Virginia's
Forests, 2001

Anita K. Rose

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About the Author

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Front cover photos: top left, Appalachian Trail; top right, the George Washington–Jefferson National Forest, seen here from the Blue Ridge Parkway, accounts for the majority of national forest land in Virginia; bottom, butterfly feeding on nectar of a native azalea (Rhododendron spp.). Back cover photos: top right, Appalachian Trail; top left, beaver pond along the Creeper Trail in southwest Virginia; bottom, violet (Viola spp.) on Blue Ridge Parkway in Virginia. (photos by Anita Rose)

Native azalea in flower. (photo by Anita Rose)

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James River as it passes through the gap in the Blue Ridge Mountains near Big Island, VA. (photo by Anita Rose)

Welcome...

Carl E. Garrison III

Peter J. Roussopoulos

The distribution and composition of Virginia's forests have changed dramatically since the first European colonists landed in Jamestown 400 years ago. While forests still cover nearly two-thirds of the State, they are continually changing—but where and how? To ensure that all Virginians continue to realize the many benefits provided by their forests, we must have information we can use to assess the condition of this resource and determine where and how it is changing. Since the 1930s, the U.S. Forest Service has provided the means for tracking the changes in Virginia's forests through the Forest Inventory and Analysis (FIA) program, which conducts physical inventories of public and private land, nationwide, at regular time intervals.

Recently, FIA has approached this inventory in a new way by forming partnerships with State forestry organizations. The working partnership between the Virginia Department of Forestry and the U.S. Forest Service Southern Research Station FIA Program has strengthened and improved the forest inventory of Virginia.

This report contains information about the forest land of the Commonwealth of Virginia that can be used by decision makers, foresters, landowners, loggers, industry producers, students, and researchers in forestry and related fields. Information about timber volume and the number of trees present cannot fully describe the status of forest resources. Thus, this report includes information about forest health and an evaluation of the goals and objectives of Virginia's forest landowners.

It is with great pride that we present this report about the forests of Virginia. We view it as the first product of a partnership that will deliver the best and most useful information about Virginia's forests now and in the future.

Carl E. Garrison III
Virginia State Forester

Peter J. Roussopoulos
Director, Southern Research Station

The Southern Research Station's Forest Inventory and Analysis (FIA) Research Work Unit and cooperating State forestry agencies now conduct annual forest inventories of the 13 Southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the Commonwealth of Puerto Rico, and the U.S. Virgin Islands. In order to provide more frequent and nationally consistent information on the forest resources of the United States, the change to annual surveys was mandated by the Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill).

The primary objective of these inventories is to develop the resource information needed to formulate sound forest policies and programs. This is done by gathering and analyzing data about forest resources including, but not limited to: forest area, forest ownership, forest type, stand structure, timber volume, growth, removals, and management activity. In addition, new assessments that address issues of ecosystem health have been added. These include information about ozone-induced injury, down woody material, soils, lichens, and tree crown condition. The information presented is applicable at the State and unit level; it furnishes the background for intensive studies of critical situations but is not designed to reflect conditions at very small scales.

Forty-five percent of Virginia's timberland was in the sawtimber size class, 36 percent in the poletimber size class, and 19 percent in sapling-seedling stands.

More information about Forest Service resource inventories is available in "Forest Service Resource Inventories: An Overview" (U.S. Department of Agriculture Forest Service 1992). More detailed information about new sampling methodologies employed in annual FIA inventories can be found in "The Enhanced Forest Inventory and Analysis Program — National Sampling Design and Estimation Procedures" (Bechtold and Patterson 2005).

Data tables included in FIA reports are designed to provide a comprehensive array of forest resource estimates, but additional data can be obtained for those who require more specialized information. FIA data for all States in the United States can be accessed at http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm.

Additional information about any aspect of this or other FIA surveys may be obtained from:

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

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Contents

Contents

Yellow buckeye in flower along the Virginia Creeper Trail in southwest Virginia. *(photo by Anita Rose)*

List of Figures

Page

Text Figures

Sunrise, Floyd County, VA. (photo by John A. Weidhass, Virginia Polytechnic Institute and State University, www.forestryimages.org)

List of Figures

Page

Page

List of Figures

Page

Appendix Figures

Page

Text Tables

Rockfish Valley as seen from the Blue Ridge Parkway. *(photo by Anita Rose)*

List of Tables

Page

Page

Page

Appendix Tables

Beaver pond along the Virginia Creeper Trail in southwest Virginia. *(photo by Anita Rose)*

Viburnum (*Viburnum* spp.) in flower along the Blue Ridge Parkway. *(photo by Anita Rose)*

• In 2001, about 15,844,000 acres, or 63 percent, of Virginia's land area was forested. This was a slight decrease since 1992 when forest land area totaled 16,027,000 acres. Of the 15,844,000 acres of forest land, 15,467,000 acres was classified as timberland.

• The majority (12,101,900 acres) of Virginia's forest land was in nonindustrial private forest (NIPF) ownership. The area of timberland held by NIPF owners increased by 1.4 percent since 1992. Public ownership ranked second with 2,717,900 acres (17 percent). Area of public land increased 18 percent. Forest industry owned 6 percent, or 1,024,200 acres, of forest land across the State. Forest industry ownership decreased by 33 percent.

Wood-betony (*Pedicularis* spp.) on Blue Ridge Parkway in Virginia. *(photo by Anita Rose)*

• The oak-hickory forest-type group predominated. It occupied 60 percent (9,537,100 acres) of the forest land area and contained 64 percent (20.1 billion cubic feet) of the merchantable volume across the State. Loblolly-shortleaf was the second most dominant forest-type group in both area (3,157,400 acres) and volume (5.1 billion cubic feet). The oak-pine forest-type group ranked third, occupying 1,936,800 million acres. The loblolly-shortleaf, oak-hickory, and oak-pine forest-type groups each had area and volume changes of 1 percent or less.

• For the first time, acreage of planted pine surpassed acreage of natural pine. Since 1992, the area of timberland classified as pine plantation increased by 30 percent to 1,907,000 acres. In contrast, natural pine stands decreased by about 17 percent (311,500 acres).

• Most of Virginia's timberland was in sawtimber- and poletimber-size classes. Stands in the sawtimber-size class occupied 45 percent (6,938,500 acres) of the timberland area, and stands in the poletimber-size class occupied 36 percent (5,621,200 acres). Sapling-seedling stands occupied the remaining 19 percent of timberland. On forest industry lands, sawtimber proportions dropped from 29 to 25 percent. Sapling-seedling proportions were basically unchanged, and poletimber proportions increased from 33 to 40 percent. On NIPF lands, the sapling-seedling proportion was unchanged while poletimber increased 6 percent and sawtimber decreased 7 percent. Public-owned lands showed decreases in sapling-seedling proportions, increases in poletimber, and slight decreases in sawtimber stands.

• Live merchantable volume for all trees was 31.5 billion cubic feet, and growing-stock volume was 28.0 billion cubic feet. Across the State, softwoods made up 23 percent of the live merchantable volume and hardwoods 77 percent. Live merchantable volume on timberland increased by 7 percent between 1992 and 2001.

• Yellow-poplar dominated the State's total live-tree volume with 5.5 billion cubic feet (13 percent of the total). Red maple dominated the number of live stems with 1.5 billion stems (13 percent of all live stems).

• Net annual growth for all live trees on timberland for the survey period was 990.0 million cubic feet per year, an increase of 14.5 percent over the previous survey period. Since the 1992 survey, Virginia's live-tree removals have averaged 697.9 million cubic feet per year. This was an increase of 11.3 percent over the previous survey period. Overall, the ratio between live net growth and live removals was 1.42:1. This indicates that net growth exceeded harvesting in Virginia.

• Across the State, average annual mortality was 333.6 million cubic feet per year. This was a 46-percent increase from the previous inventory. Thirty-six percent of the current survey's mortality was in softwoods and 64 percent in hardwoods.

• Weather-caused disturbance affected an estimated 7 percent of Virginia's timberland between 1992 and 2002. Insect damage was the next most significant natural disturbance, affecting 3 percent of the timberland.

• Volume of coarse woody debris on P3 plots averaged 407 cubic feet per acre for the State. The amount of carbon in coarse woody debris and fine woody debris averaged 1.3 and 1.2 tons per acre, respectively.

• Most P3 plots in Virginia (72 percent, n = 92) had 10 percent or less bare soil. The majority of the mineral soil samples had a pH < 5.0. The forest floor accounted for 5.3 tons per acre of organic carbon, and mineral soil accounted for 17.2 tons per acre.

Cressy Creek in Smyth County, VA. *(photo by Charles W. Becker III, Virginia Department of Forestry)*

Appalachian Trail. *(photo by Anita Rose)*

Field measurements for this forest inventory of Virginia began in June 1997 and were completed in February 2002. Although measurements were spread over several years, this survey is dated 2001. The six previous surveys and State analytical reports were completed in 1940 (Craig 1949), 1957 (Larson and Bryan 1959), 1966 (Knight and McClure 1967), 1977 (Knight and McClure 1978), 1986 (Bechtold and others 1987), and 1992 (Thompson and Johnson 1994). Numerous other publications were developed from these previous surveys.

The tables and figures in this report present data for the 2001 survey, as well as estimates of trends. Most trend estimates are based on comparisons of data from the 2001 and 1992 surveys. The appendices describe survey methods, discuss data reliability, define terms, list tree species sampled in the survey, and provide standard tables.

During the survey, 4,404 plots were visited, 3,037 of which were at least partially forested. A total of 78,418 trees ≥ 5.0 inches in diameter at breast height (d.b.h.) were measured, of which 73,113 were alive. A total of 19,952 live saplings (1.0 to 4.9 inches d.b.h.) and 29,613 live seedlings (< 1.0 inch d.b.h.) were measured on smaller microplots. To obtain growth, removal, and mortality estimates, an additional 34,898 trees were measured on plots used in the 1992 survey's sample design.

Land area for Virginia in 2001 totaled 25,340,000 acres. This was a slight change from that reported in 1992 (25,410,000 acres). This difference was due to the use of new census area estimates (U.S. Department of Commerce, Bureau of the Census 2000).

