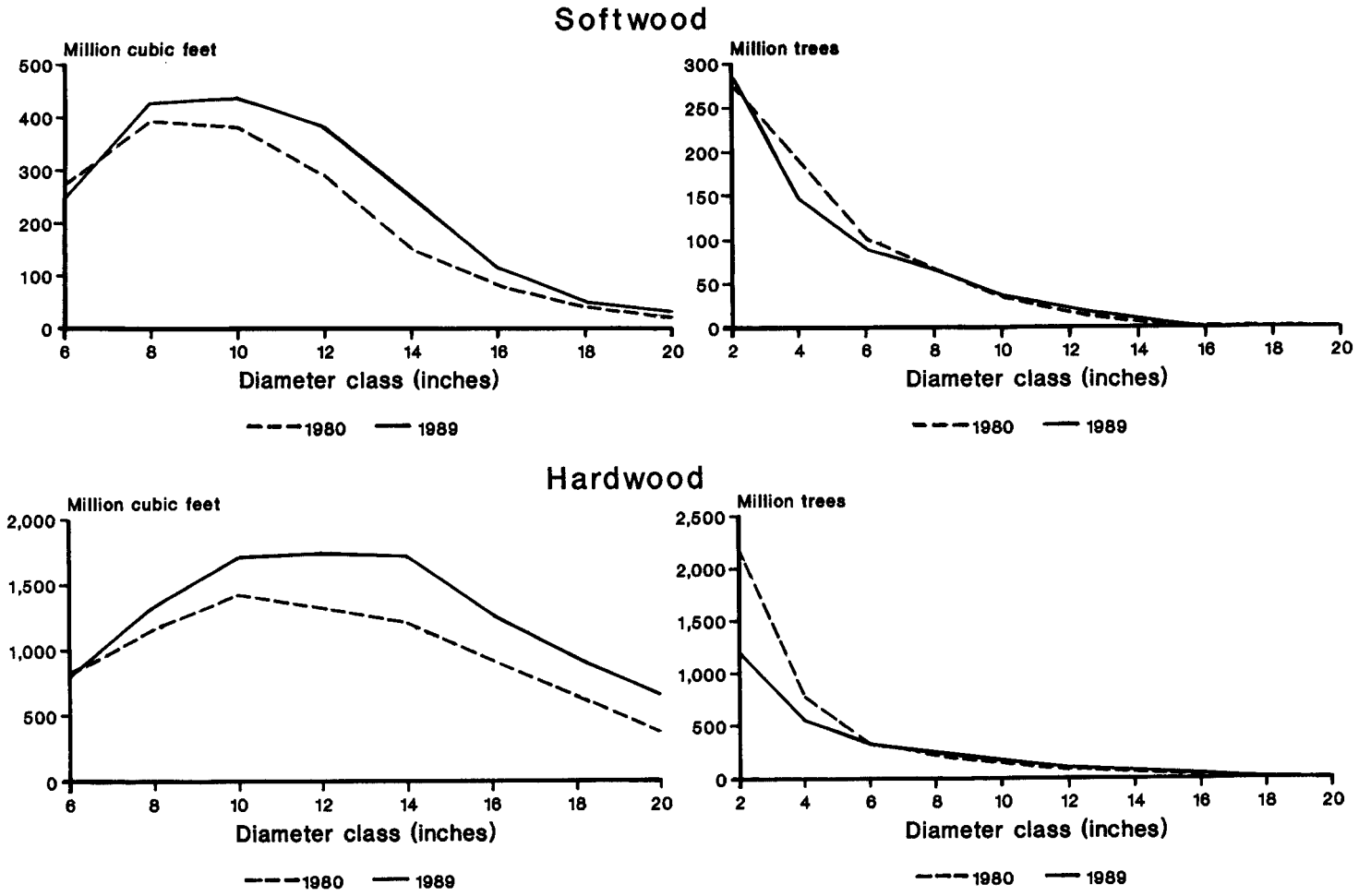


Figure 28.—*Volume and number of growing-stock trees on other private timberland by diameter class and species group, Tennessee, 1980 and 1989.*

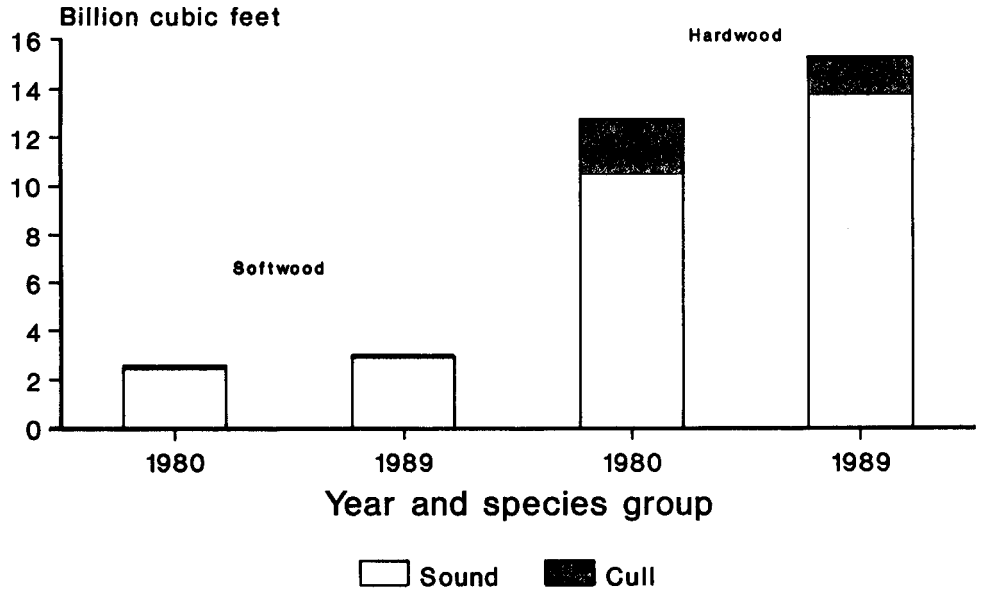
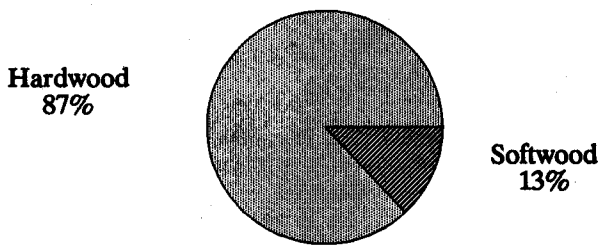
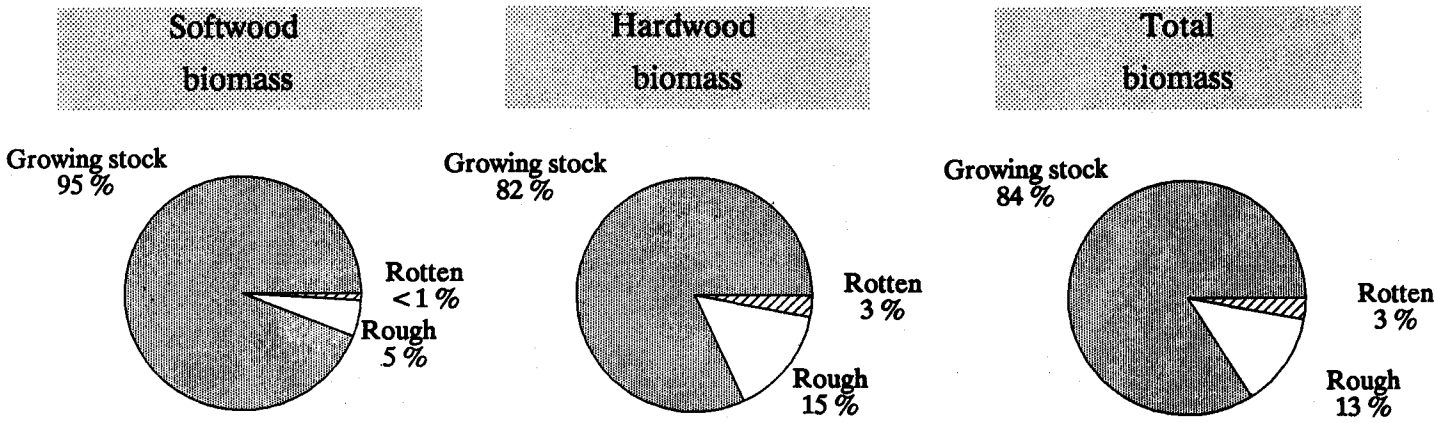


Figure 29.—*Volume of live timber on timberland by species group and class of timber, Tennessee, 1980 and 1989.*

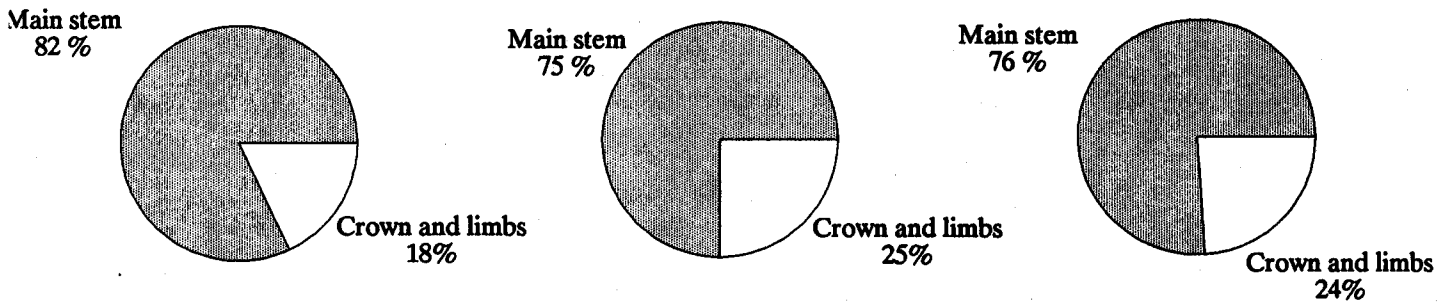
Total live biomass --1,191.8 million green tons



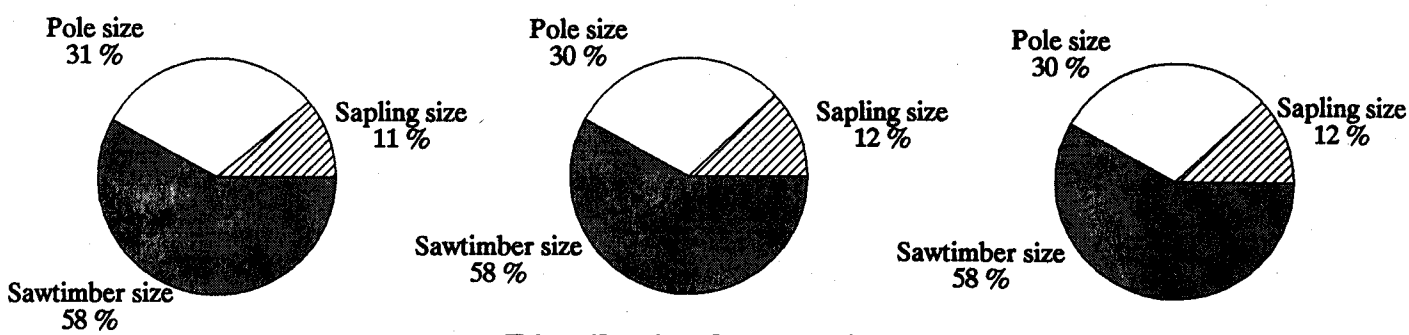
Distribution by species group



Distribution by tree class



Distribution by tree components



Distribution by tree size

Figure 30.—*Inventory of live biomass by species group, tree class, tree component, and tree size, Tennessee, 1989.*

Sawtimber Quality

The quality of the sawtimber inventory is of special interest, especially in a State where hardwoods comprise four-fifths of the sawtimber inventory. Unfortunately, the increased volume of the maturing hardwood resource has not been accompanied by an increase in quality. Since 1980, the hardwood volume in grade 1 has declined and the volume in grade 2 has increased only slightly (fig. 31). Together, grades 1 and 2 provide the basis for the State's hardwood lumber industry, but these grades have declined from 44 to 30 percent of the total hardwood inventory since 1980. The volumes in the two lowest grades (3 and 4) have increased substantially, however, with the volume in tie and timber quality trees, grade 4, doubling since 1980. Although some of these lower grade trees will provide the stock for future increases in the higher grades, the decline in the inventory of quality trees is a concern. The reasons for these trends can be seen in table III, which shows the components of volume change of each class of tree grade since 1980.

The inventory changes in each grade reflect that grade's gross growth, as affected by human-caused removals and natural mortality. Gross growth for each grade includes: (1) the volume change of trees that retained the same grade over time, (2) the volume of trees recruited into that grade over time, and (3) the volume of trees leaving that grade over time. As evidenced by the size of both the recruitment and attrition components for each grade, the volume increment within each grade is highly sensitive to the natural and human-caused factors influencing changes in tree sizes and defects over time. In both the recruitment and attrition components, the volume increment caused by the increased size and improved quality of lower grade trees has generally been exceeded by the volume increment caused by trees that, after peaking in quality, have been degraded by senescence, disease, insects, and other factors. As a result of this and the concentration of new tree recruitment volume in smaller size and lower quality trees, most of the gross growth since 1980 has been accumulated in the lower grades.

Removals are the main source of volume drain in all grades. Both removals and mortality levels are more intensive in the higher grades. As a result, more of the net inventory increase has shifted to the lower grades. Overall, growth is concentrated in the lower grades, and volume drain is concentrated in the higher grades.

To improve the quality of Tennessee's hardwood resources, growth and volume drain must be more advantageously distributed across all tree grades. Three types of action could be effective. First, more of the removals should be shifted to the lower grade trees. This method at first seems questionable; better grades of wood yield better products, which bring higher prices. However, with the development and implementation of new sawmill technologies, such as scanning/optimizing, edge-glue-rip, and saw-dry-rip (Haygreen and others 1986; Kellison 1986; Miller 1990), the quantity and quality of products recovered from each log processed could increase, reducing the need to cut as many higher grade trees. In addition, other new technologies make it possible to manufacture reconstituted wood panel and lumber products from low-quality hardwoods, which could also help reduce the reliance on higher grade trees. Second,

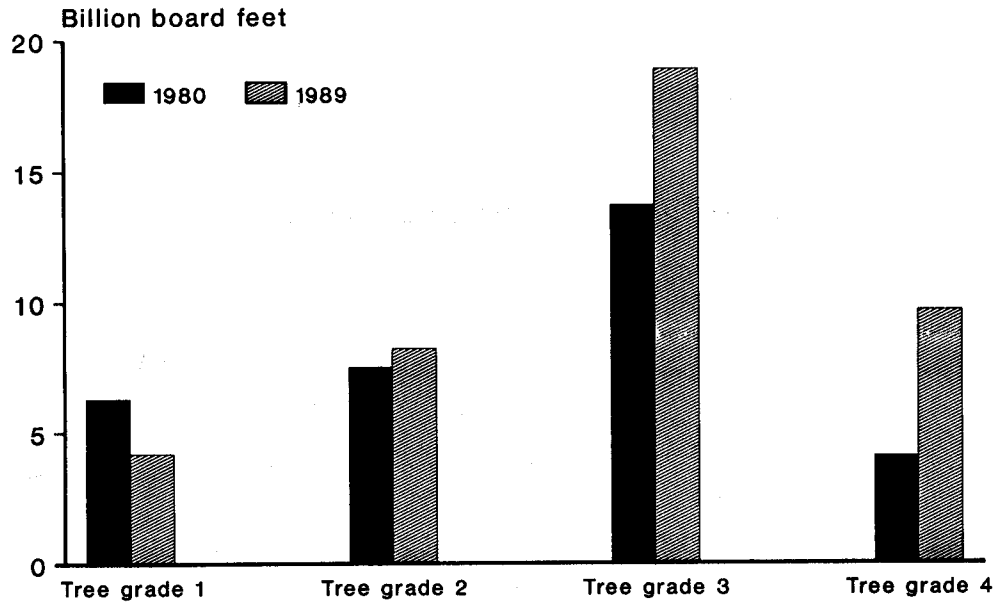


Figure 31.—*Volume of hardwood sawtimber on timberland by tree grade, Tennessee, 1980 and 1989.*

Table III.—*Average annual components of volume change of hardwood tree grades, Tennessee, 1980–89*

Tree grade	Survivor volume change	Recruitment: Volume from lower grade trees	Recruitment: Volume from higher grade trees	Recruitment: Volume from new sample trees	Attrition: Volume to lower grade trees	Attrition: Volume to higher grade trees	Gross growth	Volume drain: Removals	Volume drain: Mortality	Net volume change	Inventory volume
	*Million board feet**										
1	26.4	191.3	.....	101.1	−315.6	.....	3.2	158.9	58.3	−214.0	4,176.9
2	42.3	337.3	151.2	212.8	−330.4	−97.0	316.2	167.9	56.1	92.2	8,187.4
3	160.8	287.1	336.9	810.9	−324.9	−268.1	1,002.7	255.0	121.6	626.1	18,930.3
4	50.6	113.9	415.2	409.6	−25.9	−194.5	769.1	84.8	35.5	648.8	9,655.9

* International ¼-inch rule.

mortality should be prevented, reduced, or captured when economically justified. Mortality control will likely become more important and viable as the State's hardwood resource continues to mature. Last, management activities that promote the growth and quality of preferred species should be adopted. Doing so will shorten the time the trees need to meet minimum grade-size requirements so that a maximum amount of defect-free wood can be accumulated more quickly. Also, sawtimber-size trees will be recruited into higher grades sooner and their attrition from higher grades slowed, and pole-size trees will be positioned to enter sawtimber size at the highest possible grades and with the greatest potential for future improvements.

Although the trends are not promising, a sizable volume of quality hardwood timber still exists in Tennessee that can meet industry's current demands, while steps are taken to reverse the downward trend in quality. The distribution of this high-quality hardwood sawtimber within the State is portrayed in figure 32. An additional, but unknown, volume of high-quality hardwood sawtimber is also contained in the upper logs of trees with nongradeable butt logs.

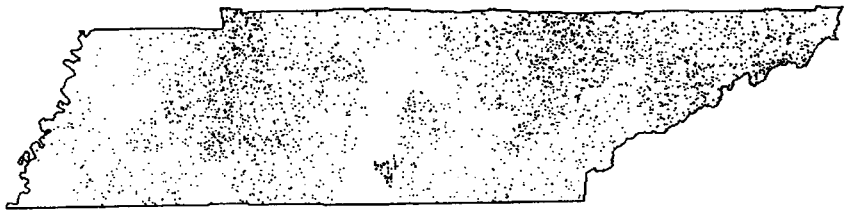
For the softwood resource, where quality is largely a function of size, the situation is better (fig. 33). Since 1980, the volume of lower grades has generally increased, while grade 1 volume has remained unchanged, largely because of the shifting species composition of the yellow pine resource. The replacement of the mature shortleaf resource with younger loblolly pine plantations has resulted in a loss of higher grades and an influx into lower grades as the plantations grow to sawtimber size. Also, the increasing volume of Virginia pine, with its inherent form and branching characteristics, has helped swell the lower grades.