Virginia includes a variety of physiographic provinces (fig. 1). The Appalachian Plateaus form the western boundary of the State

Rhododendron in flower. (photo by Anita Rose)

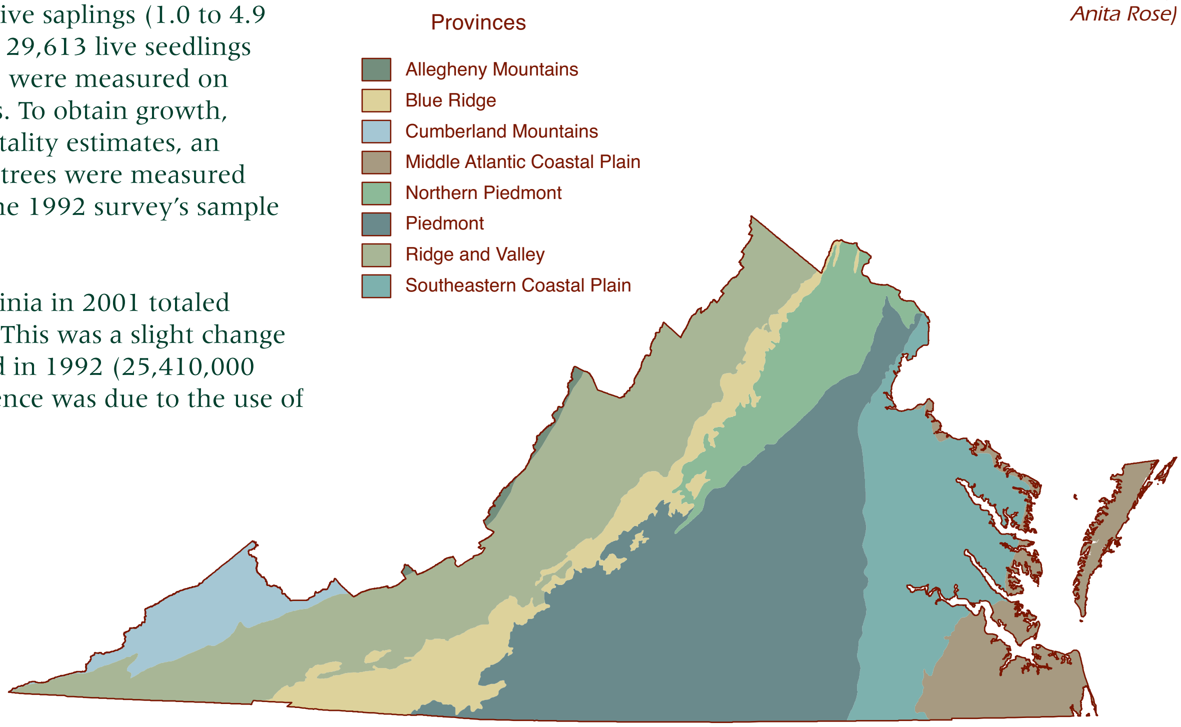


Figure 1—Physiographic provinces in Virginia.

and consist of the eastern escarpment of the Cumberland and Allegheny Mountains. To the east of these mountains is the Piedmont, which ranges from rolling hills in the west to several nearly level basins in the east. The easternmost part of the State lies on the Coastal Plain, which extends inland approximately 125 miles from the coast and about the same distance from the Potomac to the southern boundary. The Coastal Plain is defined by the eastern Atlantic shore and the rolling and dissected area where it meets the Piedmont at the fall line (Fenneman 1938). The elevation ranges from sea level to just over 5,700 feet on Mount Rogers in the George Washington and Jefferson National Forests. For the purposes of this report Virginia is divided into five units that approximate the physiographic provinces that occur in the State. These units are the Coastal Plain, Southern Piedmont, Northern Piedmont, Northern Mountains, and Southern Mountains (fig. 2). Any reference to the Piedmont includes the Southern and Northern Piedmont survey units, and any reference to the mountains includes the Southern and Northern Mountain survey units.

Fringetree (*Chionanthus virginica* L.) on the Blue Ridge Parkway. *(photo by Anita Rose)*

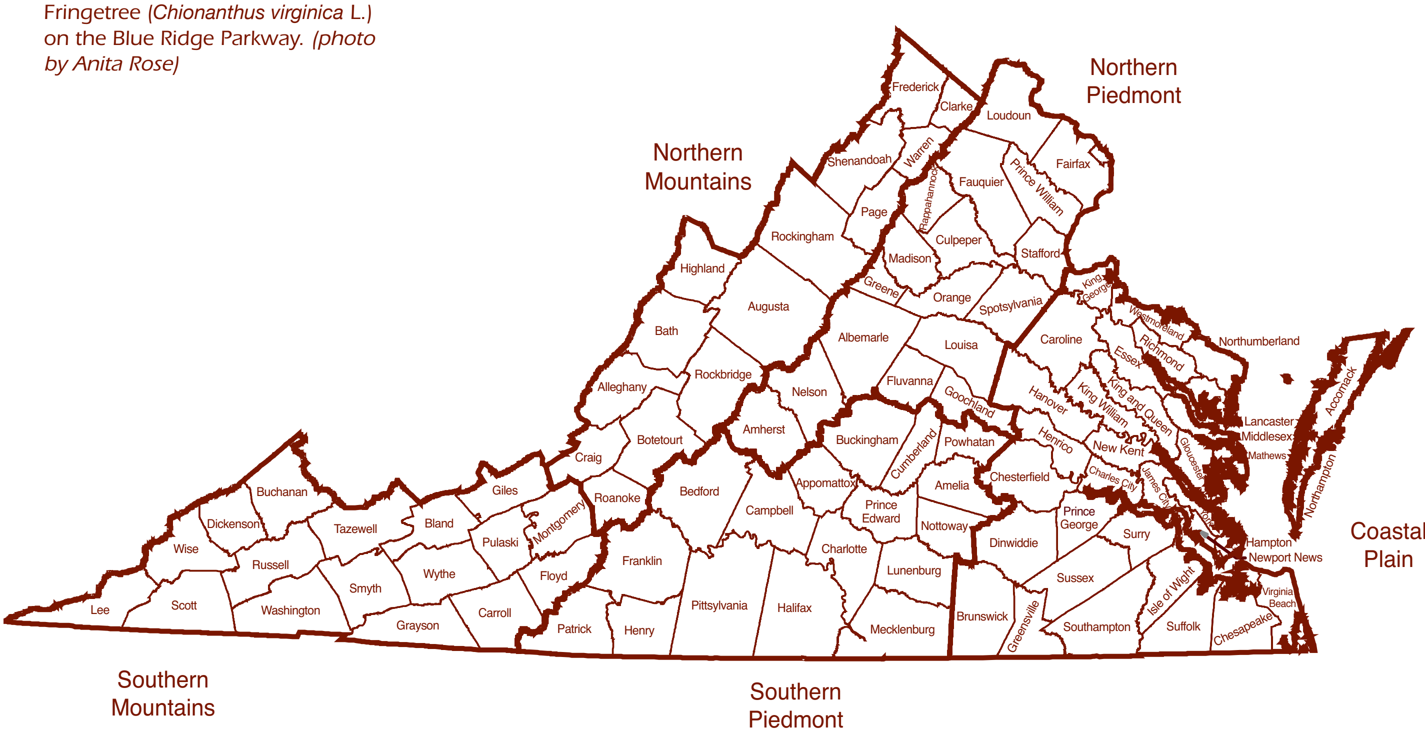


Figure 2—Counties and forest survey units in Virginia, 2001. (Note: 37 city-counties are omitted from this map.)

In 2001, about 15,844,000 acres, or 63 percent, of Virginia's land area was forested (table 1). Of the 15,844,000 acres of forest land, 15,467,000 acres was classified as timberland. A total of 371,200 acres of the remaining acreage was classified as reserved timberland, such as wilderness, parks, and historic sites where commercial timber harvesting is prohibited by statute. About 5,800 acres was classified as other forest land, or forest land incapable of commercial timber production because of adverse site conditions (land that cannot produce 20 cubic feet of wood per acre per year).

Total land area and total forest land area varied by survey unit. The Coastal Plain had the greatest total land area and the greatest total area of forest land. In contrast, the Northern Mountains had the least total land area, and the Northern Piedmont had the least total forest land area. Proportionally, the Southern Piedmont was the most heavily forested (68 percent), and the Northern Piedmont the least (55 percent) (fig. 3).

In 2001, about 15,844,000 acres, or 63 percent, of Virginia's land area was forested. Of this, 15,467,000 acres was classified as timberland. Timberland acreage peaked around 1977, fell slightly between 1977 and 1986, and has remained fairly constant since then.

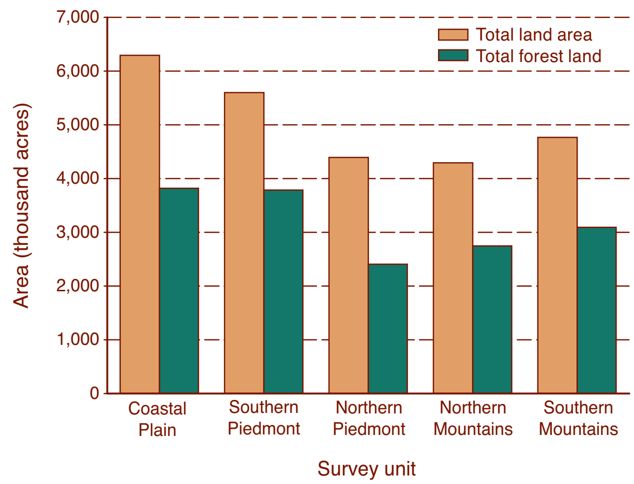


Figure 3—Total land area and forest land area by survey unit, Virginia, 2001.

Across the State, only six counties had more than 80 percent of their total land area in forest land (fig. 4). These counties were in the Southern and Northern Mountains, and the Southern Piedmont. Just over one-half of all the counties in the State had 61 to 80 percent of their land area in forest land, and 10 counties had < 40 percent of their land area in forest land. The least forested counties were in the northernmost part of the State and along the coast.

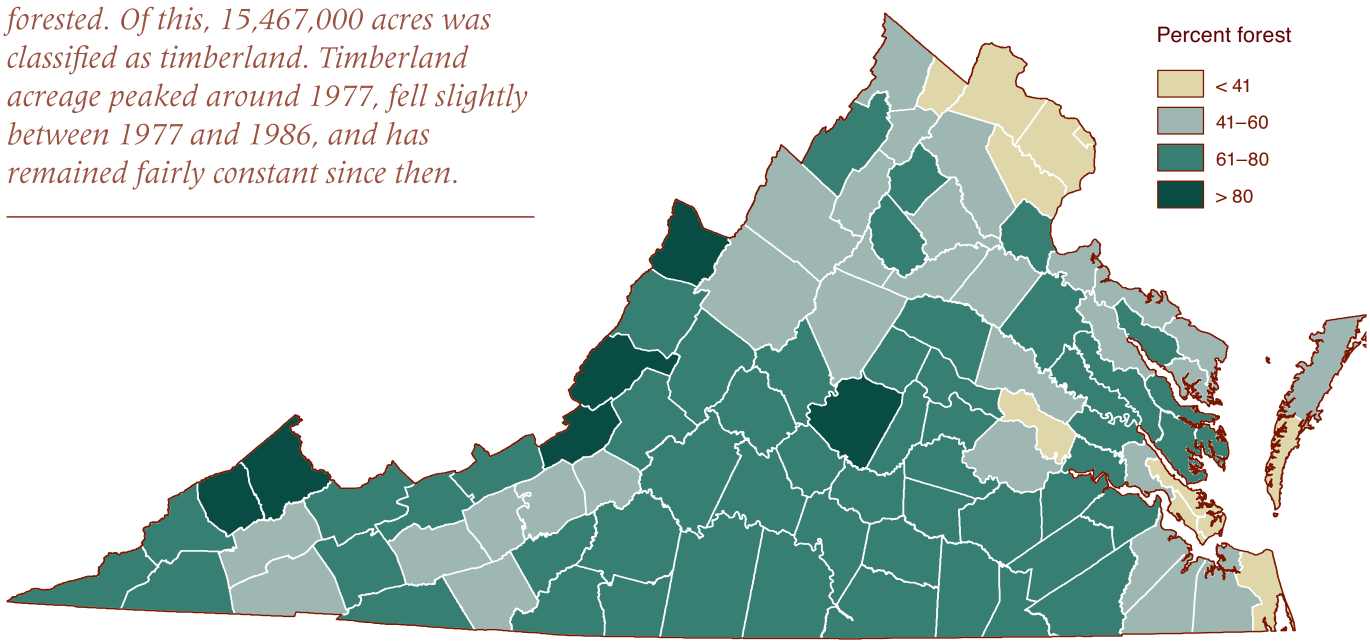


Figure 4—Percent forest land by county, Virginia, 2001.

Agricultural and urban land uses dominated on Virginia's nonforest land. In 2001, 5,959,200 acres were in agriculture and 3,178,400 acres were considered urban. Each of the five units had between 1,114,500 and 1,295,500 acres of agricultural land and between 421,400 and 1,010,400 acres of urban land. The Northern Piedmont had the highest proportion of its land area in agricultural (27 percent) and urban (18 percent) land use.

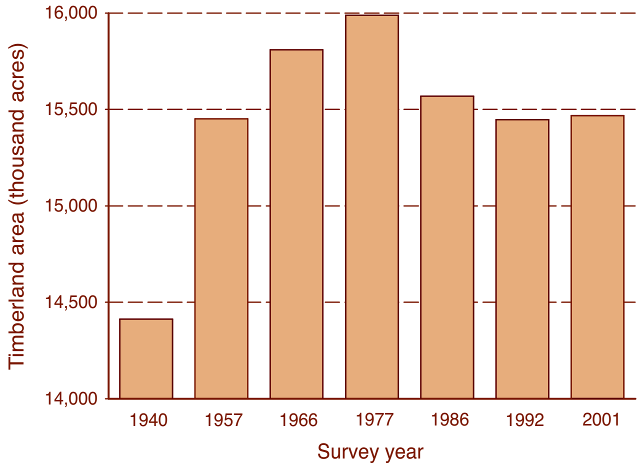


Figure 5—Trends in timberland area, Virginia, 1940 to 2001.

Trends in Forest Area

Timberland area increased from 15,448,000 acres in 1992 to 15,467,000 acres in 2001 (table 2). Timberland acreage reached its peak around 1977, fell slightly between 1977 and 1986, and has remained fairly constant since then (fig. 5) (Craig 1949, Knight and McClure 1967, Larson and Bryan 1959, Thompson and Johnson 1994). The gain of 0.1 percent (19,000 acres) since 1992 represented both reversions from nonforest and diversions to nonforest. Between 1992 and 2001, 290,000 acres of nonforest land reverted back to forest, and 271,000 acres of timberland were diverted to a nonforest land use. Between 1986 and 1992, reversions to timberland were 244,000 acres and diversions to nonforest use were 366,300 acres (Thompson and Johnson 1994).

Eighty percent of the gain in timberland came from the reversion of agricultural land. Sixty-five percent of the agricultural reversions occurred in the Southern Piedmont and the Northern Mountains.

Note the reversion to forest occurring just upslope of this farm on the James River. *(photo by Anita Rose)*

The reversion of agricultural land is a continuation of a trend that extends back to the first survey of Virginia (fig. 6).

Thirty-seven percent of the diversions of timberland were to agriculture, and this type of diversion was most common in the Southern Piedmont. Losses to urban development and other nonagricultural uses accounted for 63 percent of all diversions. This category includes residential and industrial development, roads and highways, utility rights-of-way, strip mining, and many other uses. The diversion of timberland to urban land use was highest in the Coastal Plain and the Northern Piedmont where the populations also tended to be highest (fig. 7). The population of Virginia was approximately 6.2 million in 1990 and approximately 7.1 million in 2000 (U.S. Department of Commerce, Bureau of the Census 2000), an increase of about 14 percent. The increase in population was not uniform across the State, however. Increases in population were greatest in the Northern Piedmont, which also had the smallest percentage of forest land (55 percent) and the greatest loss of timberland area between surveys (6 percent).

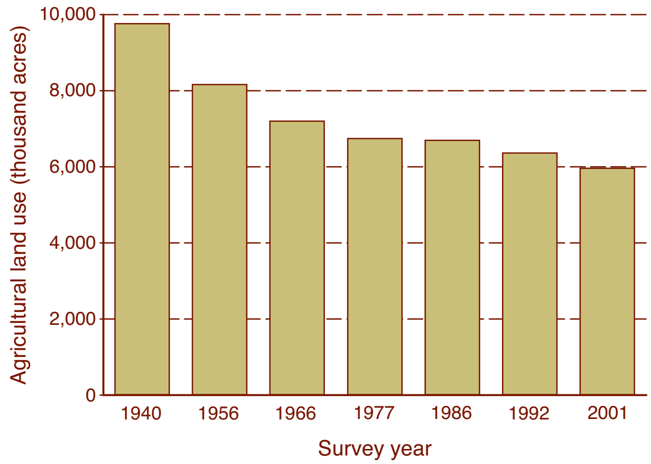


Figure 6—Trends in agricultural land use, Virginia, 1940 to 2001.


Utility line right-of-way as seen from the Blue Ridge Parkway. *(photo by Anita Rose)*

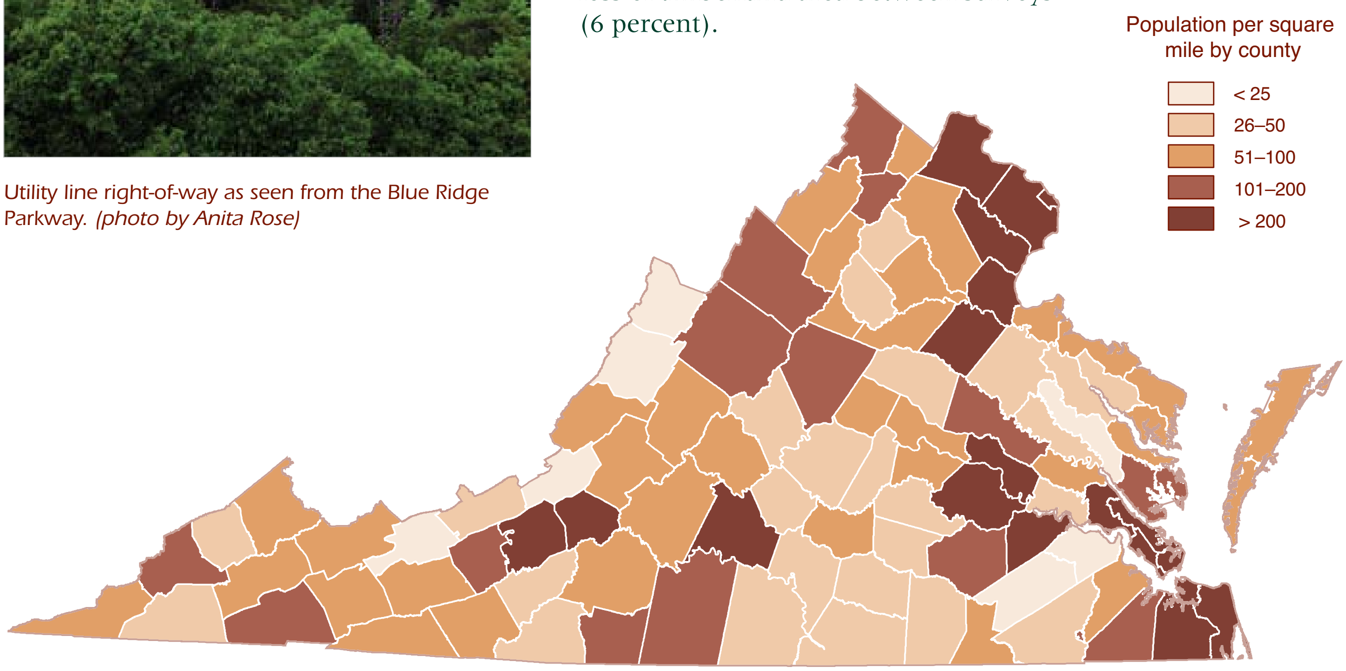


Figure 7—Population of Virginia, 2000.

Ownership

Just over three-fourths (12,101,900 acres) of Virginia's forest land was held in NIPF ownership (table 3). By unit, the NIPF ownership held a minimum of 51 percent and a maximum of 86 percent of the forest land acreage (fig. 8). Corporations and private individuals accounted for 16 and 84 percent, respectively, of NIPF owners.

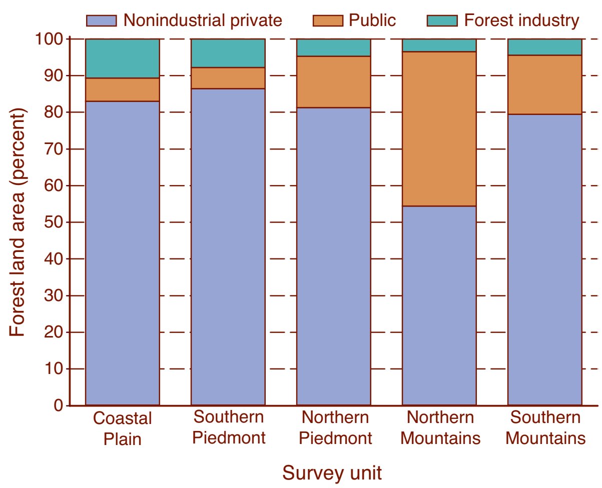


Figure 8—Percentage of forest land area by ownership class and survey unit, Virginia, 200l.

Just over three-fourths of Virginia's forest land was in nonindustrial private forest (NIPF) ownership. Seventeen percent of forest land was publicly owned, and 6 percent was owned by forest industry.

Public ownership ranked second with 2,717,900 acres (17 percent). Sixty-eight percent of public lands were in the Northern and Southern Mountains, where 32 percent of the forest land was publicly owned. In contrast, the Southern Piedmont had the least public land (213,800 acres), or 6 percent of the forest land in that unit. The National Forest System owned 62 percent of public lands across the State, with the George Washington and Jefferson National Forests accounting for most of that. Other Federal lands, with a total area of 540,000 acres, included the Shenandoah National Park, the Great Dismal Swamp National Wildlife Refuge, the Marine Corps Base at Quantico, and the Fort A.P. Hill and Fort Pickett military reservations. State forests and parks accounted for a large portion of the remaining public lands in Virginia.

Forest industry owned 6 percent, or 1,024,200 acres, of forest land across the State. Seventy percent of the land

The George Washington–Jefferson National Forest, seen here from the Blue Ridge Parkway, accounts for the majority of national forest land in Virginia. *(photo by Anita Rose)* controlled by forest industry was in the Coastal Plain and Southern Piedmont; here it made up 9 percent of the total forest land acreage. The Northern Mountains had the least forest industry owned land (71,900 acres). This amounted to 3 percent of the forest land in this unit. Both South Carolina and Georgia had a higher percentage of forest industry owned land than did Virginia (fig. 9) (Conner and others 2004, Thompson and Thompson 2002).

Forest industry ownership has been decreasing in Virginia and throughout the South. Timber industry management organizations (TIMOs) now own a substantial portion of the timberland liquidated by forest industry.

Due to changes in sampling methods between surveys, the analysis of area trends in timberland ownership is limited and should be used with caution. For a more detailed discussion of these changes, see the "Inventory Methods" section in the appendix A. The area of timberland held by NIPF owners has increased by 1.4 percent to 12,096,100 acres since 1992 (fig. 10). Forest industry ownership had the first recorded decrease (16 percent) between 1986 and 1992 (Thompson and Johnson 1994). This downward trend continued between 1992 and 2001, with a 33-percent decrease. This trend is not unique to Virginia, however, as it has been noted throughout the South. Timber industry management organizations now own a substantial portion of the timberland liquidated by forest industry. Area of public land increased 18 percent. These trends are indicative of changes in area of ownership. However, the magnitude of these changes is less certain due to changes in methods.