Basal Area

The average basal area per acre, an expression of the density of trees on Tennessee's timberland (Appendix, table 6), has not changed appreciably since 1980. Three-quarters of the basal area remains in growing-stock trees, of which hardwoods still make up more than four-fifths. What has changed significantly is the distribution of basal area among tree-size classes. As the State's timber resource has matured, the basal area has shifted from the smaller size classes to the sawtimber-size class, which now contains almost half of the basal area. This shift is most prevalent in the maturing hardwood portion of the resource and holds for all owners except the forest industry. On forest-industry timberland, the conversion of mature natural pine stands and hardwood stands to pine plantations has caused a general decline in the presence of hardwoods and shifted the softwood basal area from the

Hardwood sawtimber
1 dot = 10 million board feet

White oaks
1 dot = 1 million board feet
1

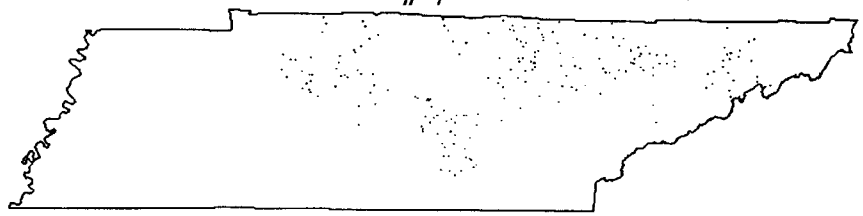


Red oaks
1 dot = 1 million board feet
2

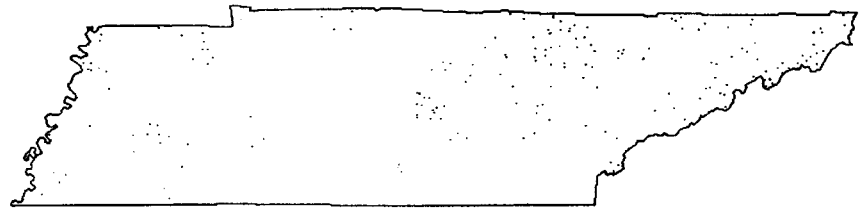
Yellow poplar
1 dot = 1 million board feet
3

Ash
1 dot = 1 million board feet
6

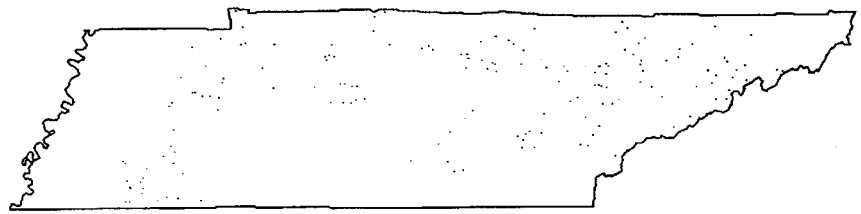
Hard maple
1 dot = 1 million board feet
7



Soft maple
1 dot = 1 million board feet
8



Blackgum
1 dot = 1 million board feet
9



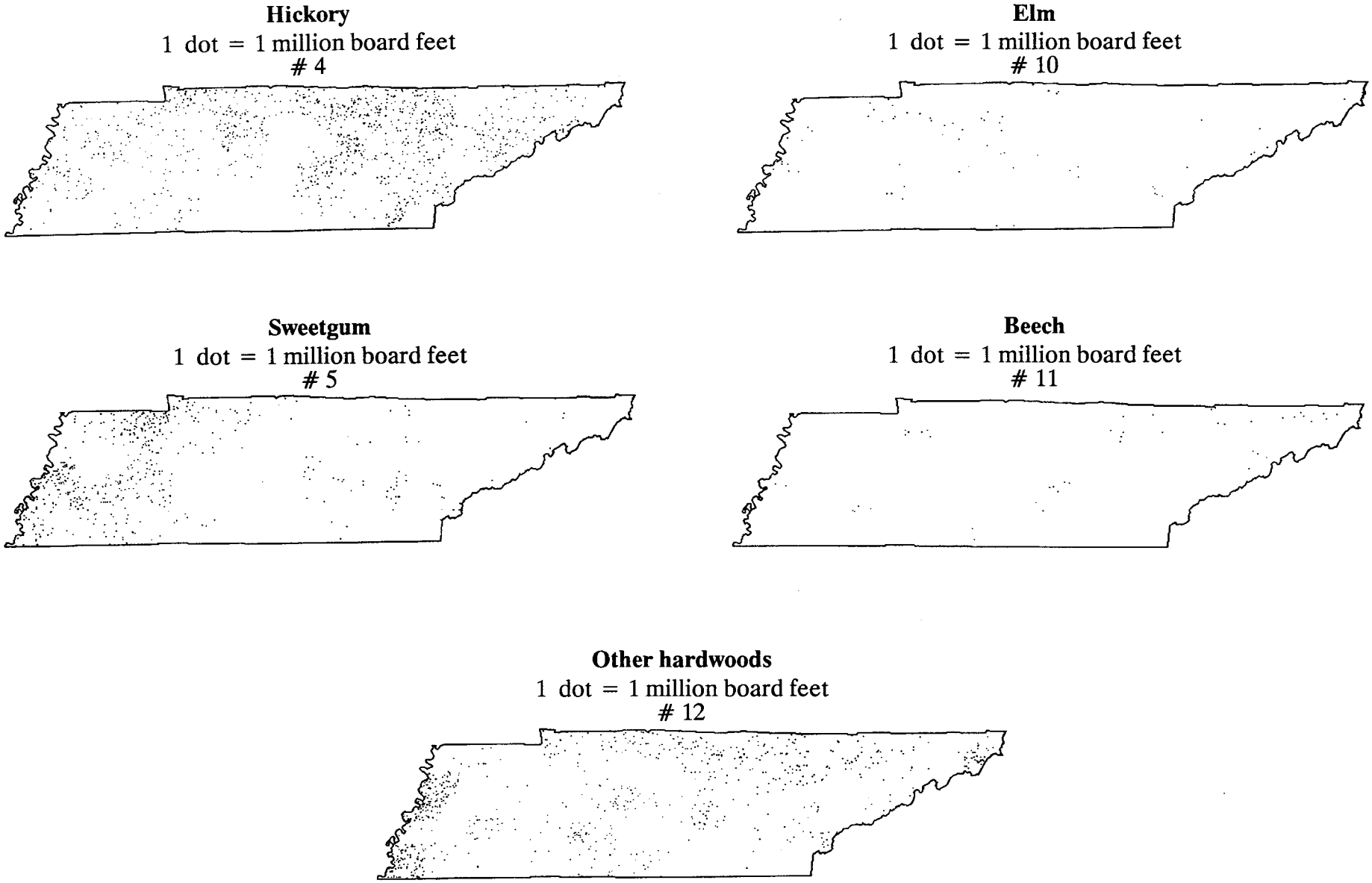


Figure 32.—*Distribution of grade 1 and 2 hardwood sawtimber by species grouping and volume ranking of named species, Tennessee, 1989.*

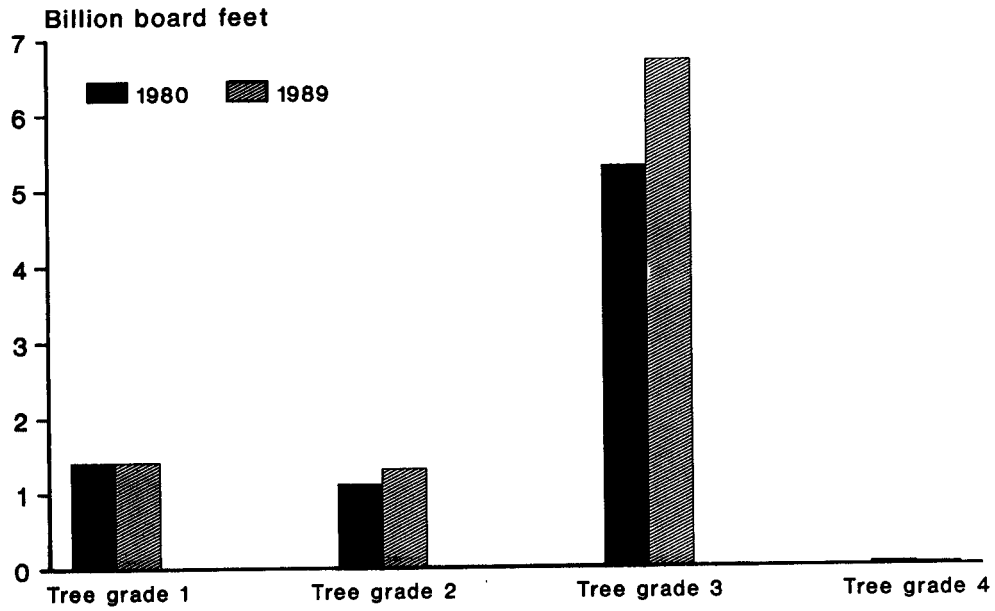


Figure 33.—*Volume of softwood sawtimber on timberland by tree grade, Tennessee, 1980 and 1989.*

sawtimber-size to the pole-size and sapling-size classes. This shift has been dramatic; the basal area has doubled for poles and increased by two-thirds for saplings since 1980.

Species Ranking

Phytographs are used to depict the relative importance of each tree species or species group recorded in the State based on its proportional contribution to the State totals for each of four inventory attributes: (1) number of live trees, (2) live-tree volume, (3) basal area, and (4) sawtimber volume (fig. 34). Ranking of the relative importance of each species is based on the area within the polygon constructed by graphing, on the appropriate axis, proportional contributions of each species to each of the four inventory attributes and connecting the points with solid lines. The species are ranked from left to right down the page from most to least important.

In addition to ranking the relative importance of each species, the differing shapes of the polygons reflect the relative position of each species within the general stand structure of the State's timberland, as exemplified by the difference in shape between yellow-poplar and red maple. Although both species rank as highly important components of Tennessee's timberland, they obviously are occupying different structural positions within the timberland. More than 100 tree species and species groups were recorded during the 1989 survey (see Appendix), but many are not considered important components of the State's timberland in terms of the four inventory attributes selected, as exemplified by the fact that the 3 top-ranked species account for close to half of the total accumulated area within the polygons and the 10 top-ranked species account for about three-quarters of the total area.

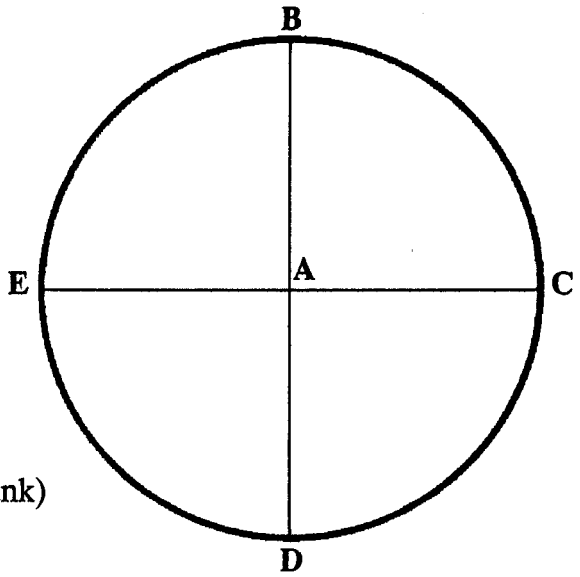
Timber Availability

These reported inventory statistics provide an estimate of the wood volume existing on the State's timberland. Not all of this reported inventory is necessarily available for harvest. The factors affecting wood availability are varied and include landowner attitudes, operability constraints, economic conditions, and legal restrictions. These factors must be taken into consideration when assessing potential timber supplies from reported inventory statistics.

For example, a substantial difference exists between the reported and available inventories of Tennessee's upland hardwood resource (table IV). The difference is due initially to discounting the reported inventory for stands that are not currently profitable to log. The determination of profitability was based on a comparison of revenues and costs associated with harvesting wood from upland hardwood stands and delivering it to the nearest wood-using mill. The costs and revenues were derived from wood price reports and cost predictions based on the size and volume of harvested wood, the distance the wood was hauled, and production functions of a conventional logging system working under typical logging conditions.[1] Under these

[1] May, Dennis M.; LeDoux, Chris B. Assessing economic availability of upland hardwood forests in Tennessee. Unpublished manuscript. On file at USDA FS, Southern Forest Experiment Station, Starkville, MS 39759.

Figure 34.—*Phytographs ranking the relative importance of individual tree species and species groups, Tennessee, 1989.*



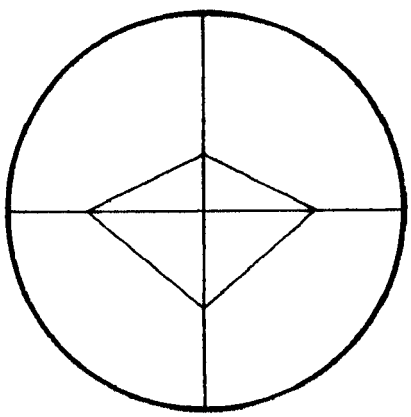
Species/species group polygon area (basis for rank)

AXIS A-B - Ranges from 0 to 20 percent and represents the number of live trees of a given species expressed as a percentage of the total number of live trees in the State.

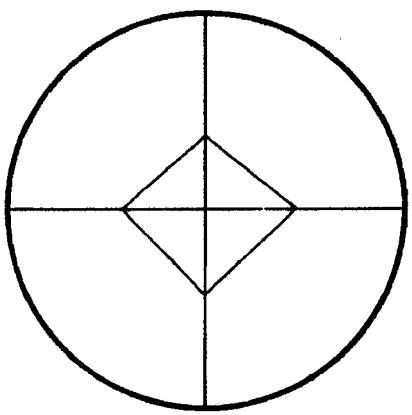
AXIS A-C - Ranges from 0 to 20 percent and represents the live-tree volume of a given species expressed as a percentage of the total live-tree volume in the State.

AXIS A-D - Ranges from 0 to 20 percent and represents the basal area of a given species expressed as a percentage of the total basal area in the State.

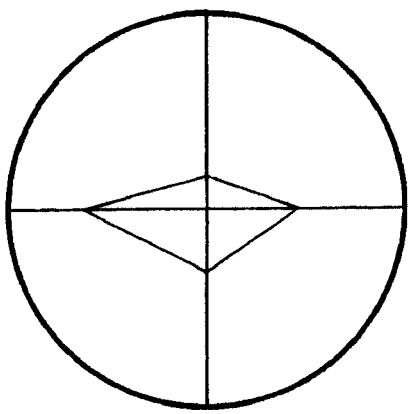
AXIS A-E - Ranges from 0 to 20 percent and represents the sawtimber volume of a given species expressed as a percentage of the total sawtimber volume in the State.



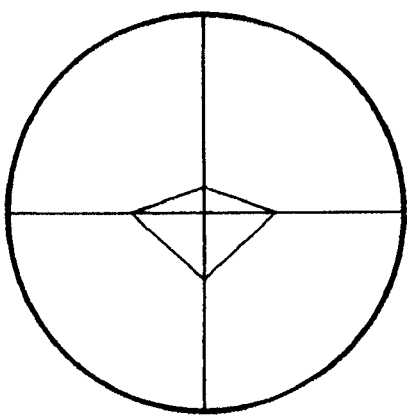
White oak
178.968



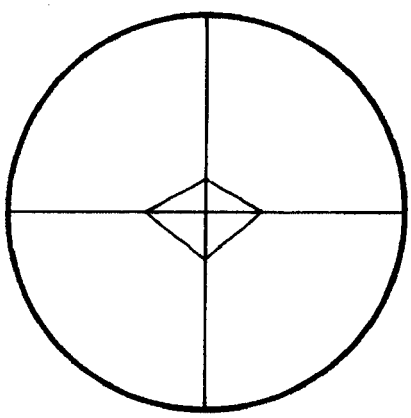
Hickory
142.111



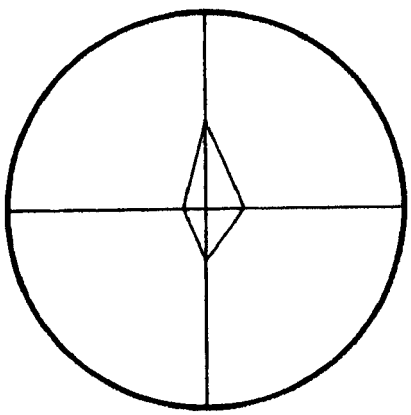
Yellow poplar
106.934



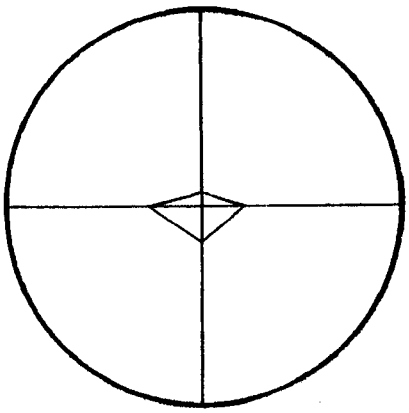
Chestnut oak
68.278



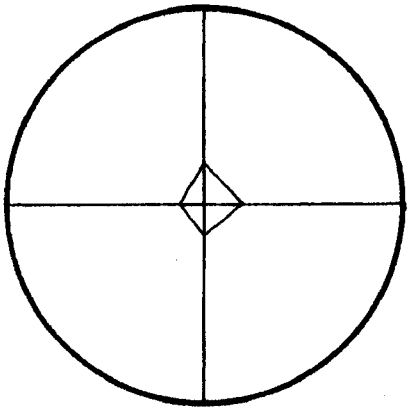
Virginia pine
47.479



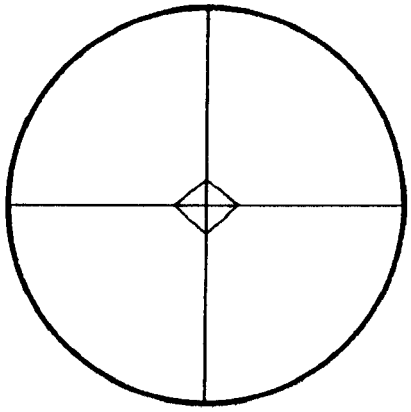
Red maple
43.410



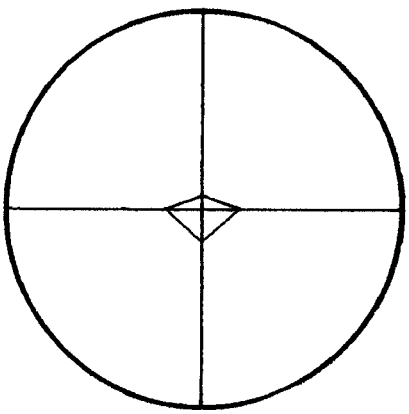
Black oak
24.838



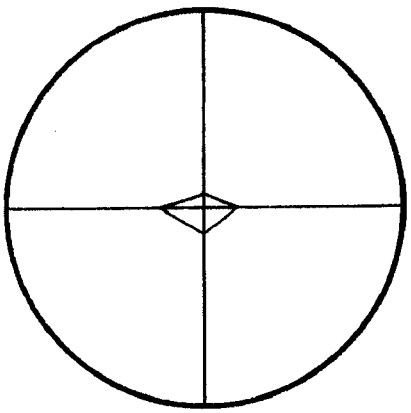
Sugar maple
23.635



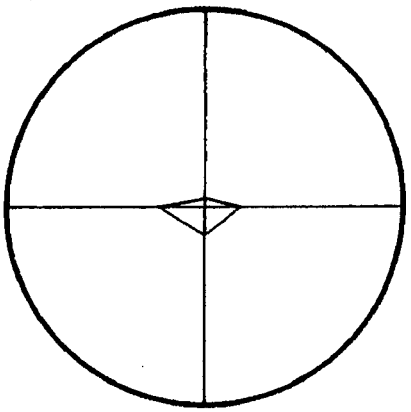
Sweetgum
18.070



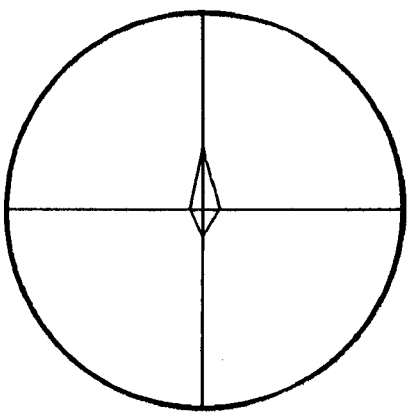
Scarlet oak
17.662



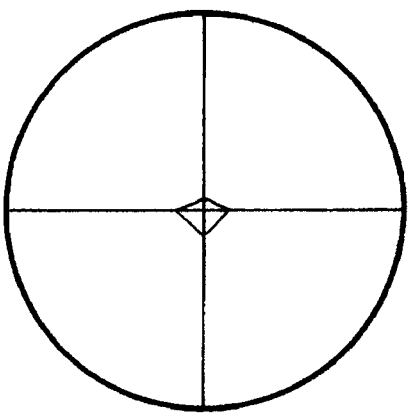
Shortleaf pine
16.198



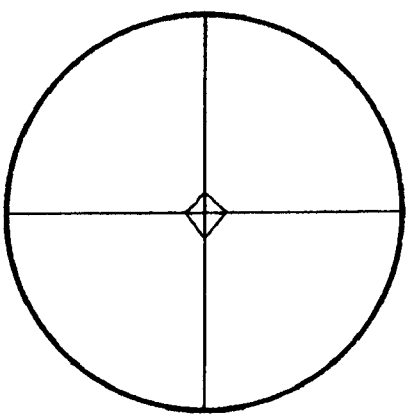
Northern red oak
15.809



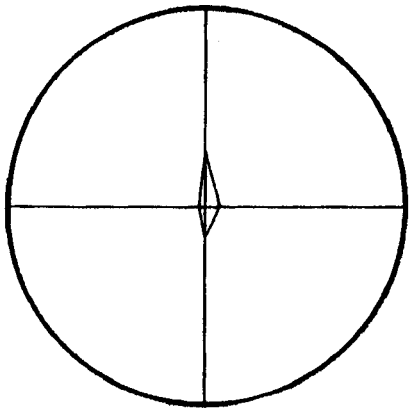
Blackgum/tupelo
13.772



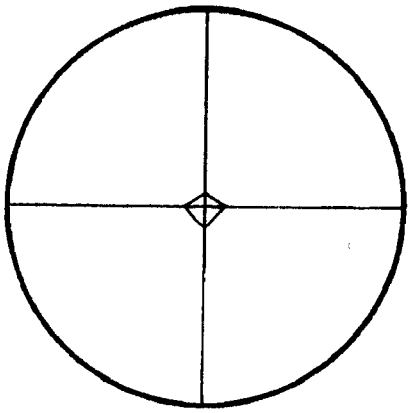
Southern red oak
10.586



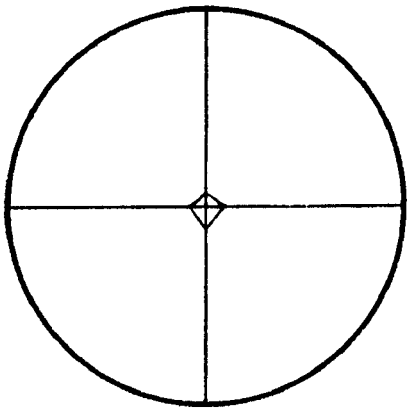
Loblolly pine
9.715



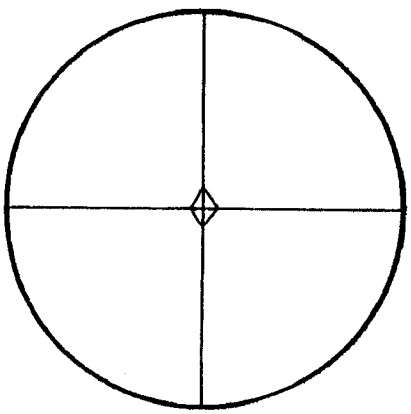
Eastern redcedar
9.437



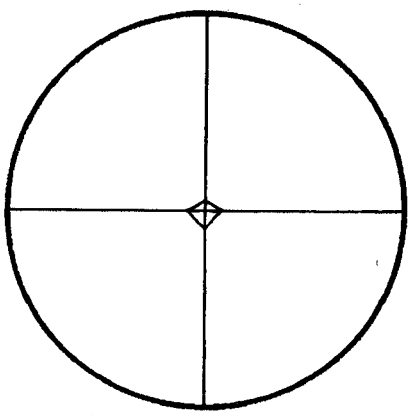
American beech
7.552



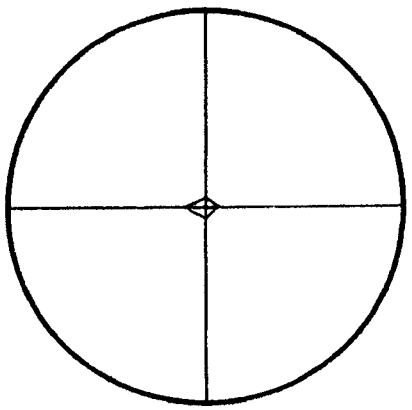
Post oak
6.558



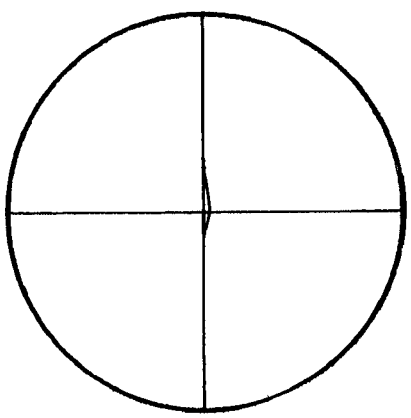
White ash
5.653



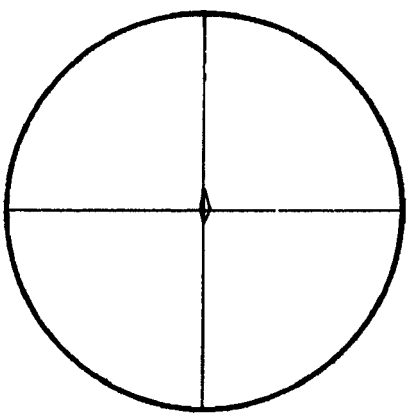
Other oaks
5.076



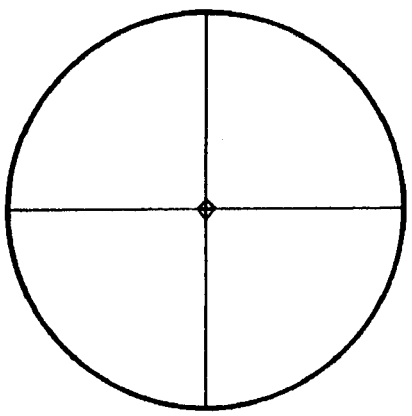
Eastern white pine
3.773



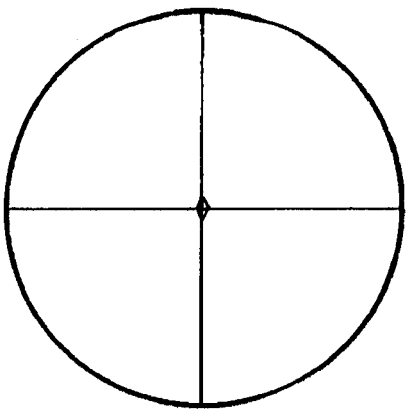
Sourwood
2.686



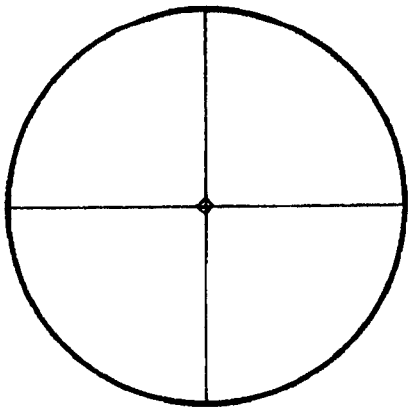
Sassafras
1.964



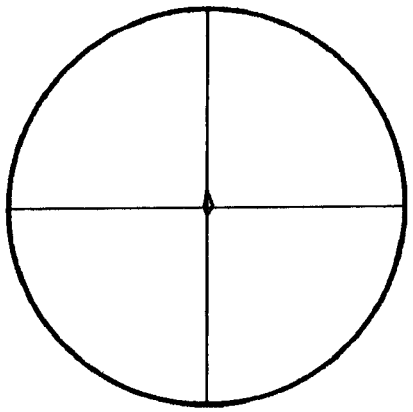
Green ash
1.851



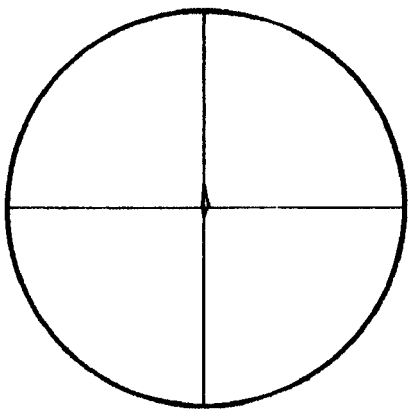
Hackberry/sugarberry
1.533



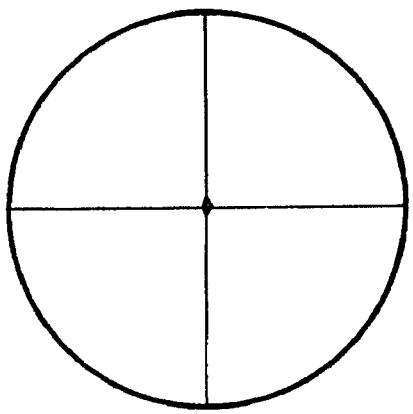
Eastern hemlock
1.422



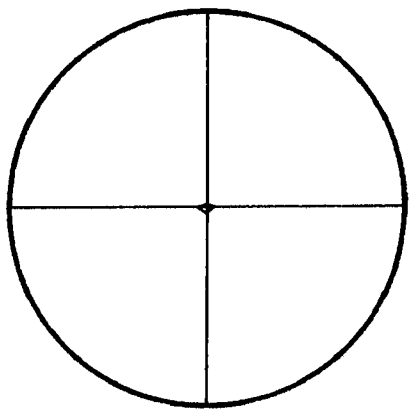
Black cherry
1.312



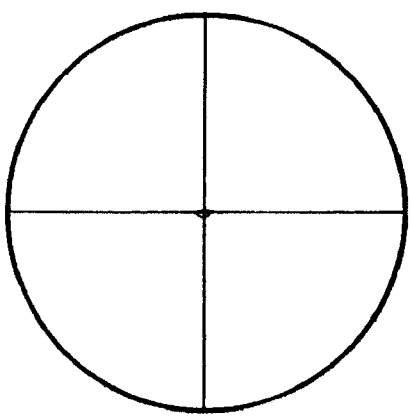
Winged elm
1.236



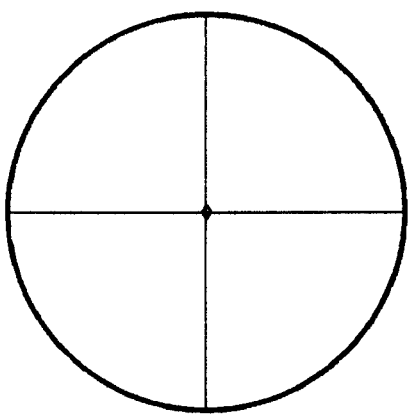
American elm
0.947



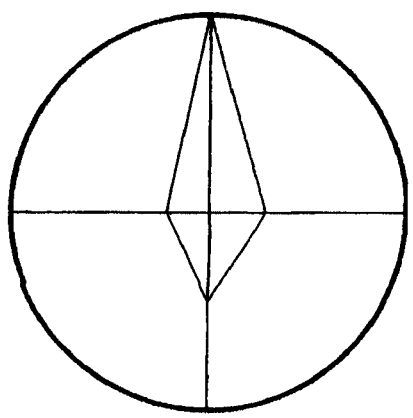
Baldcypress
0.904



Cherrybark oak
0.847



Black locust
0.708



Other species
145.987

Table IV.—*Estimated area and volume of upland hardwood forests available for harvest using conventional logging systems, under average wood price and landowner attitude assumptions, Tennessee, 1989*

Inventory attributes	Unit of measure	Reported inventory	Profitable to log inventory	Percent of reported inventory	Available inventory	Percent of reported inventory
Timberland	*Thousand acres*	9,587.9	4,912.7	51	2,735.3	29
Growing-stock volume	*Million cubic feet*	12,138.1	8,822.1	73	4,967.5	41
Sawtimber volume	*Million board feet**	39,363.4	31,988.6	81	17,997.6	46

* International ¼-inch rule.

assumptions, about half of the upland hardwood timberland, containing three-quarters of the reported inventory volume, was considered profitable to log.

Being profitable to log does not necessarily mean the inventory is available for harvest; therefore, the profitable inventory was discounted further to account for landowner attitudes. In determining the willingness of landowners to harvest timber, the assumption was made that timber harvesting would occur on forest-industry timberland and that timber production would remain one of the multiple benefits derived from public timberland. However, most of Tennessee's upland hardwood timberland is in other private ownership, an ownership group composed of diverse owners with varying ownership objectives, of which timber production is only one of many. Consequently, this ownership group has been the subject of recent studies to determine the willingness of these owners to sell or not sell timber and the reasons for their decisions.

In 1976, a study in central Tennessee showed that almost 60 percent of the timberland held by other private owners was available for harvest (Wells 1977). A more recent statewide study revealed that less than half (45.7 percent) of the timberland held by these owners would be available in the near future.[2] Applying this latest percentage to the inventory considered profitable to log in other private ownership resulted in the final available inventory estimate for Tennessee's upland hardwood resource.

Although substantially smaller than the reported inventory, the available inventory is still large enough to meet the harvest demands placed upon it. The magnitude of the reduction emphasizes the importance of accounting for the factors that affect wood availability when assessing timber supplies from reported inventory statistics.

[2] Baird, A. W.; Doolittle, Larry. 1990. Nonindustrial private forest owners and resources of Tennessee. Starkville, MS: Social Sciences Center, Mississippi Agricultural and Forestry Experiment Station, Mississippi State University. Final report; cooperative agreement FS-SO-4801-1-90-32. On file at USDA FS, Southern Forest Experiment Station, Starkville, MS 39759.

GROWTH, MORTALITY, AND REMOVALS

Since the first forest survey in 1950, the State's inventory of growing-stock volume has steadily increased and its timberland base has remained relatively stable. This favorable trend exists because, on the whole, the volume increment of the inventory has exceeded the volume drain caused by natural mortality and human-caused removals. Because of this favorable growth-to-drain ratio, a positive net change has occurred in the inventory over time. Much the same can be said of the volume change in the inventory since 1980, which can be examined in detail by analyzing current 1980-89 estimates of average annual gross growth (sum of survival growth, ingrowth, growth on cut and mortality, and cull increment), net growth (gross growth minus mortality), and net change (net growth minus removals) (tables V, VI) and the change occurring in the estimates since the 1971-80 survey (figs. 35, 36).

Gross Growth

The improving condition of Tennessee's timberland has allowed more of the growth potential of these acres to be used by a more optimal number of growing-stock trees of preferred species. Gross growth has thus increased (figs. 35, 36), which is one of the main reasons for the growing-stock inventory's continued increase in volume since 1980. Because hardwoods comprise such a dominant share of the State's timber resource, they also constitute most of the inventory's annual gross growth. This hardwood growth has been concentrated in larger size trees because of the maturing nature of the hardwood resource and the reduced level of ingrowth into growing stock (fig. 37).

Softwood gross growth, on the other hand, has tended to be concentrated in smaller size trees (fig. 38). However, the buildup of growth in the smaller size classes because of the proliferation of young plantations on forest-industry holdings has been countered by the lack of ingrowth on public and other private

Table V.—*Components of average annual change in the volume of growing stock by species group and survey region, Tennessee, 1980–89**

Survey region	Species group	Survivor growth[†]	Ingrowth[‡]	Growth on removals	Growth on mortality	Cull increment[§]	Mortality	Timber removals	Land-clearing removals	Net change
		Million cubic feet								
West	Softwood	9.4	2.5	1.6	0.8	0.4	2.9	5.9	0.2	5.7
	Hardwood	86.3	8.2	2.2	4.5	24.8	23.9	20.0	8.4	73.7
	Total	95.7	10.7	3.8	5.3	25.2	26.8	25.9	8.6	79.4
West-Central	Softwood	6.1	2.1	1.5	0.9	0.1	2.3	6.7	1.7	.....
	Hardwood	72.0	7.5	5.4	4.3	16.1	22.7	41.4	1.4	39.8
	Total	78.1	9.6	6.9	5.2	16.2	25.0	48.1	3.1	39.8
Central	Softwood	3.7	2.3	0.1	.....	1.3	0.5	0.8	0.3	5.8
	Hardwood	76.7	8.0	3.1	4.8	21.8	19.3	23.6	5.4	66.1
	Total	80.4	10.3	3.2	4.8	23.1	19.8	24.4	5.7	71.9
Plateau	Softwood	27.6	6.7	1.7	1.5	2.1	8.2	7.5	1.4	22.5
	Hardwood	92.8	12.6	4.5	4.5	30.0	23.1	33.6	6.1	81.6
	Total	120.4	19.3	6.2	6.0	32.1	31.3	41.1	7.5	104.1
East	Softwood	46.1	5.8	3.6	3.9	0.9	18.9	21.4	6.4	13.6
	Hardwood	114.8	12.2	2.2	5.1	26.9	24.6	16.3	10.9	109.4
	Total	160.9	18.0	5.8	9.0	27.8	43.5	37.7	17.3	123.0
All regions	Softwood	92.8	19.4	8.5	7.0	4.8	32.8	42.3	9.9	47.5
	Hardwood	442.6	48.6	17.4	23.1	119.6	113.6	135.1	32.1	370.5
	Total	535.4	68.0	25.9	30.1	124.4	146.4	177.4	42.0	418.0

* Rows and columns may not sum to totals due to rounding.
[†] Includes nongrowth trees.
[‡] Includes ongrowth trees.
[§] Includes trees that changed tree class due to a change in the definition of growing stock (see Appendix).

Table VI.—*Components of average annual change in the volume of sawtimber by species group and survey region, Tennessee, 1980–89**

Survey region	Species group	Survivor growth†	Ingrowth‡	Growth on removals	Growth on mortality	Cull increment§	Mortality	Timber removals	Land-clearing removals	Net change
		*Million board feet***								
West	Softwood	20.8	13.8	4.6	1.5	2.4	7.8	15.4	.....	19.9
	Hardwood	240.5	137.2	9.6	11.3	95.6	74.6	92.6	26.8	300.2
	Total	261.3	151.0	14.2	12.8	98.0	82.4	108.0	26.8	320.1
West-Central	Softwood	14.4	10.7	6.0	0.6	0.1	4.2	23.6	2.9	1.1
	Hardwood	148.5	140.5	23.3	8.1	51.1	51.0	161.2	4.0	155.3
	Total	162.9	151.2	29.3	8.7	51.2	55.2	184.8	6.9	156.4
Central	Softwood	2.0	7.5	0.4	0.1	2.5	0.1	1.5	1.2	9.7
	Hardwood	188.9	113.4	14.3	5.5	80.4	35.4	105.7	13.6	247.8
	Total	190.9	120.9	14.7	5.6	82.9	35.5	107.2	14.8	257.5
Plateau	Softwood	72.6	41.1	4.8	2.5	7.0	24.7	24.4	3.1	75.8
	Hardwood	242.8	161.1	16.3	9.0	119.0	60.9	148.3	17.4	321.6
	Total	315.4	202.2	21.1	11.5	126.0	85.6	172.7	20.5	397.4
East	Softwood	145.2	80.0	16.5	7.8	3.1	50.6	75.3	15.4	111.3
	Hardwood	328.4	178.1	8.5	8.9	95.9	49.8	66.4	30.7	472.9
	Total	473.6	258.1	25.0	16.7	99.0	100.4	141.7	46.1	584.2
All regions	Softwood	255.0	152.9	32.3	12.6	15.2	87.4	140.1	22.6	217.9
	Hardwood	1,149.1	730.3	71.9	42.9	442.1	271.7	574.2	92.4	1,498.0
	Total	1,404.1	883.2	104.2	55.5	457.3	359.1	714.3	115.0	1,715.9

* Rows and columns may not sum to totals due to rounding.
† Includes nongrowth trees.
‡ Includes ongrowth trees.
§ Includes trees that changed tree class because of a change in the definition of growing stock (see Appendix).
** International ¼-inch rule.

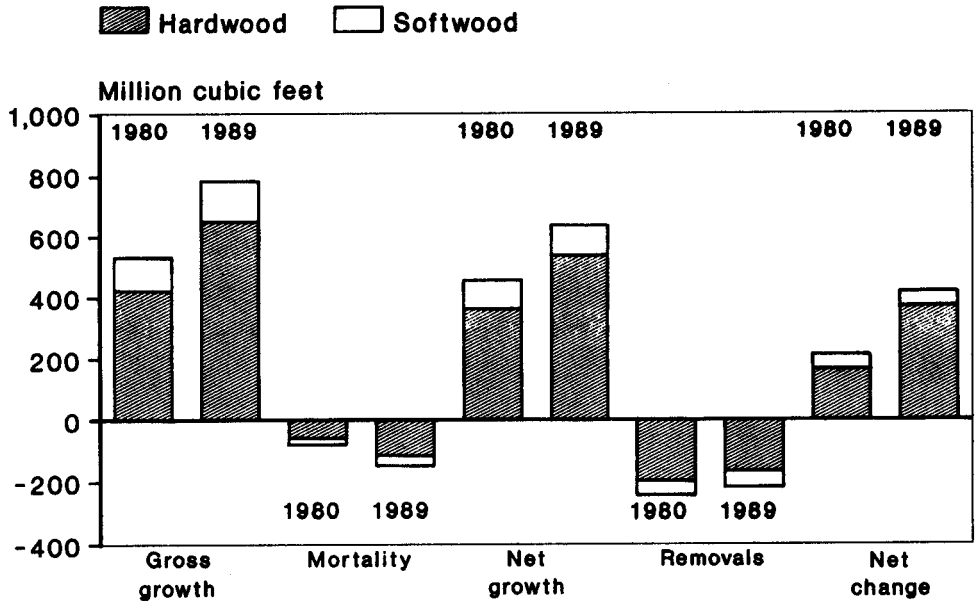


Figure 35.—*Average annual estimates of growing-stock growth and volume drain by species group, Tennessee, 1980 and 1989.*

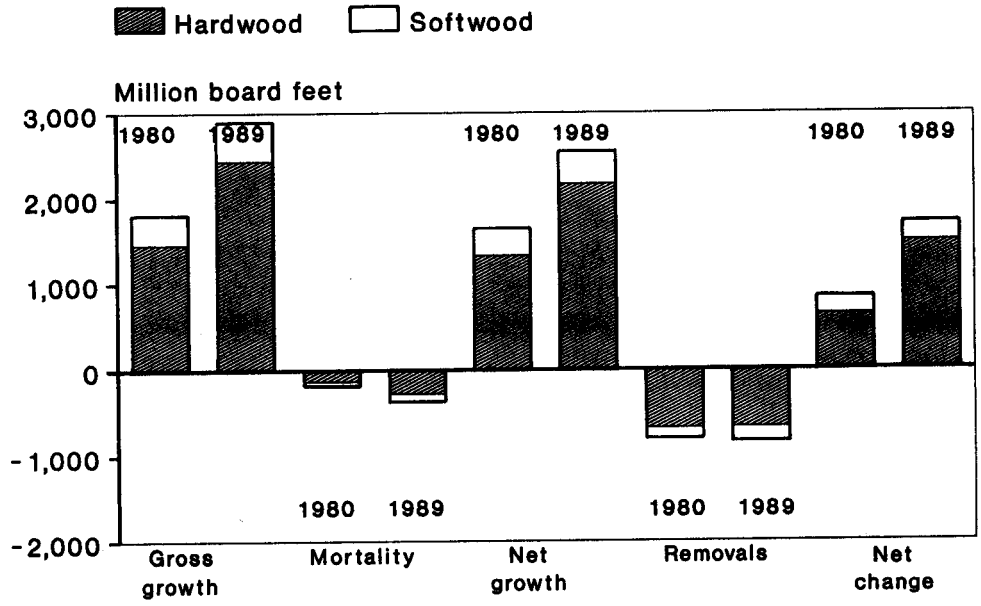


Figure 36.—*Average annual estimates of sawtimber growth and volume drain by species group, Tennessee 1980 and 1989.*