In Virginia, an estimated 373,000 people own 10,113,000 acres classified as individual owned within the NIPF category. Because so much of the forest land in the United States is privately owned, the Forest Service initiated the National Woodland Ownership Survey (NWOS) in 2002. The primary goals of the NWOS are to determine who owns the forest land of the United States, why people own forest lands, and how these owners plan to use forest lands in the future (Butler and others 2005). Two key functions the NWOS serves are to facilitate the planning and implementation of forest policies, and to support forest sustainability assessments in the United States. Between 2002 and 2004,

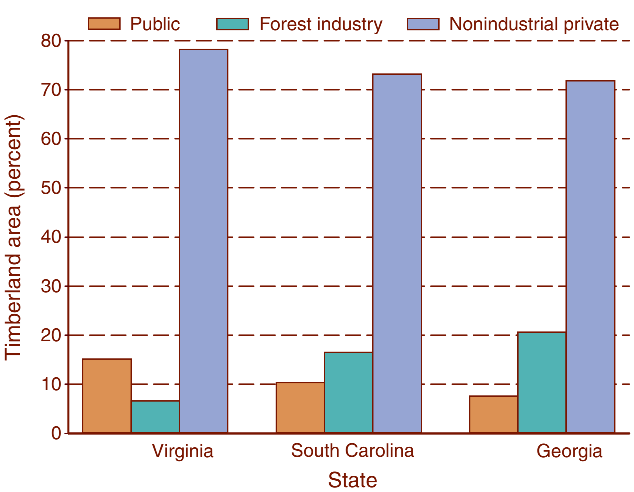


Figure 9—Percentage of timberland area by ownership class and State.

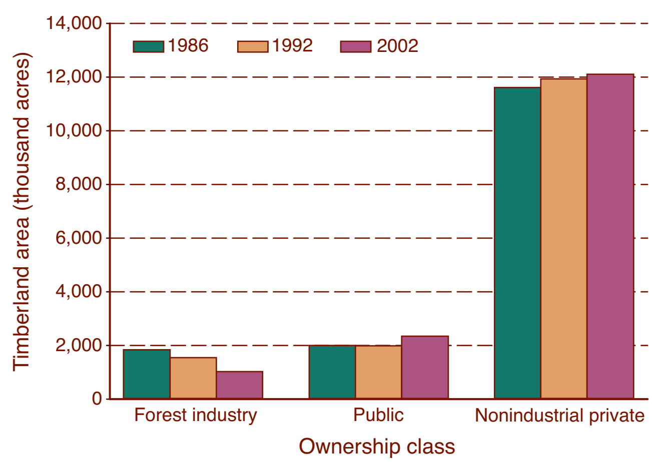


Figure 10—Area of timberland by year and ownership class, Virginia.

400 private forest land owners in Virginia responded to the NWOS. Similar surveys were also conducted in 1978 and 1994 (Birch and others 1982, 1998).

While most (88 percent) private forest land owners have < 50 acres, the majority (68 percent) of the forest land acreage is controlled by only 12 percent of private owners (fig. 11). A small number of private owners with large landholdings control the majority of land that may potentially be available for timber harvesting. As size of forest tracts decreases, harvesting costs increase and economic opportunities decrease. Since 1978, the percentage of individuals owning < 10 acres has decreased, while the percentage of acreage in this category increased slightly. The number of landowners with 500 or more acres has decreased also, while the number of persons owning 10 to 49 acres has increased substantially (fig. 12). These changes have resulted in a decrease in the percentage of acreage held in large contiguous tracts, especially tracts ≥ 1,000 acres.

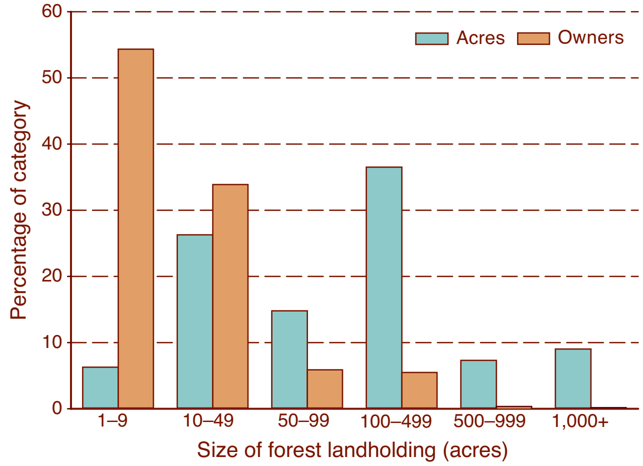


Figure 11—Percentage of area and private forest land owners by size of forest landholding, National Woodland Owner Survey, Virginia, 2004.

About one-half of all private owners have harvested timber on their land at some time in the past, a proportion that has not changed substantially since 1994 (table 4). Of those that have, 23 percent did so within the last 5 years (table 5). However, only 5 percent of private landowners (who hold 22 percent of the forest land acres) have plans to harvest timber on their land in the next 5 years. Other recent activities include posting land, private recreation, and road

Christmas tree plantation along the Virginia Creeper Trail in southwest Virginia. (photo by Anita Rose)

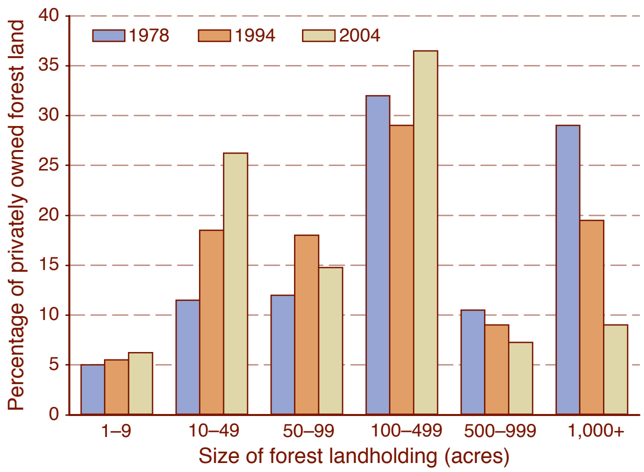


Figure 12—Percentage of privately owned forest land by year and size of forest landholding, National Woodland Owner Survey, Virginia.

or trail maintenance. Written management plans can help ensure good management practices and sustainable harvesting. Since 1994, the percentage of owners with written management plans dropped from 17 to 4 percent (table 4).

State issues, laws, and personal concerns of landowners toward forest land can affect their management practices. Over 50 percent of private landowners considered nontimber forest products, aesthetics, nature protection, or family legacy an important reason for owning their land (table 6). Also, large proportions of private owners had concerns about land development or air or water pollution issues (table 7).

With a large percentage of forest land in NIPF ownership there is concern about the effects of owner attitudes on forest sustainability, forest health, and timber supply. Because the attitudes and behavior of private landowners are important to the future of forests in Virginia, and elsewhere in the United States, an effort must be made to account for these owners in planning and issue resolution. This may include some form of tax relief (owners controlling 55 percent of forest land were concerned about property taxes) or incentive plans that help owners provide and meet sustainability, forest health protection, and product availability goals.

Forest Types

As would be expected in a State with an area of 25.3 million acres and elevation ranging from sea level to just under 6,000 feet, Virginia's forests contained a wide variety of tree species. These species often occur in associations known as forest types. Some forest types occurred across the entire State, while others were restricted to limited areas especially suitable for particular species. Due to complex interactions involving stand structure dynamics, management practices, and natural disturbance, the State's physiographic provinces had definite patterns of forest cover, and these patterns differed with respect to predominant forest types and species.

Each plot condition was assigned a forest type based on dominance of one, two, or three species according to the relative species majority, or plurality if there was not a majority. Forest typing is an artificial and somewhat arbitrary classification system and forest-type classes often do not have sharply delineated boundaries. On the landscape, they grade into one another, sometimes with considerable overlap, often forming a continuum which makes it difficult to assign forest-type names consistently and in a repeatable manner. In some sections of this report, similar forest types are aggregated into forest-type groups (table 8).

The predominant forest-type group in Virginia was oak-hickory. It occupied 60 percent or 9,537,100 acres of the forest land area and contained 64 percent (20.1 billion cubic feet) of the merchantable volume across the State (fig. 13). It was dominant in all survey units except the Coastal Plain.

Oak–hickory is the predominant forest-type group in Virginia. *(photo by John Pemberton, Virginia Department of Forestry)*

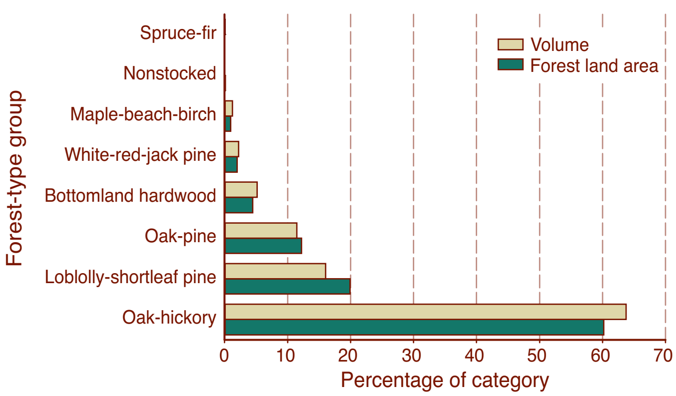


Figure 13—Percentage of total forest land area (15.8 million acres) and live merchantable volume (31.5 billion cubic feet) represented by each forest-type group, Virginia, 2001.

The oak–hickory forest-type group occupied 60 percent of the forest land area and accounted for 64 percent of merchantable volume across the State. The loblolly–shortleaf forest-type group predominated on the Coastal Plain, where it occupied 38 percent of the forest land area.

There, the loblolly-shortleaf forest-type group was the most prevalent, occurring on 1,446,700 acres (38 percent) of forest land area. Statewide the oak-hickory forest-type group was made up predominantly of the white oak-red oak-hickory and the yellow-poplar-white oak-northern red oak detailed forest types (fig. 14). Also present in the oak-hickory group, but to lesser degrees, were the mixed upland hardwood and the chestnut oak forest types.

Loblolly-shortleaf was the second most dominant forest-type group in both area and volume. It occupied about 3,157,400 acres (20 percent) of the State's forest land area, and contained 5.1 billion cubic feet (16 percent) of the live volume. Eighty-one percent of the area occupied by this forest-type group was in the Southern Piedmont and Coastal Plain. In the Coastal Plain and both Piedmont units, the loblolly pine forest type dominated the loblolly-shortleaf forest-type group. This forest type accounted for 72 percent of the acreage and 69 percent of the live volume in the loblolly-shortleaf forest-type group across the State. In the Northern and Southern Mountains, there

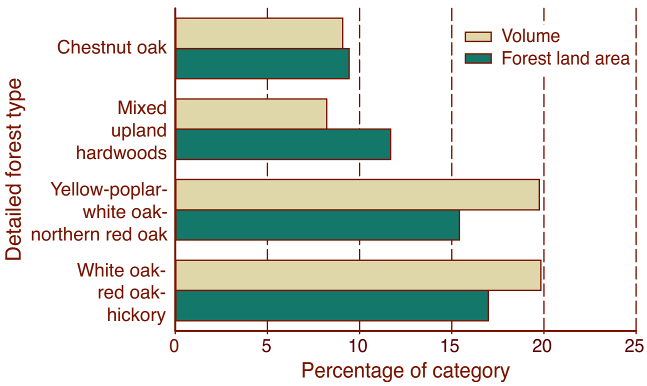


Figure 14—Top four detailed forest types of the oak-hickory forest-type group shown as a percentage of total forest land area (15.8 million acres) and live merchantable volume (31.5 billion cubic feet) for Virginia, 2001.

was virtually no loblolly pine forest-type acreage. Instead, Virginia pine, pitch pine, and eastern redcedar forest types dominated.