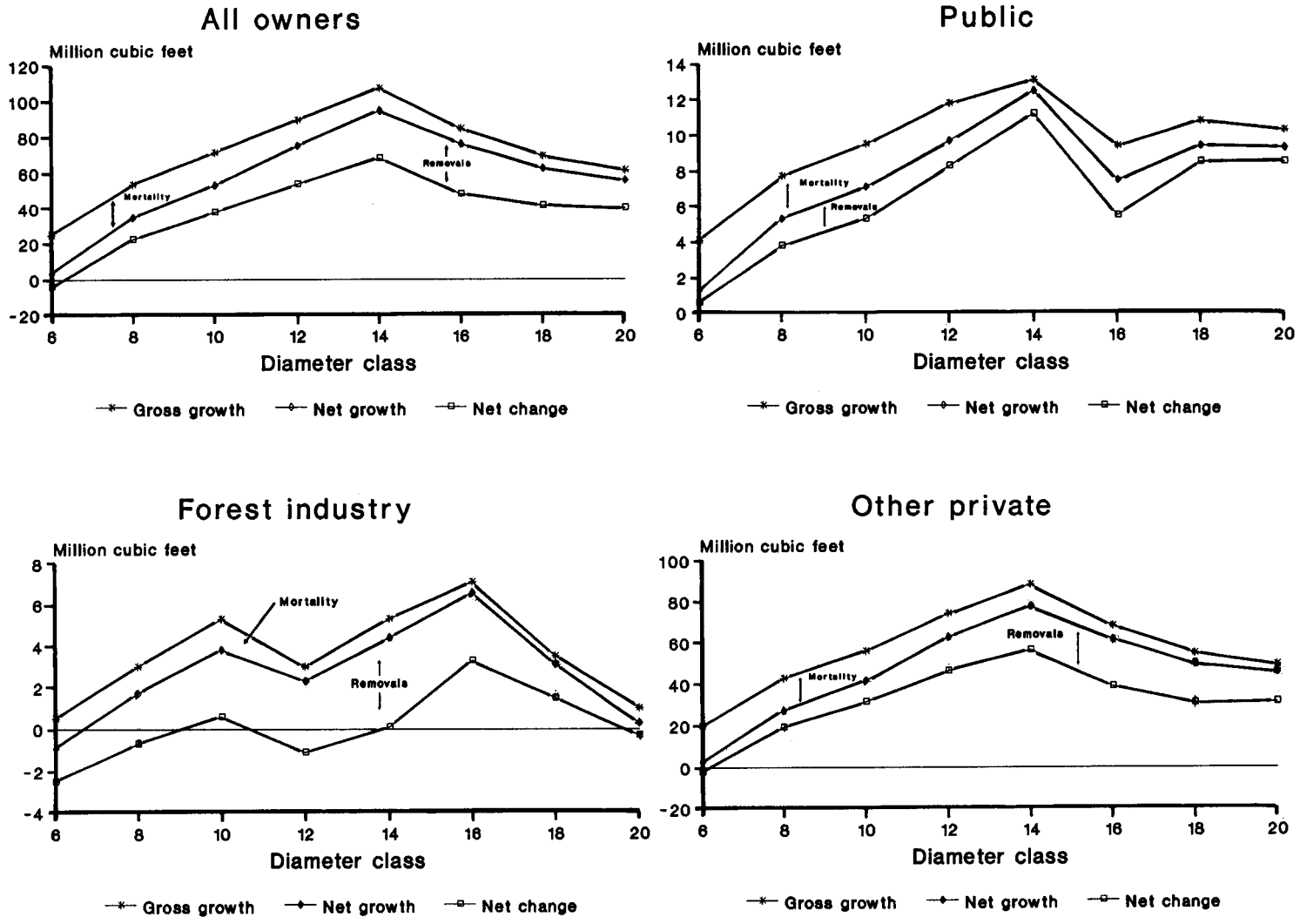


Figure 37.—*Diameter-class contributions to average annual growth and volume drain estimates for hardwood growing stock by ownership class, Tennessee, 1980–89.*

timberlands. As a result, softwood gross growth has declined overall in the smallest size classes (fig. 38).

Mortality

The amount of growing-stock volume lost to mortality has doubled since 1980 (figs. 35, 36). This jump in mortality is consistent with the general maturation of the State's timber resources, but it has also been bolstered by other factors. In the hardwood resource, two-thirds of the increase in mortality has been in oaks, mostly red oaks. Most red oak mortality has been attributed to disease, weather, and dieback, although flooding was also an important cause of death in bottomland species. These mortality characteristics suggest that oak decline, which has been documented and linked to drought conditions in the State during the 1980–89 survey period (Starkey and others 1989), has been impacting the State's hardwood timber resource. Other species of trees sharing in the increased hardwood mortality since 1980 were hickory, yellow-poplar, and sweetgum. Half of the rise in sweetgum mortality since 1980 is attributable to beaver activity.

Softwood growing-stock mortality has increased by half, while sawtimber mortality has more than doubled (fig. 35, 36). This concentration of mortality in the large-size trees has occurred mainly within the yellow pine resource of the State and is associated with increased bark beetle activity since 1980.

Overall, mortality has been concentrated in smaller trees, as might be expected in a maturing resource (figs. 37, 38). As a consequence, mortality's mitigating effect on gross growth has been more pronounced in the smaller size classes, already reduced by the lower levels of ingrowth since 1980.

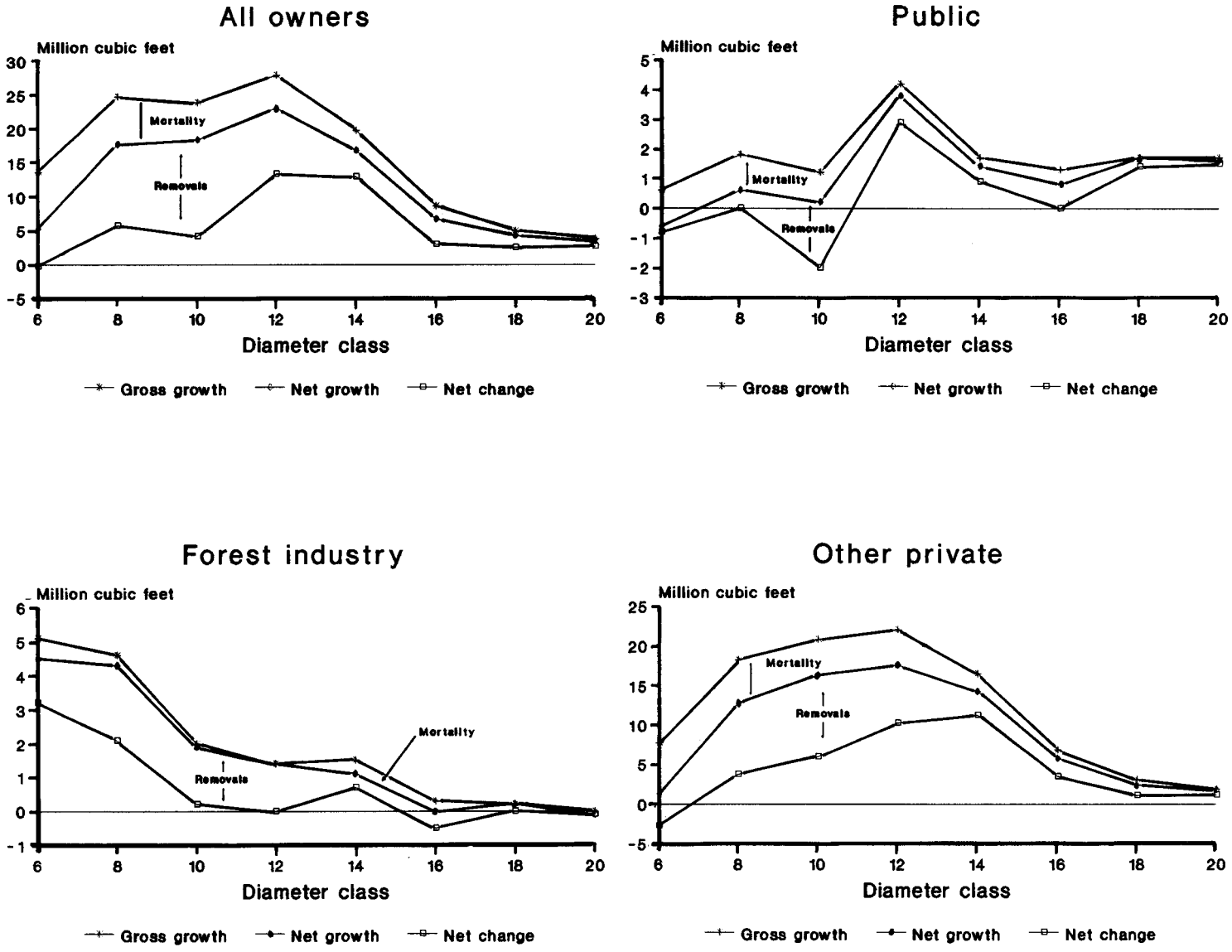


Figure 38.—*Diameter-class contributions to average annual growth and volume drain estimates for softwood growing stock by ownership class, Tennessee, 1980–89.*

Net Growth

Despite the increased losses to mortality, net growth still managed to increase after 1980 (figs. 35, 36). Net growth has shifted toward larger size classes, however, as mortality has been concentrated in smaller trees. (figs. 37, 38). Although most of the net growth is accumulated on the hardwood portion of the inventory, the concentration of hardwood mortality in the oaks has increased the proportion of net growth in the soft hardwood species. The only decline in the net growth of hardwoods since 1980 occurred on forest-industry lands in response to the emphasis placed on pine management. The net growth of the softwood resource was tempered by the lack of ingrowth and high mortality in the smaller size classes and the increased losses to pine beetles in the larger size classes.

Removals

If no other demands were made of Tennessee's timberland, the inventory would be increased by the amount of net growth accumulated annually. However, the State's timberland must supply a forest products industry, and compete against alternative land uses. As a result, the State's inventory volume is being reduced by man-caused removals to meet these needs. These human-caused demands can be categorized as: (1) timber removals associated with some form of timber management or harvesting activity or (2) land-clearing removals associated with the conversion of timberland to other land uses or set asides for wilderness reserves.

Timber Removals.—Since the 1980 survey, the average annual rate of timber removals has increased for

softwoods and decreased slightly for hardwoods (tables V, VI), reflecting the economic conditions since the 1980 survey. The recession of the early eighties severely impacted the forest products industry, the recipient of 95 percent of all timber removals. The lumber and other solid-wood product sectors of the industry were more severely affected than the pulp and paper sector.

Because most of Tennessee's softwood timber removals supply the pulp and paper industry and most of its hardwood timber removals supply the lumber industry, the decline in the annual rate of hardwood timber removals is probably due to reduced hardwood harvests during the recession years. In addition, a greater proportion of hardwoods removed for forest products has been supplied by nongrowing-stock trees in the current survey, which also helps explain the slightly reduced levels of hardwood growing-stock removals and points to improved utilization of the State's hardwood resource.

Although declining since 1980, hardwoods still comprise most of the annual timber removals. Because of the raw material preferences of the hardwood lumber and veneer industries, hardwood removals are concentrated in larger tree sizes, especially the oaks, which comprise more than half of the annual hardwood timber removals.

In contrast, softwood timber removals have increased since the 1980 survey (tables V, VI). Yellow pine constitutes all of this increase, and about nine-tenths of the total softwood timber removals. Although all ownership classes are harvesting more softwood than in 1980, the other private resource is supplying more of the current wood demand, thus taking pressure off forest-industry timberland while the shift to a plantation-based resource is completed. The current structures of the inventories of these two owners suggest a shift back to forest-industry timberland as the plantations mature and the other private resource is depleted because of insufficient regeneration.

Landclearing Removals.—Landclearing removals contribute a smaller, but locally significant, volume to the total human-caused drain. Landclearing removals have generally declined since 1980 (tables V, VI), which is consistent with the increase in timberland since 1980. Most of the volume removed is hardwood, because of hardwood's prevalence in the State and the preference for bottomlands in agriculture. About half of the total volume removed is felled to clear the land for alternative land uses. The remainder is split between wilderness designations and volume left standing on land that has changed land use. Of the volume that is felled, half of the hardwood and three-quarters of the softwood are delivered to forest-product industries. The remainder is usually piled and burned.

Total Removals.—In total, timber and landclearing removals have decreased for hardwoods and increased for softwoods (figs. 35, 36). Although declining, hardwoods still comprise the bulk of the removals. Most hardwood removals come from the larger size classes (fig. 37), reflecting the size requirements and preferences of the hardwood lumber and other solid-wood product industries. However, on forest-industry holdings, hardwood removals are more evenly distributed across all size classes because of the emphasis on softwood fiber production. Wilderness designations on public lands have also resulted in a more even distribution of hardwood removals across size classes. Overall, the concentration of hardwood removals in the larger size classes has tended to counter the concentration of mortality in the smaller-size classes, causing total hardwood volume drain to be more evenly distributed across all size classes.

In contrast to hardwood removals, softwood removals have increased because of greater demands for pulpwood. As a result, softwood removals have been concentrated in the smaller (pulpwood-size) size classes, which have already been affected by reduced ingrowth and higher mortality.

Net Change

Overall, the average annual volume of all removals has been far below the average annual net growth, with softwood removals being only half of net growth and hardwood removals but a third of net growth. Because of this favorable growth-to-removal ratio, a positive net change has occurred in the inventory since 1980 (figs. 35, 36). Much of this volume increase has occurred in the hardwood portion of the inventory because of its maturing nature and reduced removal levels. For the same reasons, most of the increase in hardwood volume has been concentrated in the larger size classes (fig. 37), with a negative net change common in the smaller size classes, especially on forest-industry timberland, where softwood management is emphasized.

Although softwood has also posted a positive net change since 1980, the magnitude of the softwood volume increase has been tempered by declining inventories of small trees on public and other private timberlands, which have offset the buildup of small-tree inventories on forest-industry timberland. As a result, most of the net change has occurred in the intermediate-size classes (fig. 38).

TIMBER HARVEST ACTIVITIES AND TREATMENT OPPORTUNITIES

Since 1980, one-fifth of the State's timberland has been affected by some form of timber harvest (table VII). Final harvests, especially partial harvests, have been the most prevalent. Final harvests have been

Table VII.—*Area of timberland affected by timber harvesting activity by survey region and harvest type, Tennessee, 1980–89*

Survey region	Final harvests		Intermediate harvests†	Total harvests	Proportion of timberland
	Partial	Clearcut*			
	Thousand acres				*Percent*
West	266.2	35.8	85.3	387.3	20
West-Central	445.0	164.0	29.3	638.3	27
Central	387.8	33.3	37.7	458.8	19
Plateau	502.1	109.1	39.8	651.0	21
East	341.1	142.3	76.2	559.6	16
All regions	1,942.2	484.5	268.3	2,695.0	20

* Also includes small areas of seedtree, shelterwood, and salvage cuts.
† Includes precommercial thinnings, commercial thinnings, and timberland improvements (cleaning, weedings, etc.).

Table VIII.—*Area of timberland affected by timber harvesting activity by owner and harvest type, Tennessee, 1980–89*

Owner	Final harvests		Intermediate harvests†	Total harvests	Proportion of timberland
	Partial	Clearcut*			
	Thousand acres				*Percent*
Public	79.4	48.0	47.5	174.9	12
Forest industry	166.6	155.5	31.9	354.0	31
Other private	1,696.4	281.1	188.8	2,166.3	20
All owners	1,942.4	484.6	268.2	2,695.2	20

* Also includes small areas of seedtree, shelterwood, and salvage cuts.
† Includes precommercial thinnings, commercial thinnings, and timberland improvements (cleaning, weedings, etc.).

concentrated in the West-Central and Plateau survey regions of the State, while intermediate harvests have been concentrated in the East and West survey regions.

Because of the size of their holdings, most harvesting has occurred on other private timberland (table VIII), but forest-industry lands (which are concentrated in the West-Central and Plateau survey regions of the State) have experienced the most intensive harvesting. Forest-industry holdings also had the highest proportion of clearcutting, as might be expected given the emphasis on plantation pine management. Public ownership had the lowest levels of harvest activity in the State.

Most harvesting has occurred in the prevalent upland hardwood forest type, where partial cutting is common (table IX). Clearcutting, on the other hand, is the most common form of final harvest in the pine type and is also very common in the mixed oak-pine type. The least affected is the redcedar type, which has been supporting a minor amount of partial harvests as the resource recovers and volumes increase in the merchantable-size classes.

Based on the number, volume, and quality of trees in the State's timber stands, many opportunities for further treatments still exist, despite all of the activities carried out since 1980. Approximately half of the State's timberland offers no treatment opportunities; however, the maturing nature of the State's timberland has more than doubled the opportunities for final harvests since 1980 (table X). Many opportunities also exist to improve the condition of stands by increasing the stocking of growing-stock trees through intermediate treatments or by reestablishing stands in which growing-stock trees are so few as to not warrant continuance. Although sizable, these two types of opportunities have declined by 30 percent since the last survey, indicating a general improvement in the condition of the State's timberland over the years.

Opportunities for both final harvests and intermediate treatments generally increase from West to East across the State, while opportunities to reestablish poor stands are highest in the center of the State because of the condition of both the redcedar and upland hardwood forests. The Central survey region also provides the most opportunities to use and

Table IX.—*Area of timberland affected by timber harvesting activity by past forest type, Tennessee, 1980–89*

Forest type	Final harvests		Intermediate harvests†	Total harvests	Proportion of timberland
	Partial	Clearcut*			
	Thousand acres				*Percent*
Pine	92.3	114.1	31.3	237.7	20
Redcedar	72.2	.....	.....	72.2	11
Mixed oak-pine	80.2	66.4	30.9	177.5	17
Upland hardwood	1,599.9	304.3	173.2	2,077.4	21
Bottomland hardwood	97.8	.....	32.5	130.3	19
All types	1,942.4	484.8	267.9	2,695.1	20

* Also includes small areas of seedtree, shelterwood, and salvage cuts.

† Includes precommercial thinnings, commercial thinnings, and timberland improvements (cleaning, weedings, etc.).

improve the resource; only one-third of its area presents no treatment opportunities. Overall, considerable opportunities exist and, if taken advantage of, could result in continued improvements in the condition and utility of Tennessee's maturing forests.

FOREST PRODUCT INDUSTRIES

With settlement, Tennessee's timberland became a source of local building materials and wood energy for heating and cooking. As settlement continued, the State's first commercial forest product industry developed around supplying fuelwood for the iron-smelting industry and the residences, hotels, railroads, and riverboats of the State. By the late 1800's, coal supplanted wood as the primary source of energy, and the firewood industry began to decline. Even in decline, fuelwood harvests from the State at the turn of the century were estimated at 5 million cords per year (Hall 1930, Sternitzke 1955).

As the State's firewood industry declined, depletion of old-growth hardwood forests in the North sent the lumber industry southward into the State in search of select hardwoods to meet the demands of the growing urban centers of the nation. Initially, only the highest quality trees of a few select species (black walnut, yellow-poplar, and white oak) were taken. Persistent demand caused the industry to make repeated entries into the forest, however, with each entry extracting the best of what was left. So started the State's premier forest product industry, the lumber industry. Many other forest product industries followed.

Lumber Industry

The lumber industry exploited the State's old-growth hardwood forest and hit its peak shortly after the turn of the century, with an annual production of 1.2 billion board feet in 1909 (Allred and others 1939). From that point, the lumber industry declined, along with the vanishing old-growth forest upon which it depended, hitting bottom in the Depression years of the 1930's, along with the rest of the economy. Lumber production recovered with the advent of World War II and the postwar era.

The forest-industry survey conducted in 1949 along with the first forest survey of the State found the lumber industry to be made up of many small, mostly portable, sawmills (fig. 39). These small mills could operate efficiently in the often poorly stocked, smaller size, poorer quality, dispersed second-growth stands left in the wake of the years of selective logging practices. Larger mills were fewer in number, but permanently established and well equipped to saw high-quality hardwood lumber. Because of the depleted nature of the State's hardwood resource, however, these larger mills had to import half of their sawlog supply from neighboring States (Sternitzke 1955).

Over the years, as the condition of the State's timberland improved, sawmill technology advanced, wages increased, and labor supply decreased, the competitive advantage shifted away from the small portable mills back to larger permanent mills. These larger mills could better afford to implement the new technologies and gain mechanical advantage to offset manpower losses and costs. As a result, the number of small sawmills dropped dramatically and the number of larger sawmills increased (fig. 39). Because of the steady attrition of smaller mills, which primarily processed softwood sawlogs, the State's harvest of softwood sawlogs also tapered off, rebounding only in recent years along with the steadily increasing hardwood harvests (fig. 40).

Overall, the State's sawlog harvest has increased and the number of sawmills has declined, indicating the increasing efficiency of the State's lumber indus-

Table X.—*Area of timberland by survey region, forest type, and treatment opportunity class, Tennessee, 1989*

Survey region and forest type	Total	No treatment	Stand reestablishment	Intermediate treatments	Final harvests
			Thousand acres		
West					
Pine	168.0	108.6	6.2	22.7	30.5
Redcedar	64.0	35.4	11.1	11.3	6.2
Mixed oak-pine	95.6	66.7	6.2	11.5	11.2
Upland hardwood	1,102.1	519.1	94.5	130.9	357.6
Bottomland hardwood	533.6	204.2	38.7	37.9	252.8
Total	1,963.3	934.0	156.7	214.3	658.3
West-Central					
Pine	126.8	73.3	12.1	25.5	15.9
Redcedar	23.2	10.5	6.4	.....	6.3
Mixed oak-pine	77.0	37.6	24.4	9.6	5.4
Upland hardwood	2,030.9	879.4	236.2	144.4	770.9
Bottomland hardwood	75.9	22.9	22.3	4.8	25.9
Total	2,333.8	1,023.7	301.4	184.3	824.4
Central					
Pine	15.1	4.9	5.3	4.9	.....
Redcedar	456.0	124.0	115.4	90.6	126.0
Mixed oak-pine	11.4	.....	6.2	.....	5.2
Upland hardwood	1,940.4	643.2	356.0	142.3	798.9
Bottomland hardwood	38.3	21.4	5.9	.....	11.0
Total	2,461.2	793.5	488.8	237.8	941.1
Plateau					
Pine	343.5	176.7	.....	63.2	103.6
Redcedar	34.3	23.4	5.2	5.7	.....
Mixed oak-pine	362.6	241.2	5.6	58.7	57.1
Upland hardwood	2,307.5	1,151.0	229.0	198.8	728.7
Bottomland hardwood	16.8	5.6	6.0	.....	5.2
Total	3,064.7	1,597.9	245.8	326.4	894.6
East					
Pine	526.0	268.9	20.9	95.2	141.0
Redcedar	105.8	25.4	43.0	19.1	18.3
Mixed oak-pine	580.0	322.5	30.4	89.6	137.5
Upland hardwood	2,212.6	1,058.4	200.7	245.7	707.8
Bottomland hardwood	17.9	11.3	6.6	.....	.....
Total	3,442.3	1,686.5	301.6	449.6	1,004.6
All regions					
Pine	1,179.4	632.3	44.5	211.6	291.0
Redcedar	683.4	218.7	181.1	126.8	156.8
Mixed oak-pine	1,126.5	668.0	72.8	169.4	216.3
Upland hardwood	9,593.6	4,251.1	1,116.4	862.1	3,364.0
Bottomland hardwood	682.4	265.3	79.5	42.7	294.9
State total	13,265.3	6,035.4	1,494.3	1,412.6	4,323.0

try. Reliance on sawlog imports from surrounding States has also declined, reflecting the improving condition of the State's timber resource. Both the improving efficiency of the industry and condition of the resource have helped to maintain Tennessee as one of the Nation's leading hardwood lumber manufacturers.

Pulp Industry

In addition to the lumber industry, Tennessee's timberland also supports a variety of nonlumber forest product industries. At the time of the first forest-industry survey, a small wood-pulping industry existed in the State (fig. 41) and drew upon the State's hardwood resources for its fiber needs (fig. 42). The State's softwood resources also helped supply the expanding southern pine pulping industries in the States along Tennessee's southern border. In the 1950's, Tennessee's own southern pine resource, from matured earlier plantings and reverted farmlands, and its developed water resources drew the southern pine pulping industry into Tennessee as well. The

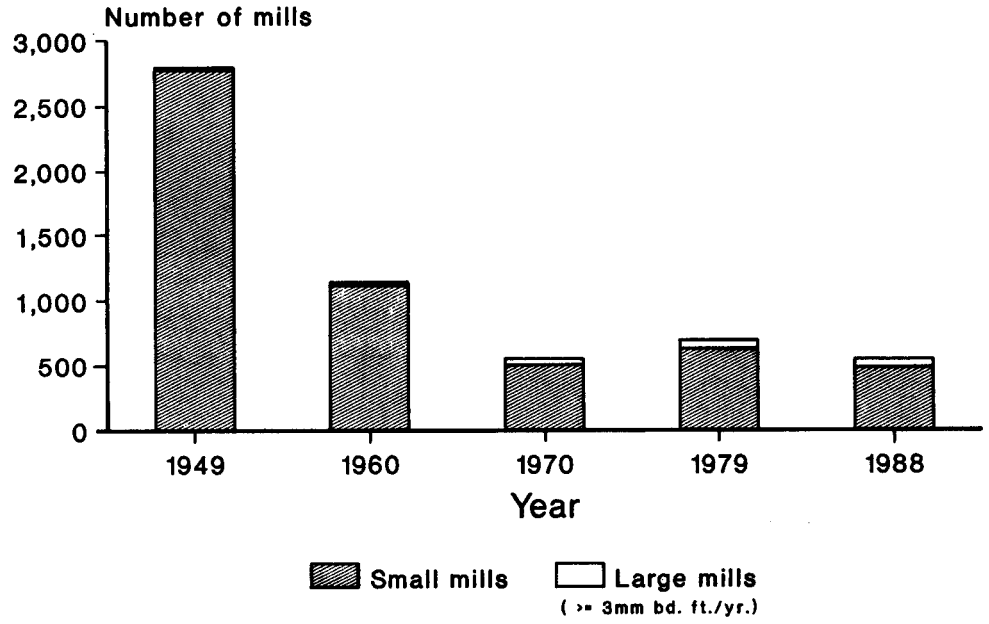


Figure 39.—*Number of sawmills operating in Tennessee by mill size, 1949–88.*

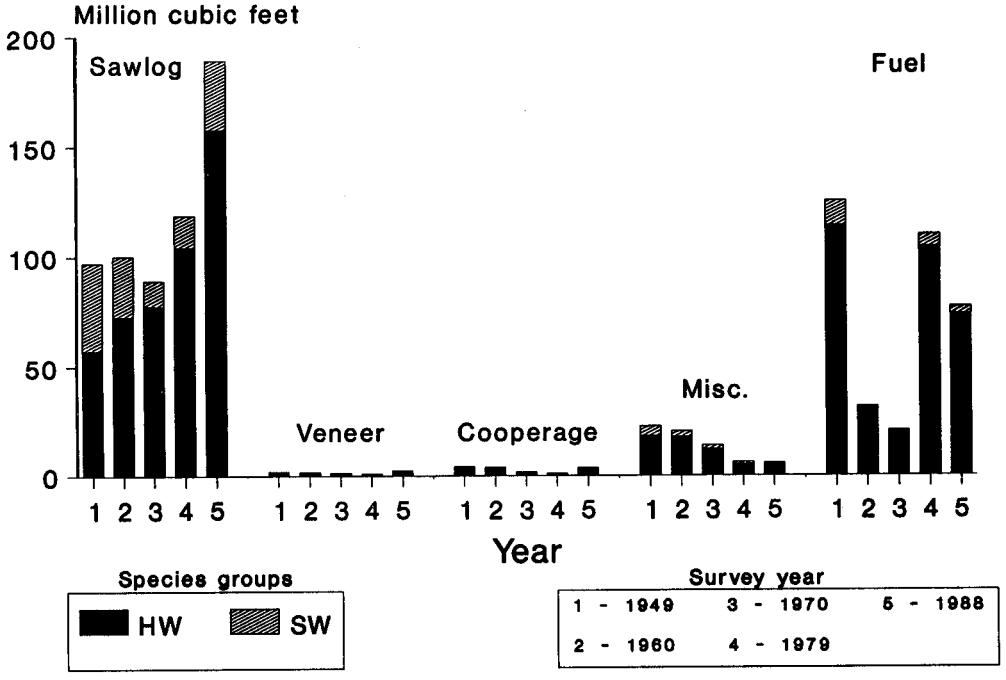


Figure 40.—*Timber product output by species group and product, Tennessee, 1949–88 (excludes pulpwood).*

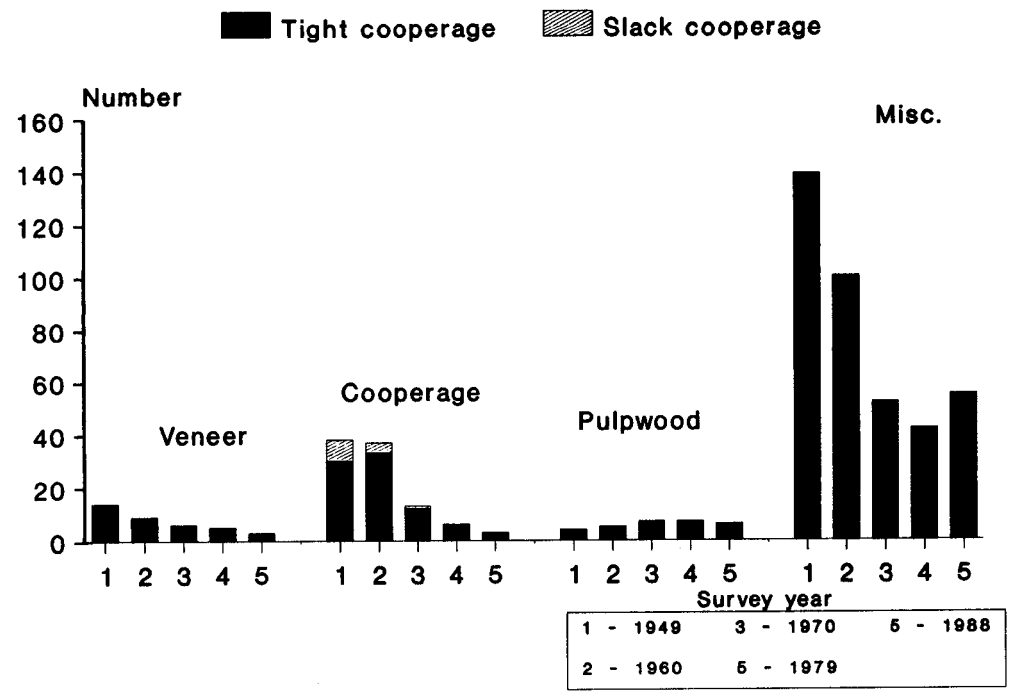


Figure 41.—*Number of nonlumber forest product mills in Tennessee by type, 1949–88.*

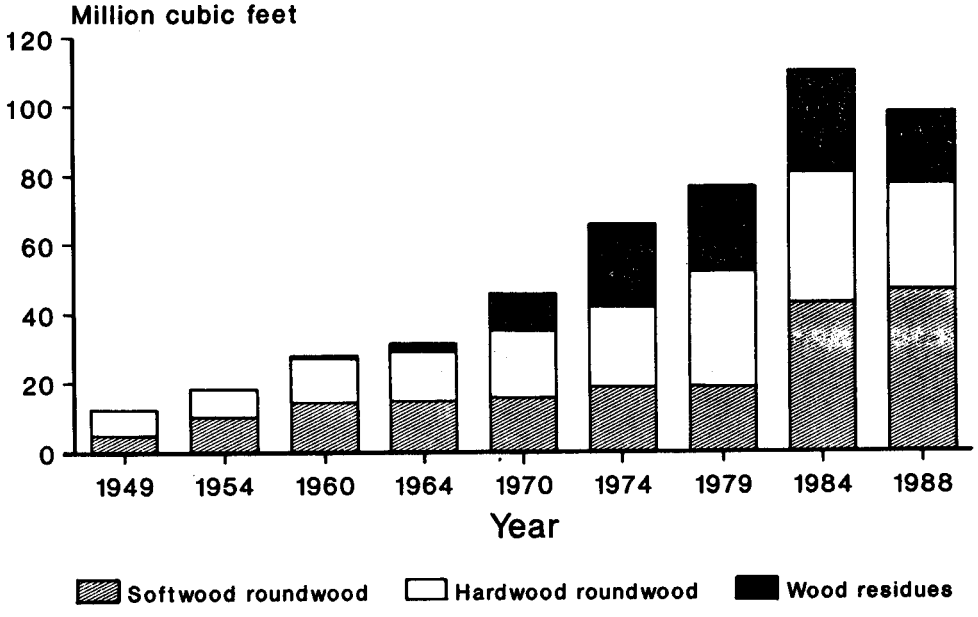


Figure 42.—*Production of pulpwood by type, Tennessee, 1949–88.*

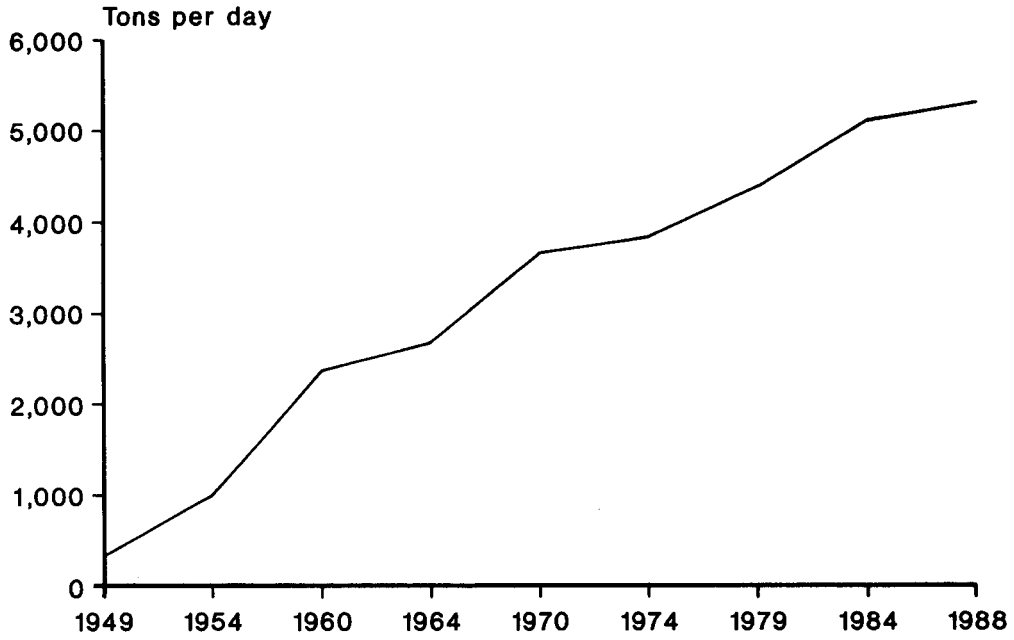


Figure 43.—*Tennessee's pulping capacity, 1948–88.*

resulting jump in pulping capacity (fig. 43) caused an increase in the production of softwood pulpwood (fig. 42) and turned the State from an exporter to a net importer of softwood pulpwood. With the establishment of the southern pine pulping industry, the State's southern pine resources began to be intensively managed for fiber production. As a result of these management efforts, the State's softwood pulpwood harvest jumped appreciably in the 1980's and currently supplies half the softwood fiber needs of the State's pulping industry.

Through the years, hardwood pulpwood production has continually risen, along with the capacity increases of the mills historically dependent on this resource. Hardwood pulpwood production picked up in the 1970's and 1980's as technological developments allowed greater use of all species of hardwoods in the manufacture of pulp and paper products. Concurrently, many pulpmills, in an effort to become more efficient during the recession of the early 1980's, increased their use of the generally abundant, under utilized, and cheaper hardwood resource (Vissage 1990).

With the advent of the debarker and residue chipper in the 1950's, a new source of pulping fiber became available to the pulping industry (Anderson 1987). Chipped mill residues did not become a significant source of fiber supply in Tennessee, however, until the late 1960's (fig. 42), primarily because the chipping technology was affordable only to larger mills, and in Tennessee the larger mills processed mostly hardwood sawlogs. Consequently, full implementation and use of the chipped-residue technology had to wait for pulping technology advances that allowed greater use of hardwoods, regardless of species composition, in all forms of pulp and paper products. Since the acceptance of hardwoods as a source of pulping fiber, the State's production of wood residues for pulp fiber has followed the general level of activity in the State's other primary forest product industries.

Veneer Industry

The veneer industry is another of the nonlumber industries built up around the hardwood resources of the State. At the time of the first survey, the industry was producing veneers for the manufacture of containers, plywood, paneling, and furniture from the soft hardwood, mainly gum and yellow-poplar, resources of the State. The State's harvest of veneer logs at that time was able to supply only about half of the industry's raw material needs. The other half was being shipped in from surrounding States. In time, these supply problems were aggravated by market shifts as veneer containers faced stiff competition in the shipping and packing industries from plastics and paperboard. Because of these pressures in raw material supply and markets, the number of veneer mills has eroded to present levels. Today, a small number of

remaining veneer mills consume only half of the State's annual production of veneer logs; the remainder is shipped out of state for processing (May and Vissage 1990).

Cooperage Industry

The cooperage industry is another specialty industry that relies on the State's hardwood resource. This industry was initially composed mostly of tight cooperage mills producing staves of white oak for the manufacture of barrels, but it also had a contingent of slack cooperage mills producing containers and tobacco hogsheads. Over the years, the industry has succumbed to the same pressures as the veneer industry; namely, market shifts in the shipping and packing industries and wood availability problems. Today, only a small number of tight cooperage mills remain, filling the needs of what remains of the whiskey-barrel market.

Miscellaneous Industries

The State has always contained a multitude of miscellaneous mills producing a variety of products (handle and furniture stock, shuttleblocks, poles, posts, pilings, excelsior, chemicals, and charcoal) from the State's forests. These mills have added diversity to the State's forest products industry and have added to the more complete utilization of the State's timber resource. Over the years, both the number of mills and the harvest of roundwood to supply them have declined as markets and product demands have changed. For example, handle mills, which make up a large proportion of these mills, have been facing stiff competition from plastics in the markets for tool handles. Another example is the slow decline in the production and use of posts as the State's population has become more urbanized.

Fuelwood Industry

Fuelwood, the State's first commercial forest product, has fallen considerably as Tennessee's populace has become more urbanized and reliant on more convenient alternative fuels, such as gas, oil, and electricity, for home heating and cooking. However, demand for wood energy increased with the oil crisis of the early 1970's, fell again with the glutted oil market of the mid-1980's, and may increase once more with the Persian Gulf crisis in 1990. This seesaw effect will likely continue into the future as fuelwood use fluctuates with the price of more convenient alternative fuels.

Forest Products Industry Outlook

Tennessee's forest products industry has changed considerably over the years as it has evolved with the changing character of the State's forest resources, product markets, and technological advances. Today, the industry is, on the whole, smaller and more efficient than in the past, with higher roundwood harvests supplying fewer mills (fig. 44). Also evident is the industry's increased reliance on the forest resources of the State, a reflection of the improving condition of the State's forests.

Today, as in the past, the forest industries, especi-

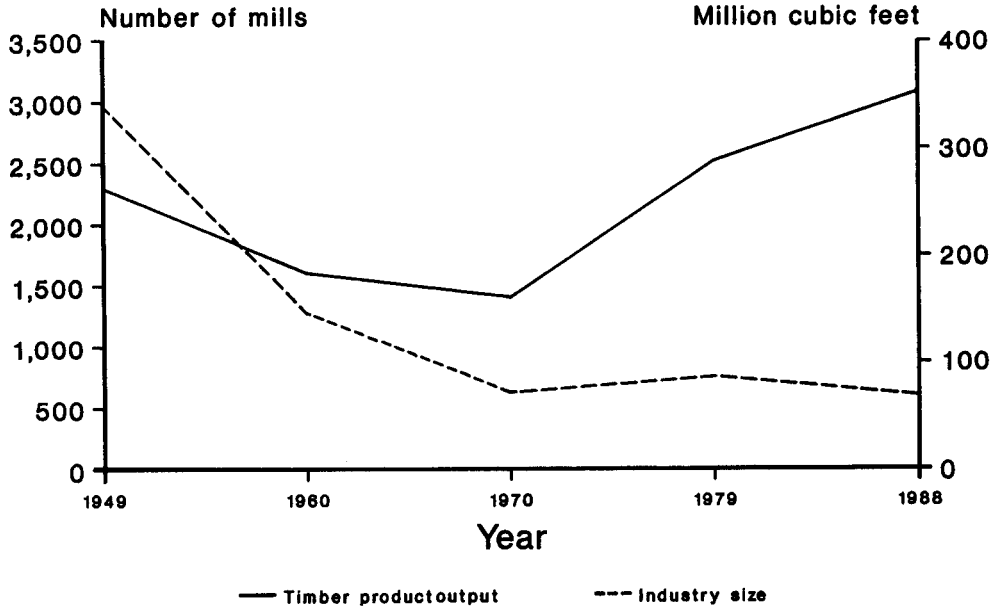


Figure 44.—*Number of primary forest product mills and timber product output in Tennessee, 1949–88.*

ally the lumber industry, rely heavily on the hardwood resources of the State (fig. 45), a reliance that is likely to continue. However, the trend toward declining hardwood quality could pose problems for those industries dependent on high quality hardwoods.

The softwood resource has become the leading supplier of pulping fiber in the State and is likely to remain so, given the emphasis being placed on intensive pine-plantation management on forest industry timberland in the State. The lack of softwood regeneration on other private timberland, however, could be cause for concern. Future increases in hardwood pulpwood production could occur if: (1) hardwood pulpwood prices, which have been increasing in recent years (Vissage, 1990), continue to remain below softwood prices; (2) technological advances, such as press drying in linerboard manufacturing (Ince 1990), continue to increase the use of hardwood fiber in pulp and paper products; and (3) the juxtaposition of Tennessee's abundant hardwood resource, the Tennessee-Tombigbee waterway, and distant domestic and foreign pulpwood markets remain intact.