The oak-pine forest-type group ranked third, with 1,936,800 million acres. This group contained 3.6 billion cubic feet of live volume. This group, like the loblolly-shortleaf group, occurred primarily (58 percent) in the Southern Piedmont and Coastal Plain. The loblolly pine-hardwood forest type was dominant in the oak-pine forest-type group. This type occupied 37 percent of the acreage and contained 42 percent of the volume in this group.

Trends in Forest-Type Acreage on Timberland

Changes in forest-type acreage can occur for a variety of reasons. The diversion of forested land to nonforest land can affect particular forest types, especially the less common ones, if diversions do not occur evenly across all types in the State. Fire can often favor softwoods, while the suppression of fire can favor hardwoods, either of which can result in shifts of forest type. Since forest-type categories are defined by indefinite boundaries, a slight shift of species dominance, real (due to natural succession) or perceived, across these arbitrary thresholds may give a false impression of dramatic changes in forest-type acreage. Forest management activities, including but not limited to harvesting, planting, control of species composition, and thinning, often result in shifts from one forest type to another. In effect, any activity, either natural or anthropogenic, that alters species populations may result in shifts in forest type.

Within the forest-type groups, only relatively small changes in acreage were noted between 1992 and 2001 (table 9). The largest percentage change was in the bottomland hardwoods group, where there was an increase of 37,300 acres (6 percent). The loblolly-shortleaf, oak-hickory, and oak-pine forest-type groups each had a change of 1 percent or less. The loss of 57,000 acres in the oak-hickory group was the largest change in total acreage.

While relatively small changes occurred within forest-type groups between surveys, certain specific forest types within the groups had relatively large changes. Most notably, area of the loblolly pine forest type (within the loblolly-shortleaf pine forest-type group) increased by 285,800 acres. This 14-percent increase brought the total area for this type to 2,262,800 acres, which exceeded for the first time the 2,016,000 million acres recorded in the earliest (1940) survey. As previously noted, this forest type occurred primarily on the Coastal Plain and Piedmont units of the State.

The Virginia pine forest type, the second most abundant pine type, decreased by 202,400 acres (25 percent). The shortleaf pine type also decreased in acreage. In 2001, this forest type occupied only 22 percent as much acreage as reported in the 1966 survey and a mere 4 percent as much acreage as reported in the 1940 survey.

This trend corresponded closely with the decreasing trend in volume of shortleaf pine as a species. It has been theorized that these later two subclimax forest types became established on abandoned farmland in the later part of the 19th century and the early part of the 20th century. It is estimated that as much as 12,000,000 acres of land was cleared for agriculture in Virginia before 1860 (Williams 1989). Then, around the time of the Civil War, large areas of this land were abandoned and allowed to revert back to forest (Davis 1983). Over time, a myriad of factors have impacted these early successional pine types, including but not limited to timber harvesting, stand invasion by hardwoods, and conversion of stands to a nonforest land use or plantations. These types, which were dominant over much of Virginia when the first survey was initiated, have become but a remnant and reminder of Virginia's agrarian history.

Changes within the loblolly-shortleaf pine forest-type group may be explained by a number of factors, including the increase in plantations. Since 1992, the area of timberland classified as pine plantation increased by 30 percent to 1,907,000 acres. It had increased by approximately the same amount in the previous survey. In contrast, natural pine stands decreased by approximately 17 percent (311,500 acres) since 1992 and had decreased by 14 percent in the previous survey. For the first time, planted acreage surpassed naturally regenerated acreage in this group (table 10). Ninety percent of the planted pine acreage and 69 percent of the natural pine acreage was in the Coastal Plain and Southern Piedmont (fig. 15). It was only in these units that acreage in planted pine exceeded acreage in natural pine. All units had a loss in acreage of natural pine, while all units except for the Northern Piedmont showed increases in acreage of planted pine.

The loblolly-shortleaf pine forest-type group accounted for 94 percent of the planted pine acreage and 87 percent of natural pine acreage, and any reference to these types of stands refers to this group. Within this group, the loblolly pine forest type accounted for 93 percent and 32 percent of the planted pine and natural pine stand acreage, respectively. The Virginia pine forest type accounted for 38 percent of the natural pine stand acreage. While fairly significant changes occurred in the planted versus natural pine acreage, the overall change in acreage of the loblolly-shortleaf forest-type group was very small.

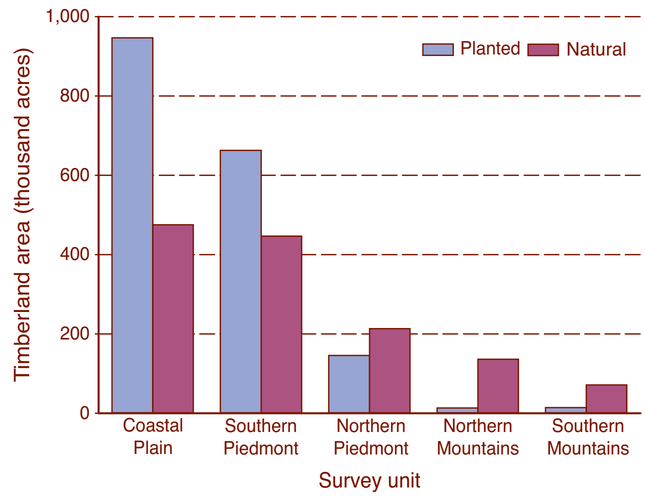


Figure 15—Area of planted and natural loblolly-shortleaf pine forest-type group by survey unit, Virginia, 2001.

Although approximately 24 percent of planted pine stand acreage was created by conversion of natural stands, less than half of the natural stand acreage was originally in natural pine stands (fig 16). One-half of the natural stands that were converted to pine plantations were originally in the oak-hickory forest-type group. Nearly 60,000 acres, or 4 percent of current pine plantations, were established on acreage that was classified as nonforest in the previous survey.

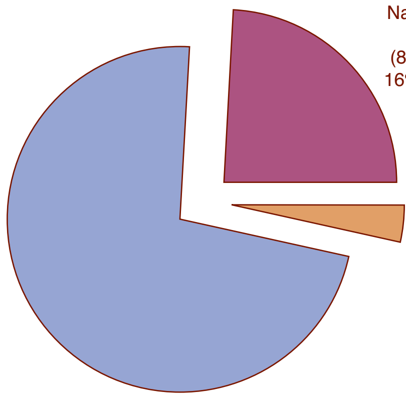


Figure 16—Origins of planted pine stand acreage since 1992, Virginia.

The decrease in natural pine stand acreage is explained by several factors. While most natural pine stand acreage (63 percent) remained in that category, some was converted to a nonforest land use (5 percent) and some was converted to pine plantations (8 percent). The largest change within natural pine stands was a change in forest type. Twenty-three percent of the acreage in this category had changes in forest type but still remained in the broader natural stand category.

Figures for changes in acreage of detailed forest types should be considered cautiously because different sampling procedures were used in the 1992 and 2001 surveys. Also, forest typing in the field is somewhat subjective, and this adds uncertainty when trends are tracked over time. Natural succession complicates matters further. Stands of naturally occurring pine may have converted to, or are in the process of converting to, another forest type. All of these factors, in combination with the relatively small sample size in this particular category (9 percent of the total timberland acreage and 10 percent of the total natural timberland acreage), make it hard to determine exactly how much natural pine acreage was lost between the two surveys.

Loblolly pine - the predominant species of the loblolly-shortleaf forest-type group in Virginia. *(photo by Anita Rose)*

Current Stand Volume

The total live volume for all trees ≥ 1.0 inch d.b.h. on forest land was 42.5 billion cubic feet. Live merchantable volume for all trees ≥ 5.0 inches d.b.h. was 31.5 billion cubic feet, and growing-stock volume was 28.0 billion cubic feet. The Coastal Plain had the largest amount of live merchantable tree volume and the Northern Mountains had the smallest (table 11). On a per acre basis, the Northern Piedmont ranked first, with an average of 2,203 cubic feet of live merchantable volume per acre. The Southern Piedmont ranked last in volume per acre, with an average of 1,758 cubic feet per acre. This may have been partly because the Southern Piedmont had a higher proportion of stands in the sapling-seedling stand-size category than the other units. In addition, the Southern Piedmont had the highest ratio of removals to growth (see discussion about growth, removals, and mortality). Across the State, softwoods made up 23 percent of the live merchantable volume and hardwoods 77 percent. As previously noted, over 60 percent of the total live-tree volume for the State was in the oak-hickory forest-type group (fig. 13).

About 6 percent of the total volume of trees sym 5.0 inches d.b.h. (live and standing dead) was dead (2.2 billion cubic feet). This varied by survey unit—in the Northern Mountains, 11 percent of the total volume was dead, while only 4 percent was dead in both the Coastal Plain and Southern Piedmont. Thirty percent, or 652.2 million cubic feet, of all dead volume was in the Northern Mountains (fig. 17).

Softwoods—The total live-tree volume of softwoods ≥ 1.0 inch d.b.h. was 9.1 billion cubic feet. Live merchantable volume of softwoods ≥ 5.0 inches d.b.h. was 7.1 billion cubic feet, while growing-stock volume of softwoods was 6.8 billion cubic feet. Softwoods, as a group, did not dominate area or volume in any survey unit (fig. 18). Softwood live merchantable

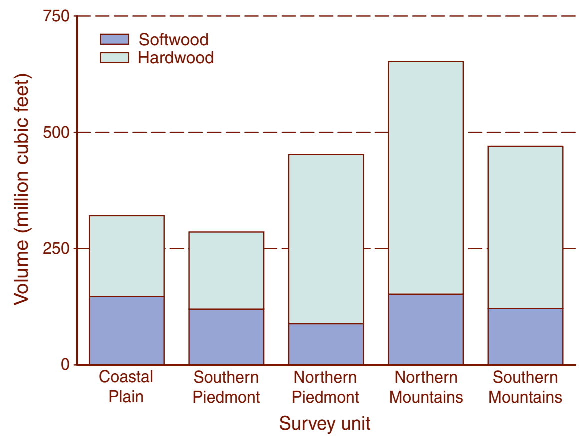


Figure 17—Volume of dead trees (≥ 5.0 inches d.b.h.) on forest land by major species group and survey unit, Virginia, 2001.

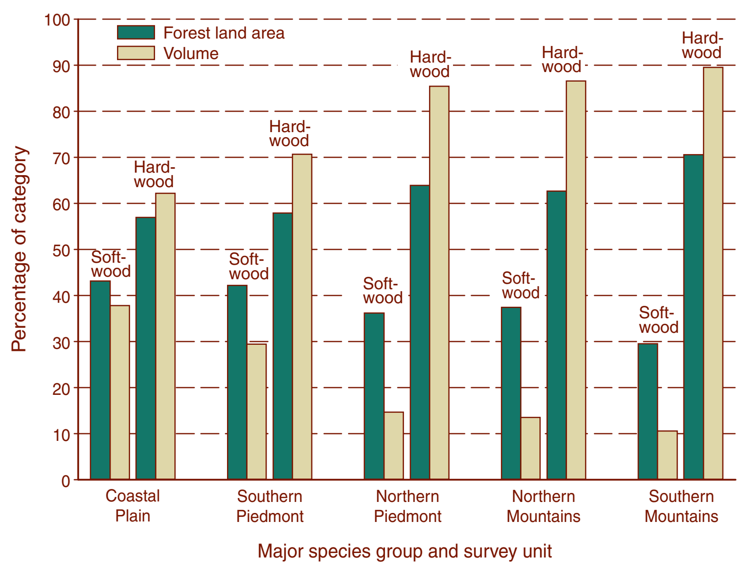


Figure 18—Percentage of forest land area and live merchantable volume in each survey unit represented by major species group, Virginia, 2001.

volume was concentrated in the Coastal Plain and Southern Piedmont, where it totaled 5.0 billion cubic feet, or 70 percent of the total for the State.

Trees from 5.0 to 12.9 inches d.b.h. accounted for 63 percent of the total live softwood volume (fig. 19). Over 90 percent of all the live softwood trees in Virginia were < 11.0 inches in diameter (table 12). About 8 percent of softwood trees ≥ 5.0 inches d.b.h. were dead. As expected in a State with a majority of forest land in private ownership, the majority (77 percent) of softwood volume was in nonindustrial private ownership.

Hardwoods—The total live-tree volume of hardwoods ≥ 1.0 inch d.b.h. on forest land was 33.4 billion cubic feet. Live merchantable volume for hardwoods ≥ 5.0 inches d.b.h. was 24.4 billion cubic feet, while growing-stock volume was 21.2 billion cubic feet. Hardwoods dominated acreage as well as volume in all units (fig. 18). The Southern Mountains, with 5.8 billion cubic feet, had the highest live merchantable volume of hardwoods (table 11).

Trees in the range of 7.0 to 16.9 inches d.b.h. contained 55 percent of the live hardwood volume (fig. 20). As was the case with softwoods, the majority of trees were < 11.0 inches d.b.h. (table 12). Analyses of volume by diameter class are confounded by the fact that larger trees have more volume. So, while trees in the range of 13.0 to 22.9 inches d.b.h. had 42 percent of the volume, only 3.2 percent of all live trees were actually in this size range. About 6 percent of hardwood trees ≥ 5.0 inches d.b.h. were dead. The majority (76 percent) of hardwood volume, like the majority of softwood volume, was in nonindustrial private ownership.

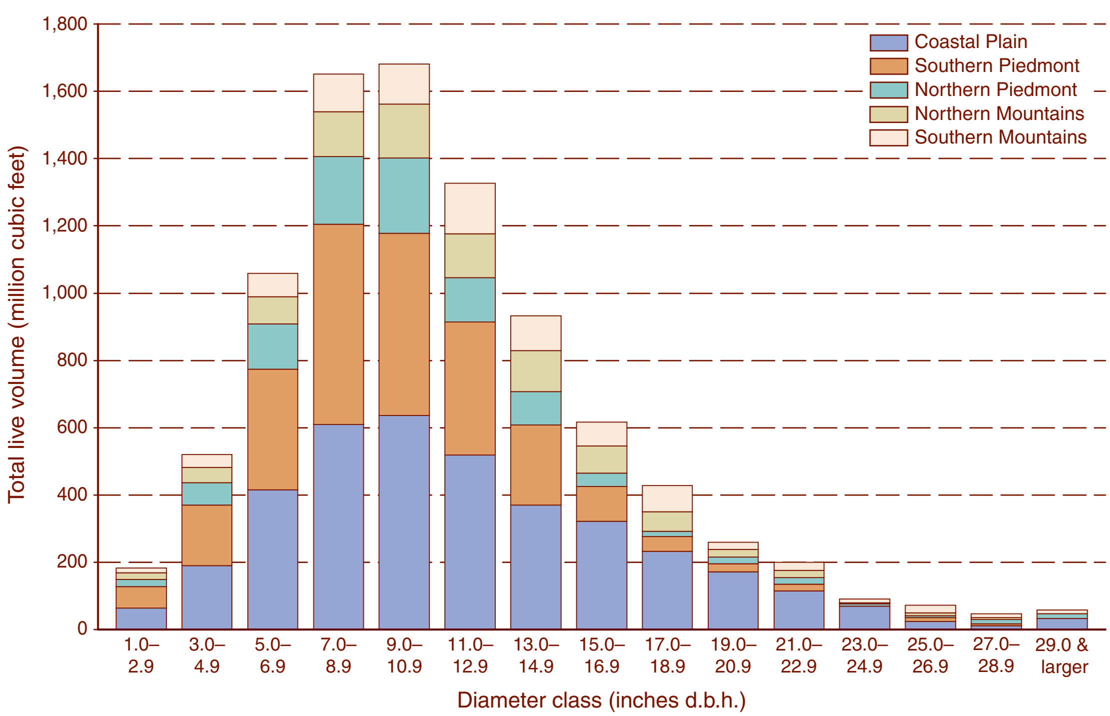


Figure 19—Total live volume of softwood trees ≥ 1.0 inch d.b.h. on forest land by diameter class and survey unit, Virginia, 2001.

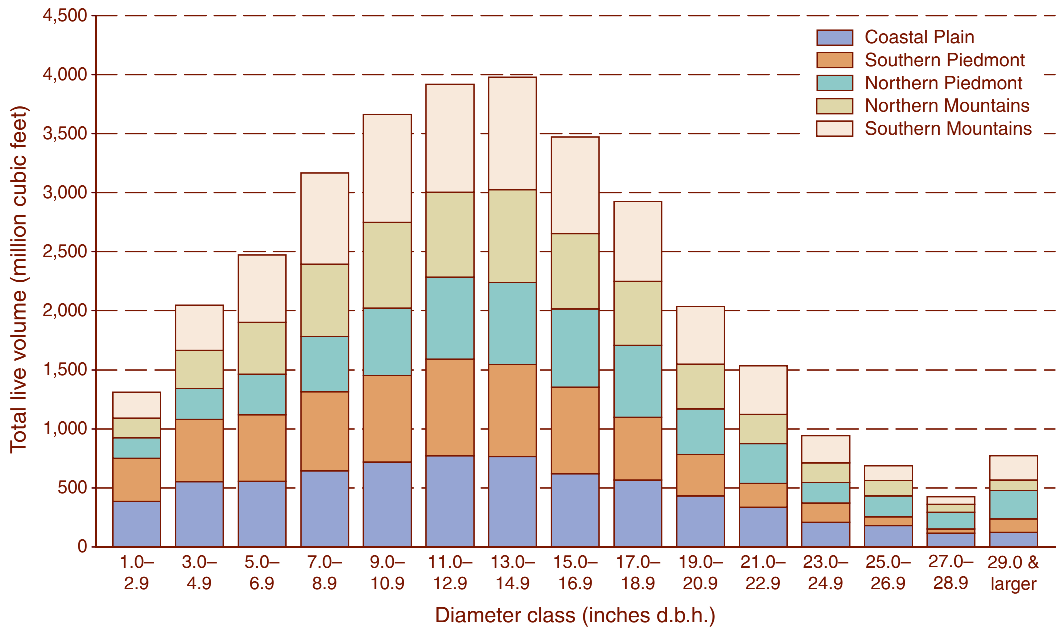


Figure 20—Total live volume of hardwood trees ≥ 1.0 inch d.b.h. on forest land by diameter class and survey unit, Virginia, 2001.

Trends in Volume on Timberland

Live merchantable volume on timberland increased from 28.6 billion cubic feet in 1992 to 30.6 billion cubic feet in 2001, a change of 7 percent (table 13). Change in volume was not uniform across the State. Volume in the Coastal Plain increased by 1.0 billion cubic feet, or 16 percent, while volume in the Northern Piedmont only increased by 47.3 million cubic feet, or 1 percent. Fifty-two percent of the total live merchantable volume increase was in the Coastal Plain.

Live merchantable volume on timberland increased by 7 percent between 1992 and 2001. Fifty-two percent of the total live merchantable volume increase was in the Coastal Plain.

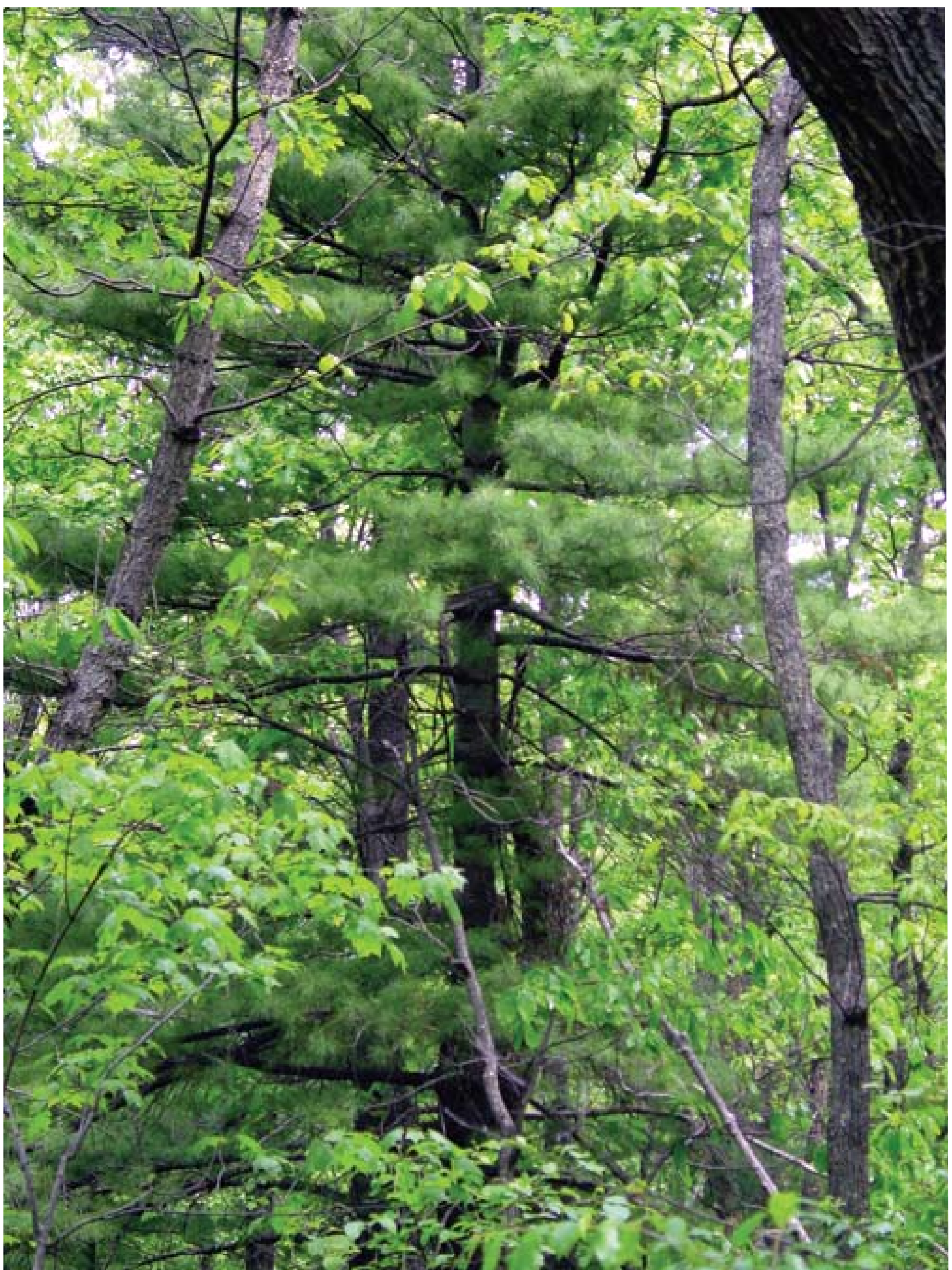
Trends in volume by ownership tended to mimic trends in acreage by ownership. Acreage of forest industry land decreased by 34 percent and live merchantable volume on forest industry land decreased by 36 percent. Changes in volume correlated with changes in acreage in the other ownership categories also.