The future of Tennessee's two main forest product industries, lumbering and pulping, and its many smaller industries will depend on the same factors that influenced the composition of today's industry, namely, the evolutionary process of interacting with the changing resource base, technological advances, and market shifts to best meet the demands of the future.

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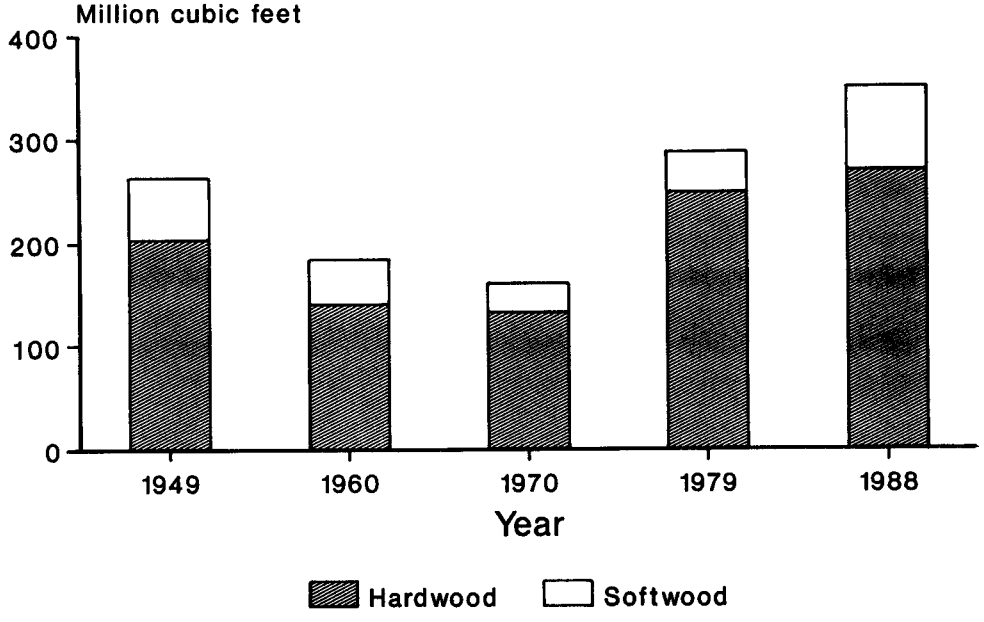

Figure 45.—*Tennessee's timber product output by species group, 1949–88.*

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APPENDIX

Survey Methods

Forest resource statistics were obtained by a systematic sampling method involving forest-nonforest classification on aerial photographs, ground checks of land use, and on-the-ground measurements of trees at selected locations. Inventory volume and area statistics are required to give precise answers at the State level to one standard deviation of the total, equal to 1 percent per million acres of forest land and to 5 percent per billion cubic feet.

The estimate of timberland area is based on the forest-nonforest photo interpretation of recent aerial photography for points representing approximately 230 acres. The photo interpretation of these points was checked in the field at sample locations representing approximately 3,840 acres. These field checks are used to correct photo interpretation errors and adjust the proportion of forest to nonforest area for each county. The proportion of forest area is combined with U.S. census land area data to develop county-level forest area statistics.

Descriptive forest resource statistics come from permanent sample plots located at the intersection of a 3- by 3-mile grid, representing, on average, 5,760 acres. The sample plots are remeasured each survey to allow assessments of changes and trends as well as current status of the forest resources. In Tennessee, 4,698 sample plots were visited, of which 2,275 are currently forested. Each sample plot consists of a cluster of 10 sample points. This satellite point system is combined with a large-factor prism to get a representative sample of stand conditions at each sample-plot location. This method eliminates the effect that vegetation clumping and open gaps would induce if only one point or fixed plot were used at each location.

At each forested sample plot, trees 5.0 inches in d.b.h. and larger were selected with a 37.5-factor prism from each of the 10 sample points, thus each tree selected with the prism represented 3.75 square feet of basal area per acre. Trees smaller than 5.0 inches in d.b.h. were tallied on a 1/275-acre circular plot fixed around the first 3 points of the 10-point cluster. Pine seedlings were tallied on a 1/1000-acre circular plot established at each of the 10 points.

Volumes in Tennessee were derived from deterministic measurements of trees on all sample locations. These deterministic measurements included d.b.h., bark thickness, total height, bole length, log length, and four upper-stem diameters. Volumes for these trees were computed by means of Smalian's formula. Volume equations were developed for seven species groups, and these equations were used to estimate volumes at time of removal or death for trees that did not survive the remeasurement period and to estimate the past volume for new sample trees.

Each tally tree is assigned a classification of growing stock or cull based on its ability to produce sawlogs. Since the 1980 survey, a new tree-classification and tree-grading system has been initiated to achieve greater compatibility in the definition of growing stock among Forest Inventory and Analysis Projects (May and others 1990). Under this new system, tree grade 5 is used to designate trees currently or prospectively capable of producing at least one 12-foot log or two 8-foot logs in the sawlog portion, but not able to produce a 12-foot log in the butt 16 feet. These trees, formerly classified as rough or rotten culls, are now included in growing stock. The impact of this change in definition on the inventory volumes is shown in table XI.

Table XI.—*Changes in volume and growth estimates due to inclusion of tree grade 5 in growing-stock inventory, Tennessee, 1989*

	Tree grade 5		
	Excluded from growing stock	Included as growing stock	Percent change
	------- *Million cubic feet* -------		
Softwood			
Growing-stock volume	2,827.8	2,895.3	2.3
Rough and rotten volume	154.2	86.8	−43.7
Growing-stock growth	92.1	99.8	8.4
Hardwood			
Growing-stock volume	12,903.3	13,787.4	6.9
Rough and rotten volume	2,127.8	1,243.7	−41.5
Growing-stock growth	437.3	537.6	22.9
	------ *Million board feet** ------		
Softwood			
Sawtimber volume	9,408.0	9,615.4	2.2
Sawtimber growth	357.2	380.4	6.5
Hardwood			
Sawtimber volume	40,950.5	43,998.2	7.4
Sawtimber growth	1,819.4	2,164.5	18.9

* International ¼-inch rule.

Components of inventory volume change (growth, removals, and mortality) are estimated from tally tree data on remeasured sample plots. The remeasurement of sample plots allows the history and volume change of each tally tree to be tracked. This information can then be used to assign tally trees into one of eight components of growth (survivor growth, ingrowth, mortality growth, cut growth, cull increment, mortality, cut, and landclearings), and, in turn, these components can be combined to estimate gross growth, net growth, and net change using a Beers and Miller (1964) approach, as modified by Van Deusen and others (1986) and demonstrated by May (1988). The growing-stock definition change initiated since the last survey has caused a one-time increment of the 1989 growing-stock inventory volume due to trees changing from cull to growing stock over the period. The volume of these trees is included in the cull increment component of growth to insure that all of the volume change since 1980 is accounted for. The impact of this change in definition on the inventory growth estimates is shown in table XI.

Measurements at each forested location also included collection of data on site productivity, stand origin, stand age, size of forest tract, distance from road, slope, aspect, disturbance, management, evidence of use, and nontimber resources. Ownership information was obtained for each plot from county tax assessors' records and contact with owners in the field. Personnel from public agencies and other contacts were consulted when classifying absentee owners as farmers, individuals, corporations, or leasors.

Field work was started in June 1988 and completed in June 1989.

Reliability of the Data

Reliability of the Forest Inventory and Analysis (FIA) estimates may be affected by two sources of error. The first source, "estimating error," arises from mistakes in measurement, judgment, recording, or compiling and from limitations of the equipment. Estimating error is minimized by FIA through comprehensive training, supervision, quality-control programs, and emphasis on careful work.

The second type of error, "sampling error," is the error associated with natural and expected deviation of the sample mean from the true population mean. Thus, the deviation is susceptible to a mathematical evaluation of the probability of error. Sampling errors for State totals are based on one standard deviation (table XII). That is, the chances are two out of three that if the results of a 100-percent census were known, the sample results would be within the limits indicated.

Estimates smaller than State totals will have larger sampling errors. The smaller the area examined, the larger the sampling error. Furthermore, as area or volume totals are stratified by forest type, species, diameter class, ownership, or other subunits, the sampling error increases and is greatest for the smallest divisions. The magnitude of this increase is depicted in table XIII and shows the sampling error to which the estimates are liable, two chances out of three.

Table XII.—*Sampling errors for estimates of total timberland area, volume, net annual growth (1980–1989), and annual removals (1980–1989), Tennessee, 1989*

Item	Total	Units	Sampling error
			Percent
Timberland area	13,265.2	*Thousand acres*	0.3
Growing stock			
Volume	16,682.7	*Million cubic feet*	1.4
Periodic net annual growth	637.4	*Million cubic feet*	1.9
Periodic annual removals	219.4	*Million cubic feet*	6.0
Sawtimber			
Volume	53,613.6	*Million board feet**	2.0
Periodic net annual growth	2,545.0	*Million board feet**	2.4
Periodic annual removals	829.4	*Million board feet**	6.1

* International ¼-inch rule.

Table XIII.—*Sampling error to which estimates are liable, two chances out of three, Tennessee, 1989**

Sampling error	Timberland area	Volume	Periodic net annual growth	Periodic annual removals	Volume	Periodic net annual growth	Periodic annual removals
Percent	*Thousand acres*	*Million cubic feet*			*Million board feet*†		
1.0	1,193.9	.....	.....	.....	.....	.....	.....
2.0	298.5	8,174.5	575.3	.....	53,613.6	.....	.....
3.0	132.7	3,633.1	255.7	.....	23,828.3	1,628.8	.....
4.0	74.6	2,043.6	143.8	.....	13,403.4	916.2	.....
5.0	47.8	1,307.9	92.0	.....	8,578.2	586.4	.....
10.0	11.9	327.0	23.0	79.0	2,144.5	146.6	308.6
15.0	5.3	145.3	10.2	35.1	953.1	65.2	137.2
20.0	3.0	81.7	5.8	19.7	536.1	36.6	77.2
25.0	1.9	52.3	3.7	12.6	343.1	23.5	49.4

* By random sampling formula.
† International ¼-inch rule.

Definition of Terms

Forest Land Classes

Forest Land—Land at least 16.7 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest uses. Minimum area considered for classification is 1 acre. Forest land is divided into commercial categories (timberland and deferred timberland) and noncommercial categories (productive-reserved forest land and unproductive forest land).

Timberland—Forest land that is producing, or is capable of producing, crops of industrial wood and not withdrawn from timber utilization. Timberland is synonymous with "commercial forest land" in prior reports.

Deferred Timberland—National forest land that meets productivity standards for timberland but is under study for possible inclusion in the wilderness system.

Productive-Reserved Forest Land—Productive public forest land withdrawn from timber utilization through statute or administrative regulations.

Unproductive Forest Land—Forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Tree Classes

Commercial Species—Tree species currently or prospectively suitable for industrial wood products. Excluded are noncommercial species. See Species List.

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

Growing-Stock Trees—Live trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Trees must contain at least one 12-foot log or two 8-foot logs in the sawlog portion now or prospectively to be classed as growing stock.

Rough Trees—Live trees of commercial species that are unmerchantable for sawlogs currently or potentially because of roughness or poor form in the sawlog portion. Also included are all live trees of noncommercial species.

Rotten Trees—Live trees of commercial species that are unmerchantable for sawlogs currently or potentially because of rot deduction in the sawlog portion.

Cull Trees—Rough or rotten trees.

Hardwoods—Dicotyledonous trees, usually broadleaved and deciduous.

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

Live Trees—All trees that are alive. Included are all size classes and all tree classes.

Salvable Dead Trees—Standing or down dead trees that were formerly growing stock and are considered merchantable.

Forest Types

Spruce-Fir—Forests in which spruce or fir, singly or in combination, comprise a plurality of the stocking.

White Pine-Hemlock—Forests in which white pine or hemlock, singly or in combination, comprise a plurality of the stocking.

Loblolly-Shortleaf Pine—Forests in which yellow pines (except longleaf or slash pine), singly or in combination, comprise a plurality of the stocking. Common associates include oak, hickory, and gum.

Cedar—Forests in which eastern redcedars comprise 25 percent or more of the stocking. Common associates include southern pines, oak, and hickory.

Oak-Pine—Forests in which hardwoods (usually upland oaks) comprise a plurality of the stocking, but in which pines comprise 25 to 49 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, comprise a plurality of the stocking, except where pines comprise 25 to 49 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 cypress, singly or in combination, comprise a plurality of the stocking, except where pines comprise 25 to 49 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, comprise a plurality of the stocking. Common associates include willow, sycamore, beech, and maple.

Maple-Beech-Birch—Forests in which maples, beech, yellow birch, or sweet birch, singly or in combination, comprise a plurality of the stocking.

Nontyped—Timberland currently unoccupied with any live trees, for example, very recent clearcut areas.

Dimension Classes of Trees

Sawtimber trees—Trees 9.0 inches and larger in d.b.h. for softwoods and 11.0 inches and larger for hardwoods.

Poletimber Trees—Trees 5.0 to 8.9 inches in d.b.h. for softwoods and 5.0 to 10.9 inches for hardwoods.

Saplings—Trees 1.0 inch to 4.9 inches in d.b.h.

Seedlings—Trees less than 1.0 inch in d.b.h.

Rough, Rotten, and Salvable Dead Trees—See "tree classes."

Stand Size Classes

Sawtimber Stands—Stands at least 16.7 percent stocked with live trees, half or more of this 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 live trees, half or more of this stocking in sawtimber or poletimber trees, and with poletimber stocking exceeding that of sawtimber stocking.

Sapling-Seedling Stands—Stands at least 16.7 percent stocked with live trees, more than half of this stocking in saplings or seedlings.

Nonstocked Stands—Stands less than 16.7 percent stocked with live trees.

Stocking

Stocking is a measure of the extent to which the growth potential of the site is used by live trees or preempted by vegetative cover. Stocking is determined by comparing the stand density in terms of number of trees or basal area with a specified standard (May 1990); therefore, full stocking is 100 percent of the stocking standard.

Arbitrarily defined stocking categories are defined as follows.

Understocked—Stands 0 to 60 percent stocked with growing-stock trees. These stands will take a very long time to reach full stocking. Meanwhile, poor bole form will result and much of the productivity will be placed on heavy limbs instead of on the bole.

Optimally stocked—Stands 61 to 100 percent stocked with growing-stock trees. These stands are growing toward a fully stocked condition (ideal space required for each tree increases with age). Optimum growth and bole form occur in this range.

Overstocked—Stands greater than 100 percent stocked with growing-stock trees. These stands will become stagnant with mortality of individuals increasing as stocking increases over 100 percent.

The tabulation below shows the density standard in terms of trees per acre by size class required for full stocking.

D.b.h. (inches)	Number of trees	D.b.h. (inches)	Number of trees
Seedlings	600	16	72
2	560	18	60
4	460	20	51
6	340	22	42
8	240	24	36
10	155	26	31
12	115	28	27
14	90	30	24

Volume

Volume of Cull—The cubic-foot volume of sound wood in rough and rotten trees at least 5.0 inches in d.b.h., from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem, or to the point where the central stem breaks into limbs.

Volume of Growing Stock—The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches in d.b.h., from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem, or to the point where the central stem breaks into limbs.

Volume of Live Trees—The cubic-foot volume of sound wood in growing-stock, rough, and rotten trees at least 5.0 inches in d.b.h., from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem, or to the point where the central stem breaks into limbs.

Volume of Sawtimber—The board-foot volume (international 1/4-inch rule) of sound wood in the sawlog portion of growing-stock sawtimber trees.

Volume of Timber—The cubic-foot volume of sound wood in growing-stock, rough, rotten, and salvable dead trees at least 5.0 inches in d.b.h., from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem, or to the point where the central stem breaks into limbs.

Biomass

Merchantable Dry Weight—Dry weight of woody biomass of all growing-stock trees greater than 5.0 inches in d.b.h. from a 1-foot stump to a 4.0-inch top d.o.b. or to a point prior to 4.0-inch d.o.b. because of branching, forking, or other factors.

Residual Dry Weight—Dry weight of woody biomass of the nonmerchantable portion of all growing-stock trees greater than or equal to 5.0 inches in d.b.h., included are all saplings, all noncommercial trees, all rough trees, and all rotten trees.

Total Dry Weight—Dry weight of woody biomass for all live woody vegetation greater than 1.0 inch in d.b.h. Included are growing-stock, commercial, noncommercial, rough, and rotten (sound portion) trees.

Woody Biomass—The amount of live organic material in woody vegetation. Included are bark and wood; excluded are fruits, leaves, stump, and roots.

Growth Classes

Gross Growth—Total increase in stand volume computed on growing-stock trees. Gross growth equals survivor growth, plus ingrowth, plus growth on removals, plus growth on mortality, plus cull increment.

Net Growth—Increase in stand volume, computed on growing-stock trees. Net growth is equal to gross growth minus mortality.

Net Change—Increase or decrease in stand volume, computed on growing-stock trees. Net change is equal to net growth minus removals.

Classes of Trees Used in Growth Computations

Survivor trees—Merchantable-and-in at time 1 (previous inventory) and time 2 (current inventory).

Ingrowth Trees—Submerchantable-and-in at time 1 and merchantable-and-in at time 2.

Ongrowth Trees—Submerchantable-and-out at time 1 and merchantable-and-in at time 2; included with ingrowth component for growth computation.

Nongrowth Trees—Merchantable-and-out at time 1 and merchantable-and-in at time 2; included with survivor growth for growth computation.

Removal Trees—Merchantable-and-in at time 1 and removed prior to time 2.

Mortality Trees—Merchantable-and-in at time 1 and dead prior to time 2.

Ownership Classes

National Forest Land—Federal lands that have been legally designated as national forests or purchase units and other lands under the administration of the USDA FS, including experimental areas.

Other Federal Land—Federal lands other than national forests; lands administered by the Bureau of Land Management and Indian Lands.

State, County, and Municipal Lands—Lands owned by States, counties, and local public agencies or municipalities, or lands leased to these governmental units for 50 years or more.

Forest-Industry Land—Lands owned by companies or individuals operating wood-using plants (either primary or secondary).

Farmer-Owned Land—Lands operated as a unit of 10 acres or more from which the sale of agricultural products totals $1,000 or more annually.

Nonindustrial Private Land (Individual)—Lands privately owned by individuals other than forest industry, farmers, or miscellaneous private corporations.

Nonindustrial Private Land (Corporate)—Lands privately owned by private corporations other than forest industry and incorporated farms.

Miscellaneous Definitions

Average Net Annual Growth—Average net annual volume increase of growing-stock trees for the inter-survey period.

Average Annual Mortality—Average annual soundwood volume of growing-stock trees dying from natural causes.

Average Annual Removals—Average net annual volume of growing-stock trees removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use.

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.

Cull Increment—The change in growing-stock volume due to growing-stock, rough, or rotten trees changing tree class between time 1 and time 2.

D.b.h. (Diameter at Breast Height)—Tree diameter in inches, outside bark, usually measured at 4 1/2 feet above ground.

Diameter Classes—The 2-inch diameter classes extend from 1.0 inch below to 0.9 inch above the stated midpoint. Thus, the 12-inch class includes trees 11.0 inches through 12.9 inches in d.b.h.

Log Grades—A classification of logs based on external characteristics as indicators of quality or value.

Mortality—Number or sound-wood volume of growing-stock trees dying from natural causes during a specified period.

Natural Stands—Stands with no evidence of artificial regeneration. This includes those stands established by seed-tree-regeneration methods.

Plantations—Stands evidenced by regeneration from planting or seeding. FIA categorizes plantations by forest type based on plot tally.

Removals—The net volume of growing-stock trees removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use.

Sawlog Portion—The point on the bole of a sawtimber tree between a 1-foot stump and the sawlog top.

Sawlog Top—The portion of the bole of a sawtimber tree above which a sawlog cannot be produced. The minimum sawlog top is 7.0 inches in diameter outside bark (d.o.b.) for softwoods and 9.0 inches of d.o.b. for hardwoods.

Select Red Oaks—A group of select species in the red oak (*Erythrobalanus*) subgenus; may include one or more of the following species: cherrybark oak (*Quercus falcata* var. *pagodifolia*), northern red oak (Q. rubra), or Shumard oak (*Q. shumardii*). Other red oak species are included in the "other red oaks"group.

Select White Oaks—A group of select species in the white oak (*Leucobalanus*) subgenus; may include one or more of the following species: white oak (*Quercus alba*), swamp white oak (*Q. bicolor*), Durand oak (*Q. durandii*), bur oak (*Q. macrocarpa*), swamp chestnut oak (*Q. michauxii*), or chinkapin oak (*Q. muehlenbergii*). 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.

Tree Grade—A classification of the volume of the sawlog portion of sawtimber trees based on: (1) the log 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 sawlog portion. In past surveys, a log grade was assigned to each upper log based on log grade standards.

Upper-Stem Portion—That part of the main stem or fork of a sawtimber tree above the sawlog top to a d.o.b. of 4.0 inches or to the point where the main stem or fork breaks into limbs.

Species List

Scientific and common names of tree species sampled in Tennessee.[3]

Commercial Species

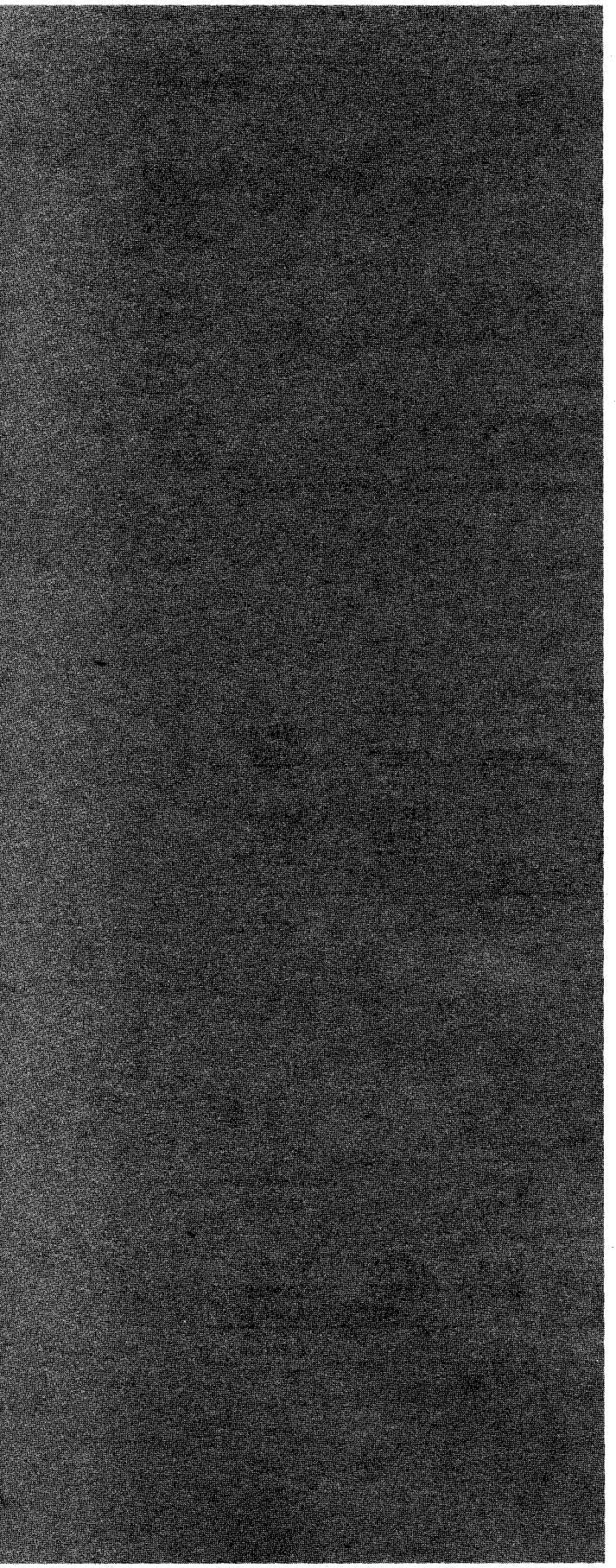
Scientific Name	Common Name
Softwoods	
Juniperus silicicola	southern redcedar
J. virginiana	eastern redcedar
Pinus echinata	shortleaf pine
P. pungens	Table Mountain pine
P. rigida	pitch pine
P. strobus	eastern white pine
P. taeda	loblolly pine
P. virginiana	Virginia pine
Taxodium distichum var. *distichum*	baldcypress
Tsuga canadensis	eastern hemlock
T. caroliniana	Carolina hemlock
Hardwoods	
Acer barbatum	Florida maple
A. negundo	boxelder
A. nigrum	black maple
A. rubrum var. *rubrum*	red maple
A. saccharinum	silver maple
A. saccharum	sugar maple
Aesculus glabra	Ohio buckeye
A. octandra	yellow buckeye
Betula alleghaniensis	yellow birch
B. lenta	sweet birch
B. nigra	river birch
Carya sp.	hickory
C. aquatica	water hickory
C. illinoensis	pecan
Castanea dentata	American chestnut
C. pumila	Allegheny chinkapin
Catalpa sp.	catalpa
Celtis laevigata	sugarberry
C. occidentalis	hackberry
Cornus florida	flowering dogwood
Diospyros virginiana	common persimmon

[3] Names according to: Little, Elbert L., Jr. 1979. Checklist of United States trees (native and naturalized). U.S. Department of Agriculture Handbook NO. 541, 375 p.

Scientific Name	Common Name
Fagus grandifolia	American beech
Fraxinus americana	white ash
F. nigra	black ash
F. pennsylvanica	green ash
F. quadrangulata	blue ash
Gleditsia aquatica	water locust
G. triacanthos	honey locust
Gymnocladus dioicus	Kentucky coffee tree
Halesia carolina	mountain silverbell
Ilex opaca	American holly
Juglans cinerea	butternut
J. nigra	black walnut
Liquidambar styraciflua	sweetgum
Liriodendron tulipifera	yellow-poplar
Maclura pomifera	osage orange
Magnolia acuminata	cucumbertree
M. grandiflora	southern magnolia
M. virginiana	sweetbay
Morus rubra	red mulberry
Nyssa aquatica	water tupelo
N. sylvatica var. *biflora*	swamp tupelo
N. sylvatica var. *sylvatica*	black tupelo, blackgum
Plantanus occidentalis	American sycamore
Populus sp.	cottonwood
Prunus serotina	black cherry
Quercus alba	white oak
Q. bicolor	swamp white oak
Q. coccinea	scarlet oak
Q. falcata	southern red oak
Q. falcata var. *pagodifolia*	cherrybark oak
Q. imbricaria	shingle oak
Q. lyrata	overcup oak
Q. macrocarpa	bur oak
Q. michauxii	swamp chestnut oak
Q. muehlenbergii	chinkapin oak
Q. nigra	water oak
Q. nuttallii	Nuttall oak
Q. palustris	pin oak
Q. phellos	willow oak
Q. prinus	chestnut oak
Q. rubra	northern red oak
Q. shumardii	Shumard oak
Q. stellata var. *stellata*	post oak
Q. stellata var. *paludosa*	Delta post oak
Q. velutina	black oak
Robinia pseudoacacia	black locust
Salix sp.	willow
Sassafras albidum	sassafras
Tilia americana	American basswood
T. heterophylla	white basswood
Ulmus alata	winged elm
U. americana	American elm
U. crassifolia	cedar elm
U. pumila	Siberian elm
U. rubra	slippery elm
U. serotina	September elm
U. thomasii	rock elm

Noncommercial Species

Aesculus sp.	buckeye
Ailanthus altissima	tree-of-heaven
Amelanchier sp.	serviceberry
Bumelia sp.	chittamwood
Carpinus caroliniana	American hornbeam
Castanea sp.	chinkapin
Cercis canadensis	eastern redbud
Cotinus obovatus	American smoketree
Crataegus sp.	hawthorn
Magnolia macrophylla	bigleaf magnolia
Malus sp.	apple
Morus alba	white mulberry
Ostrya virginiana	eastern hophornbeam
Oxydendrum arboreum	sourwood
Paulownia tomentosa	royal paulownia
Planera aquatica	water-elm
Prunus sp.	plums
Quercus incana	bluejack oak
Q. laevis	turkey oak
Q. marilandica	blackjack oak
Q. virginiana	live oak
Vaccinium arboreum	sparkleberry



Standard Tables

Table 1.—*Area by land classes, Tennessee, 1989*

Land class	Area
	Thousand acres
Forest	
Commercial	
Timberland	13,265.2
Deferred timberland	....
Noncommercial	
Productive-reserved	337.3
Unproductive	....
Total forest	13,602.5
Nonforest	
Cropland*	7,185.9
Other	5,550.7
Total nonforest	12,736.6
All land†	26,339.1

* U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, Volume 1: State and County data, issued 1989.
† Bureau of the Census, 1981.

Table 2.—*Area of timberland by ownership classes, Tennessee, 1989**

Ownership class	Area
	Thousand acres
Public	
National forest	556.0
Other federal	471.4
State	422.2
County	59.4
Total public	1,508.9
Private	
Forest Industry	1,121.5
Farmer	3,854.8
Miscellaneous private	
Individual	5,592.9
Corporate	1,187.1
Total private	11,756.3
All ownerships	13,265.2

* Columns may not sum to totals due to rounding.

Table 3.—*Area of timberland by stand size and ownership classes, Tennessee, 1989**

Stand-size class	All ownerships	National forest	Other public	Forest industry	Farmer	Miscellaneous private
	Thousand acres					
Sawtimber	6,521.2	341.3	541.8	372.1	1,962.8	3,303.2
Poletimber	4,397.5	160.4	310.1	462.1	1,264.8	2,200.1
Sapling and seedling	2,340.8	54.3	101.0	281.6	627.3	1,276.7
Nonstocked areas	5.7	.....	.....	5.7	.....	.....
All classes	13,265.2	556.0	952.9	1,121.5	3,854.8	6,780.0

* Rows and columns may not sum to totals due to rounding.

Table 4.—*Area of timberland by stand volume and ownership classes, Tennessee, 1989**

Stand volume per acre	All ownerships	National forest	Other public	Forest industry	Farmer	Miscellaneous private
Board feet†	*Thousand acres*					
Less than 1,500	3,682.5	42.5	168.2	475.3	1,086.0	1,910.5
1,500 to 5,000	5,402.1	215.0	389.3	402.1	1,612.7	2,782.9
More than 5,000	4,180.7	298.4	395.4	244.1	1,156.1	2,086.6
All classes	13,265.2	556.0	952.9	1,121.5	3,854.8	6,780.0

* Rows and columns may not sum to totals due to rounding.
† International ¼-inch rule.

Table 5.—*Area of timberland by percent growing-stock trees and cull trees, Tennessee, 1989**

Growing-stock trees	Cull trees (percent stocking)							
	Total	0–10	10–20	20–30	30–40	40–50	50–60	60+
Percent stocking	*Thousand acres*							
0–10	36.5	5.7	.....	6.0	.....	.....	5.6	19.2
10–20	63.0	.....	.....	6.3	10.9	10.4	5.6	29.8
20–30	124.5	.....	14.7	22.9	.....	12.9	11.0	63.1
30–40	247.6	17.2	15.8	4.9	38.0	28.2	67.7	75.8
40–50	644.8	25.9	34.5	84.3	153.1	130.5	124.9	91.5
50–60	1,025.8	65.4	138.5	245.5	250.8	157.6	121.1	46.9
60–70	1,708.4	98.6	341.3	475.9	380.1	305.7	85.9	20.8
70–80	2,301.9	254.4	565.4	752.2	472.2	145.0	101.3	11.4
80–90	2,314.9	403.8	835.4	680.7	283.6	80.6	25.1	5.9
90–100	2,193.1	669.4	814.9	549.0	106.4	49.8	11.9	3.6
100–110	1,339.2	534.5	554.9	212.9	36.9	.....	.....	.....
110–120	758.7	391.9	266.9	88.6	11.3	.....	.....	.....
120–130	373.0	267.5	98.9	6.5	.....	.....	.....	.....
130–140	100.1	69.2	26.6	4.3	.....	.....	.....	.....
140–150	26.7	26.7	.....	.....	.....	.....	.....	.....
150–160	6.9	6.9	.....	.....	.....	.....	.....	.....
160+	.....	.....	.....	.....	.....	.....	.....	.....
Total	13,265.2	2,837.2	3,707.8	3,140.0	1,743.4	920.7	548.2	367.9

* Rows and columns may not sum to totals due to rounding.

Table 6.—*Average basal area of live trees on timberland by ownership, tree class, species, and tree-size class, Tennessee, 1989**

Ownership and tree classes	All species	Softwood			Hardwood		
		Sapling & seedling	Poletimber	Sawtimber	Sapling & seedling	Poletimber	Sawtimber
	Square feet per acre						
National forest:							
Growing stock	89.6	3.6	5.9	16.8	6.5	23.5	33.3
Rough and rotten	17.9	0.7	0.2	0.2	6.5	4.9	5.4
Total	107.5	4.2	6.0	17.1	13.0	28.4	38.7
Other public:							
Growing stock	73.9	1.9	3.3	9.7	6.4	20.3	32.3
Rough and rotten	19.6	0.5	0.3	0.4	7.3	5.1	6.0
Total	93.5	2.4	3.6	10.1	13.7	25.4	38.3
Forest industry:							
Growing stock	66.9	3.5	10.4	5.9	8.2	18.0	20.9
Rough and rotten	13.9	0.2	0.2	0.2	7.0	3.1	3.1
Total	80.8	3.8	10.6	6.1	15.2	21.1	24.0
Farmer:							
Growing stock	66.1	1.6	3.4	3.9	5.6	21.1	30.4
Rough and rotten	18.0	0.3	0.3	0.4	6.8	4.8	5.4
Total	84.1	2.0	3.7	4.3	12.4	25.9	35.7
Miscellaneous private:							
Growing stock	67.4	1.7	4.0	5.9	7.0	20.9	28.0
Rough and rotten	17.4	0.4	0.3	0.3	7.0	4.5	4.9
Total	84.8	2.1	4.2	6.1	14.0	25.4	32.9
All owners:							
Growing stock	68.3	1.9	4.4	6.0	6.6	20.8	28.6
Rough and rotten	17.5	0.4	0.6	0.3	6.9	4.5	5.0
Total	85.8	2.3	4.7	6.3	13.6	25.3	33.6

* Rows and columns may not sum to totals due to rounding.

Table 7.—*Area of timberland by site and ownership classes, Tennessee, 1989**

Site class	All ownerships	National forest	Other public	Forest industry	Farmer	Miscellaneous private
	Thousand acres					
165 ft or more	594.8	24.8	56.1	30.6	178.6	304.6
120 to 165 ft	1,468.6	60.7	114.9	76.1	479.0	737.9
85 to 120 ft	3,602.4	136.7	323.3	328.9	1,060.1	1,753.4
50 to 85 ft	5,648.0	262.0	365.1	491.3	1,636.6	2,892.9
Less than 50 ft	1,951.4	71.8	93.5	194.6	500.4	1,091.9
All classes	13,265.2	556.0	952.9	1,121.5	3,854.8	6,780.0

* Rows and columns may not sum to totals due to rounding.

Table 8.—*Area of timberland by forest types and ownership classes, Tennessee, 1989**

Type	All ownerships	National forest	Other public	Forest industry	Farmer	Miscellaneous private
	Thousand acres					
White pine-hemlock	64.0	33.6	11.2	4.9	8.5	5.7
Loblolly-shortleaf pine	1,115.3	64.8	45.0	257.4	207.6	540.5
Redcedar	683.5	.....	57.7	.....	300.4	325.5
Oak-pine	1,126.5	116.7	93.0	112.7	176.2	627.9
Oak-hickory	9,476.5	316.6	610.2	670.7	2,874.3	5,004.7
Oak-gum-cypress	639.3	.....	110.2	61.9	230.9	236.2
Elm-ash-cottonwood	43.0	.....	14.6	8.1	15.3	5.0
Maple-beech-birch	111.4	24.2	11.1	.....	41.7	34.5
Nontyped	5.7	.....	.....	5.7	.....	.....
All types	13,265.2	556.0	952.9	1,121.5	3,854.8	6,780.0

* Rows and columns may not sum to totals due to rounding.

Table 9.—*Area of noncommercial forest land by forest types, Tennessee, 1989*

Type	Productive reserved areas
	Thousand acres
Spruce-fir	7.2
Pine*	47.5
Softwood total	54.7
Oak-pine	25.5
Oak-hickory	219.8
Maple-beech-birch	37.3
Hardwood total	282.6
All types	337.3

* Includes loblolly-shortleaf and white pine-hemlock forest types.

Table 10.—*Number of growing-stock trees on timberland by species and diameter classes, Tennessee, 1989**

Species	All classes	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
	Diameter class (inches at breast height)										
	Thousand trees										
Shortleaf pine	57,146	15,046	17,168	11,994	8,060	3,332	1,158	298	55	36	.....
Loblolly pine	72,018	36,887	20,139	9,062	3,616	1,742	312	136	93	30	.....
Virginia pine	108,089	38,752	32,485	17,670	11,464	5,490	1,683	418	96	31	.....
Pitch pine	6,486	2,330	1,737	1,068	641	377	270	25	33	5	.....
Other s. pines	2,055	604	737	422	246	11	26	.....	9	.....	.....
E. white pine	14,591	3,730	3,443	2,127	1,691	1,030	890	623	481	511	63
Redcedar	57,891	36,301	13,854	4,689	2,131	642	139	119	9	8	.....
Hemlock	11,496	4,779	2,189	1,388	1,212	771	352	376	188	227	13
Cypress	1,246	.....	170	136	31	118	139	97	117	293	146
Total softwoods	331,019	138,429	91,924	48,557	29,093	13,513	4,968	2,093	1,081	1,141	221
Select white oaks†	170,467	53,082	38,135	29,727	19,031	14,366	7,702	4,226	2,134	1,980	84
Select red oaks‡	46,632	9,072	10,283	7,745	5,784	5,369	2,999	2,064	1,437	1,685	195
Other white oaks	142,929	43,227	34,916	24,682	15,621	10,741	6,461	3,408	1,870	1,838	163
Other red oaks	150,934	38,040	32,941	27,481	18,649	14,823	8,281	5,247	2,760	2,516	196
Sweet pecan	122	.....	.....	51	.....	32	21	.....	.....	12	5
Water hickory	185	.....	.....	59	72	53	.....	.....	.....	.....	.....
Other hickories	154,137	49,944	41,908	29,245	15,945	9,135	4,294	1,930	995	697	43
Persimmon	8,264	5,372	1,778	692	323	21	46	.....	33	.....	.....
Hard maple	45,466	18,048	10,461	7,077	4,219	2,712	1,340	789	457	323	39
Soft maple	73,892	34,809	18,381	9,327	5,147	2,907	1,376	887	500	514	44
Boxelder	5,090	1,732	1,453	996	450	196	168	70	.....	17	8
Beech	19,380	4,954	4,501	3,059	1,832	1,664	1,004	913	473	837	143
Sweetgum	50,612	17,307	12,173	8,593	5,717	3,285	2,221	538	413	320	46
Blackgum	35,331	16,413	8,168	4,449	2,827	1,700	954	441	190	185	4
Other gums/tupelos	883	126	285	131	.....	170	64	68	30	9	.....
White ash	26,160	10,097	6,462	4,007	2,282	1,523	824	416	319	209	21
Other ashes	16,819	6,667	3,279	3,119	1,740	654	723	409	173	55	.....
Sycamore	5,144	1,136	847	974	376	560	391	210	267	339	44
Cottonwood	699	274	.....	48	62	21	78	42	22	69	82
Basswood	3,519	658	758	668	503	362	286	138	82	64	.....
Yellow-poplar	92,046	22,553	18,864	14,640	11,685	9,392	6,299	4,063	2,406	2,047	97
Magnolia	3,899	1,152	1,222	815	334	146	122	54	46	8	.....
Sweetbay	246	208	.....	38	.....	.....	.....	.....	.....	.....	.....
Willow	3,486	1,270	749	731	243	213	31	47	60	123	18
Black walnut	9,099	2,664	1,869	1,946	1,331	689	376	112	82	26	4
Black cherry	14,383	6,786	4,202	1,843	503	441	284	243	41	39	.....
American elm	10,177	3,689	2,546	2,062	769	632	198	111	78	73	19
Other elms	23,631	12,502	6,153	2,671	1,332	571	165	132	54	42	8
River birch	3,244	1,565	582	374	331	156	83	80	34	39	.....
Other birches	7,173	4,012	2,096	639	261	101	10	10	17	21	7
Hackberry	14,012	4,433	4,667	2,170	1,159	928	355	171	69	52	9
Black locust	10,856	3,711	3,612	1,848	670	552	195	135	90	39	.....
Other locusts	2,066	665	601	452	236	59	17	24	.....	13	.....
Sassafras	17,924	8,967	4,344	2,393	1,200	561	256	111	71	2	.....
Dogwood	5,783	5,181	577	.....	26	.....	.....	.....	.....	.....	.....
Holly	579	368	151	49	.....	.....	.....	11	.....	.....	.....
Other commercial	5,752	2,146	1,605	783	609	301	112	75	54	62	7
Total hardwoods	1,181,023	392,830	280,567	195,583	121,269	85,036	47,738	27,179	15,259	14,274	1,287
All species	1,512,041	531,259	372,490	244,141	150,362	98,550	52,706	29,271	16,339	15,415	1,508

* Rows and columns may not sum to totals due to rounding.

† Includes white, swamp chestnut, swamp white, chinkapin, and bur oaks.

‡ Includes cherrybark, northern red, and Shumard oaks.

Table 11.—*Volume of timber on timberland by classes of timber and by softwoods and hardwoods, Tennessee, 1989**

Class of timber	All species	Softwood	Hardwood
	Million cubic feet		
Sawtimber trees:			
Sawlog portion	9,040.8	1,681.0	7,359.8
Upper-stem portion	1,940.9	278.2	1,662.7
Total	10,981.7	1,959.2	9,022.5
Poletimber trees	5,701.0	936.1	4,764.9
All growing stock	16,682.7	2,895.3	13,787.4
Rough trees	1,252.3	80.4	1,171.8
Rotten trees	344.2	6.3	337.9
Salvable dead trees	124.6	34.7	89.9
All timber	18,403.8	3,016.8	15,387.0

* Rows and column may not sum to totals due to rounding.