Softwood Trends—Live softwood volume on timberland increased from 6.7 billion cubic feet in 1992 to 7.0 billion cubic feet in 2001 (table 13). Trends in softwood live merchantable volume varied by unit. Between 1992 and 2001, live softwood volume decreased by 20 percent in the Northern Piedmont and increased by 17 percent in the Coastal Plain. The loss of timberland in the Northern Piedmont may, in part, explain the large decrease in volume in that unit. Also, removals exceeded growth in the unit. The relatively small sample size and fairly high sampling error (9 percent) for live merchantable volume of softwoods in the Northern Piedmont could also have affected the estimate.

Softwood growing-stock volume in planted pine stands increased by 52 percent, but that in natural pine stands decreased by 34 percent. For the most part, these changes paralleled the changes in acreage of planted and natural pine stands (table 10). As the 1992 report predicted, the amount of softwood growing-stock volume in pine plantations continued to rise. Planted pine stands accounted for 14 percent and 22 percent of the softwood growing-stock volume inventory in 1986 and 1992, respectively. In 2001, these stands accounted for 33 percent of the softwood growing-stock volume.

Since 1992, softwood live merchantable volume in the oak-pine, or mixed, forest-type group increased 17 percent. The stands that were classified as a hardwood type showed a 34-percent increase in softwood volume (fig. 21). The volume of softwoods in softwood stands actually decreased slightly. Even with this decrease, softwood stands still accounted for 64 percent of the softwood volume.

Eastern white pine coming up in a mixed hardwood stand at Greenstone Overlook on the Blue Ridge Parkway in Virginia. (photo by Anita Rose)



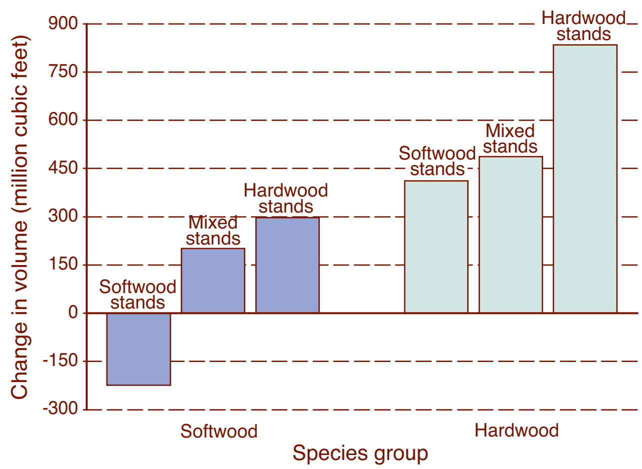


Figure 21—Change in live merchantable volume on timberland by major species group and stand type, Virginia, 1992 to 2001.

Increases in volume were noted in most diameter classes, with the exception of trees < 9.0 inches d.b.h. The largest increases were in the larger size categories. Volume increased by 54 percent in trees over 20.9 inches d.b.h. Volume in this category has almost doubled since the 1986 survey. Volume of trees in the 5.0- to 6.9-inch category decreased by 21 percent (fig. 22).

Hardwood Trends—Hardwood live merchantable volume on timberland continued to rise between 1992 and 2001, from 21.9 billion cubic feet to 23.6 billion cubic feet, an 8-percent change. Live hardwood volume rose 3 percent between 1986 and 1992 and 10 percent between 1977 and 1986. Increases were noted in all units of the State. The largest increase occurred in the Coastal Plain, where live merchantable volume rose by 604.9 million cubic feet, a 15-percent change. The smallest increase was in the Northern Mountains, where live merchantable volume rose by 218.8 million cubic feet, a 5-percent change (table 13). Gypsy moth infestations may be partly responsible for the relatively small increase in hardwood volume in the Northern Mountains.

Hardwood live merchantable volume increased by 4 percent in hardwood stand types. The largest percent increases were in the mixed and the softwood stands (fig. 21). Since 1992, softwoods had their largest percent volume increases in hardwood stands, and hardwoods had their largest percent increases in softwood stands.

Hardwood volume decreased in the four smallest size categories (fig. 23). Decreases had been noted in the three smallest size categories in the previous survey. The largest change was the 33-percent increase in volume of trees over 20.9 inches d.b.h.

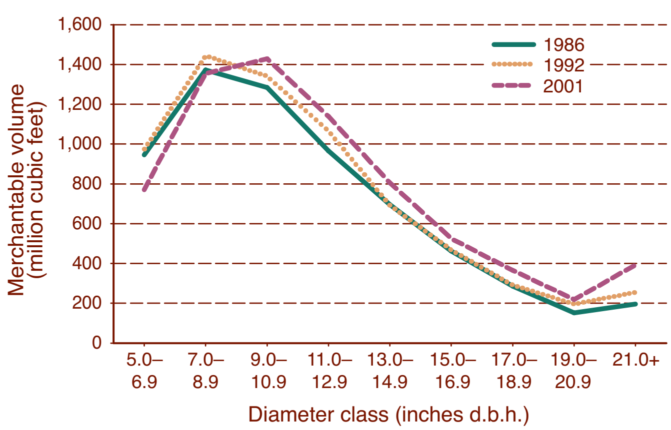


Figure 22—Live merchantable volume of softwoods on timberland by diameter class, Virginia, 1986, 1992, and 2001.

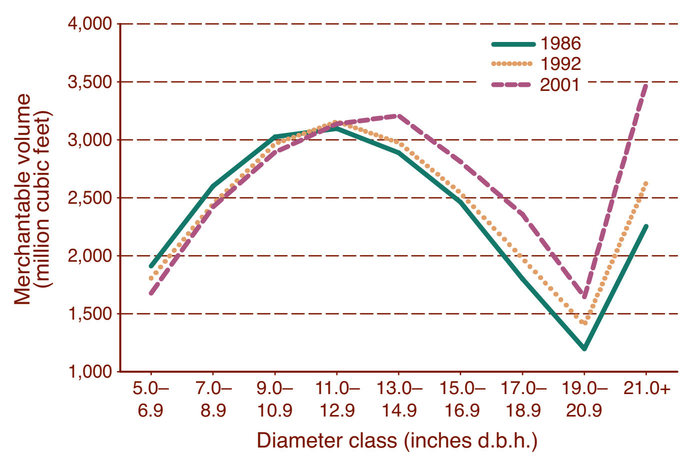


Figure 23—Live merchantable volume of hardwoods on timberland by diameter class, Virginia, 1986, 1992, and 2001.

Stand Size

If the majority of a State's forests are in the sapling-seedling stage, this is evidence of recent high levels of natural or anthropogenic disturbance. In contrast, if a State has a high proportion of its forest land in the sawtimber stand-size class this may indicate that levels of disturbance are lower or that substantial time has elapsed since the last period of disturbance. However, complex interacting factors may be occurring that complicate any analysis. When assessing stand-size dynamics it is important to consider the life-cycle characteristics of the forest stands in question—for example, hardwood stands generally take much longer to reach sawtimber size than do softwood stands. Another factor may be the presence of an early successional species component that may drop out of the stand as succession progresses. In some situations, a stand may be composed of mostly early successional species that have grown quickly to sawtimber size. This could lead to overestimation of the acreage of late-successional stands. Complex interactions between successional stages and species composition, though important factors in stand-size analysis, are beyond the scope of this report. In addition, the change in sample design and procedures for assessing stand size since the 1992 survey adds further complexity.

When data for a large area such as the State of Virginia are considered, there may be little net change in stand-size classes over time and stand dynamics may be masked. In this situation, as one stand moves from one size class to another (because of growth or decline), another stand from another size class may take its place. In effect, stands in different size classes may swap positions. A survey might show that there was no net change in area in any stand-size class when many individual stands moved from one stand-size class to another.

A poletimber-sized stand of planted loblolly pine in Hanover County, VA. *(photo by John Pemberton, Virginia Department of Forestry)*

Forty-five percent (6,938,500 acres) of Virginia's timberland was in the sawtimber-size class, and 36 percent (5,621,200 acres) was in the poletimber-size class (table 14). The sapling-seedling stands made up the remaining 19 percent of timberland area. Virginia was comparable to other Southern States in percentage of timberland area in sawtimber. For example, Arkansas, North Carolina, and South Carolina had 46, 49, and 37 percent, respectively, of their timberland in sawtimber (Brown 2004, Conner 2004, Rosson 2002). The percentage of timberland in sapling-seedling stands was lower in Virginia than in other Southern States. For example, Arkansas, North Carolina, and South Carolina had 24, 37, and 30 percent of their timberland area in this size class.

Sawtimber-sized stands were fairly evenly distributed throughout Virginia (table 14). The Southern Mountains had the most acreage in this size class (1,725,800 acres) and the Northern Piedmont the least (1,164,700 acres). The poletimber-sized stands were slightly less evenly distributed, with the Southern Piedmont having the most acreage (1,397,900 acres) and the Northern Piedmont the least (798,900 acres) in this class. The least evenly distributed size class, by unit, was sapling-seedling stands. Sixty-nine percent of the acreage in this size class was on the Southern Piedmont (1,064,000 acres) and Coastal Plain (939,000 acres). Most likely, this distribution of sapling-seedling area reflected the prevalence of pine plantation management in these units.

Most of Virginia's timberland was in NIPF ownership (12,096,100 acres, not including NIPF corporate), and the majority of each stand-size class was also in this ownership. However, stand-size distributions varied within the ownership classes. Forest industry had the most even distribution of the three stand-size classes, 35, 40, and 25 percent, for sapling-seedling, poletimber, and sawtimber-sized stands, respectively (table 15). These proportions illustrate how the intensity of forest management practices affects stand distributions. As sawtimber stands are harvested, these harvested stands will revert to sapling-seedling or poletimber stands (depending on the degree of cutting and the amount of time between surveys). Forest industry lands are typically the most intensively managed ones. Forest industry lands had a smaller percentage of acreage in sawtimber stands (25 percent) and a larger percentage in sapling-seedling stands (35 percent) than lands in other ownership categories. On NIPF land, 20, 36, and 44 percent of timberland was in sapling-seedling, poletimber, and sawtimber, respectively. The least disturbed lands were in public ownership. Both the national forest and other public categories were very similar in stand-size distributions. Only 6 to 7 percent of the timberland in these ownerships was in sapling-seedling-sized stands while > 50 percent was in sawtimber-sized stands. This is a reflection of decreased harvesting on publicly owned lands, especially national forests.