Table 12.—*Volume of growing stock and sawtimber on timberland by ownership classes and by softwoods and hardwoods, Tennessee, 1989**

Ownership class	Growing stock			Sawtimber		
	All species	Softwood	Hardwood	All species	Softwood	Hardwood
	Million cubic feet			*Million board feet*†		
National forest	1,005.0	303.0	702.1	3,611.9	1,302.1	2,309.8
Other public	1,391.2	302.2	1,089.0	4,999.4	1,245.1	3,754.3
Forest industry	1,223.6	302.6	921.0	3,466.9	750.0	2,716.9
Farmer	4,724.9	573.6	4,151.3	15,172.3	1,698.7	13,473.6
Miscellaneous private	8,337.9	1,414.0	6,924.0	26,363.1	4,619.4	21,743.7
All ownerships	16,682.7	2,895.3	13,787.4	53,613.6	9,615.4	43,998.2

* Rows and columns may not sum to totals due to rounding.

† International ¼-inch rule.

Table 13.—*Volume of growing stock on timberland by species and diameter classes, Tennessee, 1989**

Species	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										
Shortleaf pine	645.4	45.7	120.7	160.8	158.9	94.6	42.4	15.1	3.2	3.9	.....
Loblolly pine	419.4	74.7	111.3	100.9	64.9	43.1	11.0	6.5	5.2	1.7	.....
Virginia pine	1,043.3	125.5	236.5	229.9	220.7	145.4	59.1	18.1	5.9	2.2	.....
Pitch pine	57.6	5.5	10.2	10.9	10.2	8.8	8.6	0.9	1.8	0.5	.....
Other s. pines	14.8	1.8	4.2	3.8	3.7	0.3	0.8	.....	0.3	.....	.....
E. white pine	254.3	8.0	19.3	23.2	28.1	25.0	31.4	30.1	28.8	49.5	11.0
Redcedar	237.4	81.9	66.8	42.2	27.5	11.7	3.8	3.0	0.2	0.2	.....
Hemlock	141.8	10.8	12.0	15.2	21.7	19.7	12.3	16.7	11.4	20.0	2.0
Cypress	81.4	.....	1.2	2.1	0.4	2.7	4.7	4.8	6.7	31.3	27.6
Total softwoods	2,895.3	353.9	582.2	589.1	536.2	351.4	174.1	95.2	63.5	109.2	40.6
Select white oaks†	2,097.8	139.2	231.9	332.9	341.8	356.7	261.4	180.7	110.8	133.1	9.4
Select red oaks‡	837.1	23.6	65.1	85.8	104.2	135.0	100.8	88.2	76.7	130.0	27.9
Other white oaks	1,572.5	108.1	192.9	250.1	252.8	231.5	188.8	127.9	88.2	114.5	17.7
Other red oaks	2,049.7	101.5	193.7	288.9	305.0	346.8	252.5	217.5	142.3	174.9	26.6
Sweet pecan	3.8	.....	.....	0.3	.....	0.7	0.6	.....	.....	1.1	1.0
Water hickory	2.9	.....	.....	0.7	1.3	0.9	.....	.....	.....	.....	.....
Other hickories	1,601.8	120.7	241.6	323.2	300.1	241.6	157.1	91.8	58.0	60.1	7.6
Persimmon	38.2	11.8	9.4	6.8	5.4	0.7	1.7	.....	2.3	.....	.....
Hard maple	472.6	47.7	64.9	79.9	73.6	70.3	46.6	35.5	24.5	25.7	3.7
Soft maple	603.8	97.9	111.8	106.2	86.1	66.3	41.7	34.2	23.8	32.9	2.8
Boxelder	40.6	4.2	8.4	9.2	6.1	3.7	4.9	2.5	.....	1.2	0.4
Beech	314.8	13.0	25.3	33.9	32.0	39.8	32.2	35.9	23.5	64.8	14.6
Sweetgum	584.9	38.7	71.7	100.4	113.4	91.2	83.7	28.1	23.7	27.5	6.5
Blackgum	262.1	35.7	42.7	41.4	42.8	35.4	26.5	16.7	9.4	11.2	0.3
Other gums/tupelos	12.5	0.3	1.3	1.4	.....	4.2	1.7	2.1	1.2	0.4	.....
White ash	255.0	23.0	37.6	40.0	38.3	37.6	27.0	17.5	15.8	15.4	2.9
Other ashes	176.4	16.8	19.9	35.6	31.4	17.8	23.9	18.8	9.0	3.2	.....
Sycamore	106.7	3.3	5.8	10.1	6.2	14.2	13.5	8.0	14.8	24.5	6.3
Cottonwood	32.6	0.4	.....	0.4	1.2	0.7	3.4	2.2	1.5	7.0	15.8
Basswood	66.5	2.3	5.7	8.6	11.2	10.4	10.6	7.2	5.0	5.5	.....
Yellow-poplar	1,668.1	63.1	127.3	176.6	235.2	268.9	242.5	206.8	152.2	181.8	13.8
Magnolia	46.3	2.9	9.1	10.9	7.2	4.9	4.6	2.8	3.3	0.6	.....
Sweetbay	1.2	0.7	.....	0.4	.....	.....	.....	.....	.....	.....	.....
Willow	42.8	2.9	4.1	8.3	3.9	4.8	1.2	2.1	3.7	10.4	1.4
Black walnut	91.7	6.2	11.4	19.3	18.2	14.9	11.3	4.2	3.8	1.8	0.5
Black cherry	98.3	16.7	23.4	18.3	7.3	11.1	8.6	9.3	1.6	2.0	.....
American elm	91.7	9.7	14.0	19.8	12.0	14.4	6.4	4.4	3.7	5.0	2.3
Other elms	139.0	28.7	32.6	26.2	21.5	14.2	4.8	5.1	3.1	1.8	1.1
River birch	33.6	5.2	4.1	4.5	5.5	4.1	2.6	3.3	1.7	2.7	.....
Other birches	45.7	12.2	13.7	8.3	5.3	2.4	0.2	0.3	1.2	1.6	0.7
Hackberry	110.4	9.6	21.8	19.9	17.1	19.1	10.3	6.2	3.4	2.6	0.6
Black locust	88.6	9.4	19.9	19.1	10.7	11.4	6.3	4.5	4.6	2.7	.....
Other locusts	17.2	1.6	2.9	4.7	4.4	1.0	0.6	1.0	.....	1.0	.....
Sassafras	116.5	22.9	24.6	23.0	19.2	11.2	7.4	3.7	3.5	1.1	.....
Dogwood	10.5	8.6	1.5	.....	0.5	.....	.....	.....	.....	.....	.....
Holly	2.0	0.7	0.5	0.3	.....	.....	.....	0.4	.....	.....	.....
Other commercial	51.6	4.1	8.2	7.5	9.7	6.1	3.2	3.4	2.5	6.2	0.9
Total hardwoods	13,787.4	993.3	1,648.7	2,122.8	2,130.4	2,094.1	1,588.3	1,172.2	818.6	1,054.1	164.8
All species	16,682.7	1,347.2	2,231.0	2,711.9	2,666.6	2,445.4	1,762.4	1,267.4	882.1	1,163.3	205.4

* Rows and columns may not sum to totals due to rounding.
† Includes white, swamp chestnut, swamp white, chinkapin, and bur oaks.
‡ Includes cherrybark, northern red, and Shumard oaks.

Table 14.—*Volume of sawtimber on timberland by species and diameter classes, Tennessee, 1989**

Species	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†								
Shortleaf pine	2,430.0	726.0	821.2	518.4	235.8	85.7	19.1	23.8	.....
Loblolly pine	1,079.8	406.2	317.9	221.3	60.0	36.3	29.1	9.0	.....
Virginia pine	3,300.3	998.6	1,079.1	766.0	315.6	97.2	32.9	10.9	.....
Pitch pine	202.3	42.9	48.0	45.2	47.0	5.3	10.4	3.7	.....
Other s. pines	42.7	16.7	18.6	1.5	3.8	.....	2.1	.....	.....
E. white pine	1,187.2	94.3	133.0	124.2	166.2	166.2	158.4	280.1	64.9
Redcedar	369.2	165.1	117.2	53.7	18.9	13.1	0.7	0.5	.....
Hemlock	589.8	60.8	100.5	97.8	64.0	88.0	60.0	107.4	11.3
Cypress	414.0	9.3	1.1	11.1	23.1	22.6	34.7	170.7	141.5
Total softwoods	9,615.4	2,519.9	2,636.6	1,839.1	934.3	514.4	347.3	606.1	217.7
Select white oaks‡	6,667.0	.....	1,385.7	1,666.3	1,319.8	945.1	600.0	705.8	44.3
Select red oaks§	3,297.1	.....	433.7	642.0	502.7	461.6	406.1	693.6	157.3
Other white oaks	4,897.2	.....	1,051.8	1,083.4	942.5	659.9	457.9	608.7	92.9
Other red oaks	7,147.1	.....	1,229.8	1,645.5	1,275.2	1,142.5	757.0	948.3	148.7
Sweet pecan	17.4	.....	.....	3.5	2.7	.....	.....	5.7	5.4
Water hickory	9.4	.....	5.9	3.5	.....	.....	.....	.....	.....
Other hickories	4,518.4	.....	1,288.7	1,194.2	830.8	493.3	330.9	333.8	46.8
Persimmon	47.9	.....	21.1	3.7	9.1	.....	14.1	.....	.....
Hard maple	1,360.5	.....	306.1	339.1	232.2	186.4	133.3	145.1	18.2
Soft maple	1,317.5	.....	338.6	295.1	206.7	171.7	129.3	163.9	12.3
Boxelder	84.5	.....	23.9	16.7	23.8	12.2	.....	7.5	0.4
Beech	1,198.9	.....	125.7	184.2	161.4	181.1	122.3	345.7	78.6
Sweetgum	1,787.9	.....	451.5	439.6	429.0	151.8	126.0	153.7	36.4
Blackgum	687.9	.....	169.4	166.7	141.4	90.9	54.8	63.3	1.4
Other gums/tupelos	35.2	.....	.....	15.4	5.8	8.3	4.5	1.2	.....
White ash	748.5	.....	158.2	185.6	134.3	92.1	81.1	82.9	14.4
Other ashes	500.1	.....	125.2	86.5	121.2	102.5	48.7	16.0	.....
Sycamore	422.9	.....	21.4	60.3	64.4	40.8	75.3	126.4	34.3
Cottonwood	186.6	.....	5.5	3.9	19.2	11.9	7.9	44.2	94.2
Basswood	256.1	.....	52.4	52.0	53.5	41.0	27.1	30.0	.....
Yellow-poplar	6,687.0	.....	981.2	1,318.7	1,285.2	1,132.3	854.8	1,042.7	72.0
Magnolia	121.4	.....	31.2	26.6	23.9	18.2	18.4	3.0	.....
Willow	147.9	.....	14.2	21.9	6.9	10.5	26.0	60.3	8.2
Black walnut	244.5	.....	70.4	69.4	54.2	21.0	19.2	7.0	3.3
Black cherry	184.5	.....	27.6	52.8	39.6	44.9	8.7	11.0	.....
American elm	222.6	.....	47.7	63.6	32.7	22.7	19.4	23.5	12.9
Other elms	225.4	.....	82.3	63.5	23.1	23.5	17.2	8.8	7.0
River birch	93.5	.....	21.4	22.7	11.4	15.5	8.3	14.3	.....
Other birches	54.3	.....	21.1	11.2	0.9	1.2	6.6	8.9	4.2
Hackberry	258.8	.....	66.8	81.6	46.4	30.9	16.2	12.9	4.0
Black locust	182.6	.....	45.9	49.3	28.7	20.6	24.5	13.7	.....
Other locusts	34.3	.....	16.5	4.5	3.4	4.7	.....	5.2	.....
Sassafras	196.2	.....	68.8	49.7	37.3	17.6	16.6	6.1	.....
Dogwood	1.5	.....	1.5	.....	.....	.....	.....	.....	.....
Holly	2.4	.....	.....	.....	.....	2.4	.....	.....	.....
Other Commercial	153.1	.....	39.9	25.3	17.0	16.4	12.6	36.9	5.0
Total hardwoods	43,998.2	.....	8,731.0	9,947.9	8,086.3	6,175.4	4,425.1	5,730.2	902.2
All species	53,613.6	2,519.9	11,367.6	11,787.1	9,020.6	6,689.8	4,772.4	6,336.3	1,119.9

* Rows and columns may not sum to totals due to rounding.

† International ¼-inch rule.

‡ Includes white, swamp chestnut, swamp white, chinkapin, and bur oaks.

§ Includes cherrybark, northern red, and Shumard oaks.

Table 15.—*Volume of sawtimber on timberland by species and tree grades, Tennessee, 1989**

Species	All grades	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
	Million board feet†					
Yellow pines	7,055.1	735.3	777.7	5,428.4	.....	113.6
Cypress	414.0	97.0	108.2	204.9	.....	4.0
Redcedar	369.2	337.1	.....	.....	.....	32.1
Other softwoods	1,777.0	219.8	463.4	1,017.0	19.2	57.7
Total softwoods	9,615.4	1,389.2	1,349.3	6,650.3	19.2	207.4
Select white-red oaks‡	9,964.1	1,073.0	2,204.3	4,337.4	1,845.6	503.7
Other white-red oaks	12,044.3	988.2	2,091.6	5,413.1	2,811.3	740.1
Hickory	4,545.2	271.2	831.9	2,223.6	939.9	278.7
Yellow birch	10.8	.....	.....	7.0	3.8	.....
Hard maple	1,360.5	42.6	167.1	636.1	401.2	113.6
Sweetgum	1,787.9	172.5	356.1	849.8	282.5	127.1
Tupelo and blackgum	723.1	60.0	103.8	307.5	145.9	105.9
Ash-walnut-black cherry	1,677.6	183.5	430.7	702.5	207.5	153.4
Yellow-poplar	6,687.0	999.2	1,395.6	2,642.7	1,339.9	309.6
Other hardwoods	5,197.8	386.7	606.4	1,810.5	1,678.4	715.7
Total hardwoods	43,998.2	4,176.9	8,187.4	18,930.3	9,655.9	3,047.7
All species	53,613.6	5,566.1	9,536.8	25,580.5	9,675.0	3,255.1

* Rows and columns may not sum to totals due to rounding.
† International ¼-inch rule.
‡ Includes white, swamp chestnut, swamp white, chinkapin, bur, cherrybark, northern red, and Shumard oaks.

Table 16.—*Average net annual growth and average annual removals of growing stock on timberland by species, Tennessee, 1980–89**

Species	Growth	Removals
	Million cubic feet	
Yellow pines	75.4	47.7
Cypress	1.3	0.3
Redcedar	8.9	2.2
Other softwoods	14.2	2.1
Total softwoods	99.8	52.2
Select white-red oaks†	108.9	42.1
Other white-red oaks	126.3	47.2
Hickory	45.5	20.6
Yellow birch	0.2	0.9
Hard maple	26.1	4.2
Sweetgum	28.7	5.4
Tupelo and blackgum	9.9	3.2
Ash-walnut-black cherry	25.2	5.2
Yellow-poplar	82.7	20.9
Other hardwoods	84.1	17.5
Total hardwoods	537.6	167.2
All species	637.4	219.4

* Columns may not sum to totals due to rounding.
† Includes white, swamp chestnut, swamp white, chinkapin, bur, cherrybark, northern red, and Shumard oaks.

Table 17.—*Average net annual growth and average annual removals of growing stock on timberland by ownership classes and by softwoods and hardwoods, Tennessee, 1980–1989**

Ownership class	Net annual growth			Annual removals		
	All species	Softwood	Hardwood	All species	Softwood	Hardwood
	Million cubic feet					
National forest	24.4	5.7	18.8	14.3	5.4	8.9
Other public	36.4	4.9	31.6	4.5	0.7	3.8
Forest industry	52.5	20.8	31.6	28.9	7.9	20.9
Farmer	192.8	19.4	173.4	65.8	11.9	53.9
Miscellaneous private	331.3	49.1	282.2	106.0	26.3	79.6
All ownerships	637.4	99.8	537.6	219.4	52.2	167.2

* Rows and columns may not sum to totals due to rounding.

Table 18.—*Average net annual growth and average annual removals of sawtimber on timberland by species, Tennessee, 1980–1989**

Species	Growth	Removals
	Million board feet†	
Yellow pines	286.8	146.8
Cypress	5.8	1.5
Redcedar	19.9	4.7
Other softwoods	67.9	9.8
Total softwoods	380.5	162.8
Select white-red oaks‡	475.4	179.4
Other white-red oaks	540.1	186.7
Hickory	171.1	78.9
Yellow birch	0.4	3.3
Hard maple	89.9	18.3
Sweetgum	108.4	20.7
Tupelo and blackgum	34.2	9.9
Ash-walnut-black cherry	83.9	18.0
Yellow-poplar	384.6	101.4
Other hardwoods	276.6	50.1
Total hardwoods	2,164.6	666.6
All species	2,545.0	829.4

* Columns may not sum to totals due to rounding.
† International ¼-inch rule.
‡ Includes white, swamp chestnut, swamp white, chinkapin, bur, cherrybark, northern red, and Shumard oaks.

Table 19.—*Average net annual growth and average annual removals of sawtimber on timberland by ownership classes and by softwoods and hardwoods, Tennessee, 1980–1989**

Ownership class	Net annual growth			Annual removals		
	All species	Softwood	Hardwood	All species	Softwood	Hardwood
	Million board feet†					
National forest	120.4	33.2	87.3	51.9	22.2	29.7
Other public	154.6	19.4	135.3	16.2	2.3	13.8
Forest industry	151.6	40.5	111.1	87.3	21.5	65.7
Farmer	802.7	77.1	725.6	270.8	39.2	231.6
Miscellaneous private	1,315.6	210.3	1,105.4	403.3	77.5	325.8
All ownerships	2,545.0	380.5	2,164.6	829.4	162.8	666.6

* Rows and columns may not sum to totals due to rounding.
† International ¼-inch rule.

Table 20.—*Average annual mortality of growing stock and sawtimber on timberland by species, Tennessee, 1980–1989**

Species	Growing stock	Sawtimber
	Million cubic feet	*Million board feet*[†]
Yellow pines	28.2	75.6
Cypress	0.1	0.3
Redcedar	2.7	3.4
Other softwoods	1.8	8.1
Total softwoods	32.8	87.4
Select white-red oaks[‡]	16.4	44.3
Other white-red oaks	39.0	94.4
Hickory	15.6	35.9
Hard maple	1.2	1.7
Sweetgum	5.8	19.1
Tupelo and blackgum	1.5	2.7
Ash-walnut-black cherry	4.0	6.4
Yellow-poplar	5.2	13.8
Other hardwoods	24.9	53.4
Total hardwoods	113.6	271.7
All species	146.3	359.1

* Columns may not sum to totals due to rounding.
[†] International ¼-inch rule.
[‡] Includes white, swamp chestnut, swamp white, chinkapin, bur, cherrybark, northern red, and Shumard oaks.

Table 21.—*Average annual mortality of growing stock and sawtimber on timberland by ownership classes and by softwoods and hardwoods, Tennessee, 1980–89**

Ownership class	Growing stock			Sawtimber		
	All species	Softwood	Hardwood	All species	Softwood	Hardwood
	Million cubic feet			*Million board feet*[†]		
National forest	7.4	2.6	4.8	13.8	7.4	6.4
Other public	14.1	2.9	11.2	42.3	8.3	34.1
Forest industry	10.2	1.7	8.5	27.9	4.7	23.2
Farmer	40.3	7.6	32.7	96.8	21.4	75.3
Miscellaneous private	74.4	18.1	56.3	178.4	45.7	132.7
All ownerships	146.3	32.8	113.6	359.1	87.4	271.7

* Rows and columns may not sum to totals due to rounding.
[†] International ¼-inch rule.

Table 22.—*Average annual mortality of growing stock and sawtimber on timberland by causes of death and by softwoods and hardwoods, Tennessee, 1980–1989**

Ownership class	Growing stock			Sawtimber		
	All species	Softwood	Hardwood	All species	Softwood	Hardwood
	Million cubic feet			*Million board feet*[†]		
Bark beetles	7.1	7.1	.....	23.5	23.5	.....
Other insects	1.4	0.4	1.0	3.0	1.1	2.0
Disease	102.7	16.4	86.3	235.2	40.4	194.8
Fire	3.5	0.7	2.8	11.1	3.0	8.0
Beaver	2.7	.....	2.7	10.4	.....	10.4
Weather	17.2	5.8	11.4	61.6	17.5	44.1
Suppression	5.5	1.5	4.0	2.3	.....	2.3
Other	6.2	0.9	5.4	12.0	1.8	10.1
All causes	146.3	32.8	113.6	359.1	87.4	271.7

* Rows and columns may not sum to totals due to rounding.
[†] International ¼-inch rule.

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The principal findings of the fifth forest survey of Tennessee (1989) and changes that have occurred since earlier surveys are presented in the report. Topics examined include the status and trends in forest area, timber volume, growth, removals, mortality, and timber-product output.

Keywords: Biomass, forest inventory, timberland, timber supply, volume.