On forest industry lands, the proportion of acreage in sawtimber-size stands decreased from 29 percent in 1992 to 25 percent in 2001 (table 15). The proportion of acreage in sapling-seedling stands changed little, and the proportion of acreage in poletimber-size stands increased from 33 to 40 percent. On NIPF lands, the proportion of acreage in sapling-seedling stands changed little, while the proportion of acreage in poletimber stands increased from 30 to 36 percent and the proportion of acreage in sawtimber stands decreased from 50 to 44 percent. On publicly owned lands, the proportion of acreage in sapling-seedling stands decreased from 14 to 6 percent, while the proportion of acreage in poletimber stands increased from 25 to 35 percent and the proportion of acreage in sawtimber stands changed little.

Stand Age

The distribution of tree ages within a stand may vary, from one in which all trees are of a single age (even aged) to one in which trees are of a multitude of ages (uneven aged). Disturbance and frequency of disturbances affect the age distribution of stems in a stand. In addition, the age distributions can change as a stand matures naturally. A stand may be even aged following the stand initiation and stem exclusion stages but may widen its age distribution range during the understory reinitiation stage. Older stands and true old-growth stands are composed of trees of various ages. For these reasons it may be difficult to determine a single stand age for any given stand. Under such a wide range of possible scenarios of stand development, identifying whether a stand is composed of a single cohort or multiple cohorts may be difficult also (Oliver and Larson 1990).

Stand age was determined for the current inventory by averaging the ages of at least three dominant or codominant trees on each sample plot condition. The procedure depended on stand structure. For stands in which the dominant or codominant trees were in the same layer, stand age was calculated as the average age of three trees in this layer. For stands with two distinct layers, the average age of the dominant or codominant trees in the predominant layer was used. Forest stands that had more than two layers were assigned an age that reflected the average age for all dominant and codominant trees in the stand. Aging stands by dominant and codominant trees yields an age of the largest trees, and the largest trees are not always the oldest ones in the stand. This anomaly is often observed in stands that are further into the successional cycle, when shade-tolerant late-successional species become more important in stand structure and dynamics. Determining a single age for a stand of trees is difficult and highly subjective, especially as stands become older (when more time has passed since disturbance or stand initiation) and as stand structure and composition become more complex. Because of the procedures used by FIA in assessing stand age, stand age is closely correlated to stand size.

Upland hardwoods. *(photo by John Pemberton, Virginia Department of Forestry)*

The 0- to 20-year class accounted for 3,802,000 acres (25 percent of timberland) (table 16). Stands 61 to 80 years old accounted for 3,485,000 acres (23 percent of timberland). Fifty-nine percent, or 8,941,000 acres, of Virginia's timberland was > 40 years old, while 16 percent was > 80 years old.

Planted stands had most of their acreage in the youngest age classes. There were 1,293,000 acres in the 0- to 20-year class and 705,000 acres in the 21- to 40-year class. These two classes accounted for 94 percent of all planted stands. This is indicative of fairly short-rotation management.

Stands 61 to 80 years old occupied 3,458,000 acres, or 26 percent of the total area in natural stands. Area in the remaining four classes ranged from 2,020,000 acres in the 21- to 40-year group to 2,950,000 acres in the 41- to 60-year group. Much of the large amount of acreage in the 61- to 80-year age class may be stands that have recovered from the cutting that took place in the Southern United States between 1895 and 1935 (Davis 1983).

Most of Virginia's young stands were on the Coastal Plain and Southern Piedmont (fig. 24). These were the units where management activity was most intense, e.g., where stand regeneration practices were employed most widely. A total of 2,695,000 acres (17 percent of all timberland in Virginia) was in the 0- to 20-year age class in those two units. In addition, another 1,706,000 acres was in the 21- to 40-year age class. Together, these two units and age groups accounted for 28 percent of Virginia's timberland.

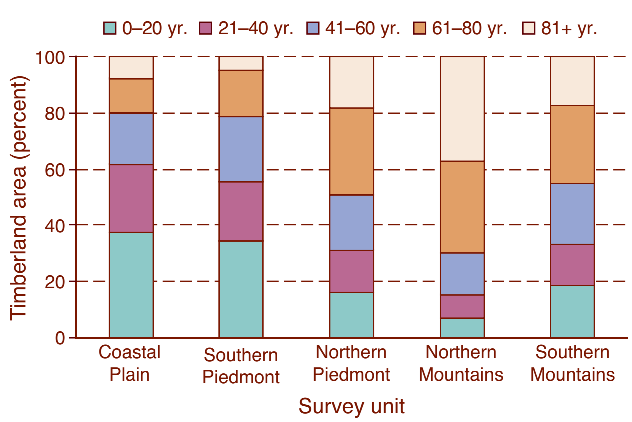


Figure 24—Percentage of timberland area by stand-age class and survey unit, Virginia, 2001.

The Northern Mountains had the largest proportion of stands > 80 years old. There were 971,400 acres in this age class, 37 percent of the timberland acreage of the unit and 6 percent of the timberland acreage of the State. Stands in the oldest age class made up 8, 5, 18, and 18 percent of the timberland area on the Coastal Plain, Southern Piedmont, Northern Piedmont, and Southern Mountains, respectively. Since 1992, area in this age class increased in all units other than the Southern Piedmont, where it decreased by 8 percent.

Acreage in young stands was greatest on forest industry timberland, which is managed more intensively than timberland in other ownership categories. Forest industry led all ownership categories with 51 percent of its timberland in the 0- to 20-year age class, while national forests had the smallest fraction (6 percent) of their timberland in that age class. Also, forest industry had the smallest proportion of its timberland in stands > 80 years old (7 percent) while national forests had 46 percent of their timberland in stands > 80 years old (table 17). This may in part be due to the shortness of rotation lengths on forest industry lands. For example, if the rotation length of a pine plantation is 25 years, then the plantation will spend 80 percent of its life in the 0- to 20-age class.

Volume

One hundred and ten live-tree species were tallied on forest land in Virginia during the 2001 survey. This number included 37 unknown live trees that were denoted collectively as one species (see appendix C). The top 50 species accounted for 98 percent of the live-tree volume in the State (table 18).

Yellow-poplar dominated the State's total live-tree volume with 5.5 billion cubic feet (table 18). This species contained 13 percent of the total live-tree volume for all species and 17 percent of the total live-tree hardwood volume in the State. Loblolly pine was the second most dominant species, with 4.7 billion cubic feet (11 percent) of the total live-tree volume. It was the predominant softwood species, accounting for 52 percent of the live-tree volume in this group. Chestnut oak, white oak, and red maple ranked next in total live-tree volume. Altogether, the top five species made up 21.2 billion cubic feet, or 50 percent of the State's total live-tree volume. The 10 next most dominant species were northern red oak, Virginia pine, sweetgum, scarlet oak, black oak, eastern white pine, pignut hickory, mockernut hickory, American beech, and southern red oak (2.2, 2.0, 1.7, 1.4, 1.3, 0.9, 0.9, 0.9, 0.8, and 0.7 billion cubic feet, respectively). Collectively, the top 15 species accounted for 80 percent of Virginia's live-tree volume.

Virginia pine, the second most dominant softwood, ranked seventh overall and contained 2.0 billion cubic feet of total live-tree volume. This value represented 5 percent of the overall and 22 percent of the softwood total live-tree volume. Eastern white pine, the third most dominant softwood, ranked 11th overall and contained 905.7 million cubic feet, or 2 percent, of total live-tree volume and 10 percent of the total softwood volume.

Other important softwoods were: shortleaf pine, eastern redcedar, pitch pine, eastern hemlock, and Table Mountain pine. Together, the top eight softwood species made up 21 percent of total live-tree volume and 98 percent of total live-tree softwood volume.

The 12 dominant hardwoods made up 62 percent of the total live-tree volume for the State and 79 percent of the hardwood live-tree volume (26.2 billion cubic feet). As oaks were so prevalent and oak-hickory the dominant forest-type group, it is not surprising that 6 of the top 15 species for live-tree volume were oaks. Altogether, 22 oak species were tallied during the survey, and these accounted for 13.8 billion cubic feet, or 32 percent, of the total live-tree volume and 41 percent of the hardwood live-tree volume.

Chestnut oak had 271.5 million cubic feet of volume in standing dead trees sym 5.0 inches d.b.h., more than any other species (table 19). Virginia pine, black locust, northern red oak, and white oak

Yellow-poplar accounted for 13 percent of the total live-tree volume for all species and 17 percent of total live-tree hardwood volume. Loblolly pine was the second most dominant species, with 11 percent of total live-tree volume. Chestnut oak, white oak, and red maple ranked next in total live-tree volume.

Yellow-poplar was the dominant species in terms of live volume. *(photo by Chris Evans, University of Georgia, www.forestryimages.org)*

were the next most dominant species in terms of dead volume. Together these five species made up 1.1 billion cubic feet, or 49 percent, of the dead volume.

Analyses of volume by species alone do not cover all aspects of a species' importance or dominance across the landscape, or portray accurately its population parameters. Two species with similar total live-tree volume may have very different distributions across size classes and extremely different stem densities. Analysis of volume by diameter classes can help elucidate the population characteristics or dominance of a species. Loblolly pine and red maple were dominant in terms of volume in the 1.0- to 8.9-inch class (fig. 25). Yellow-poplar, however, was clearly dominant in the larger size classes (> 17.0 inches). It accounted for 475 million cubic feet, or 23 percent of the volume in trees ≥ 25.0 inches d.b.h, while loblolly pine accounted for only 26 million cubic feet, or 1 percent of the volume in this size class. Northern red oak, which ranked sixth for total live-tree volume, was the second most dominant species in the ≥ 25.0-inch d.b.h class, where it contributed 321 million cubic feet, or 16 percent of the total live-tree volume.

As noted previously, species occur in associations known as forest types, and often these forest types are combined into forest-type groups. Both yellow-poplar and chestnut oak, two of the top three species for live-tree volume, occurred primarily in the oak-hickory forest-type group, which, as noted previously, was the predominant forest-type group in Virginia. Eighty-three percent (4.6 billion cubic feet) and 90 percent (3.4 billion cubic feet) of the total live-tree volume for yellow-poplar and chestnut oak, respectively, were in this forest-type group. Loblolly pine occurred primarily in the loblolly-shortleaf pine forest-type group. Seventy-seven percent (3.6 billion cubic feet) of the total live-tree loblolly pine volume was in this forest-type group.

Species dominance varied by unit. Yellow-poplar dominated volume in both Piedmont units and the Southern Mountains, and was in the top five species for the Coastal Plain. It accounted for between 5 and 20 percent of the volume in each of the five units (table 20). Loblolly pine dominated volume in the Coastal Plain and was second most dominant in the Southern Piedmont, accounting for 31 and 12 percent of the volume in those units, respectively. Together, these two units contained 94 percent of the total live-tree volume for this species in the State. Volume in the Northern Mountains was dominated by chestnut oak, which accounted for 1.7 billion cubic feet, or 24 percent of the total live-tree volume.

Species dominance or importance can be affected by artificial regeneration. A species such as loblolly pine, which tends to be the species of choice for

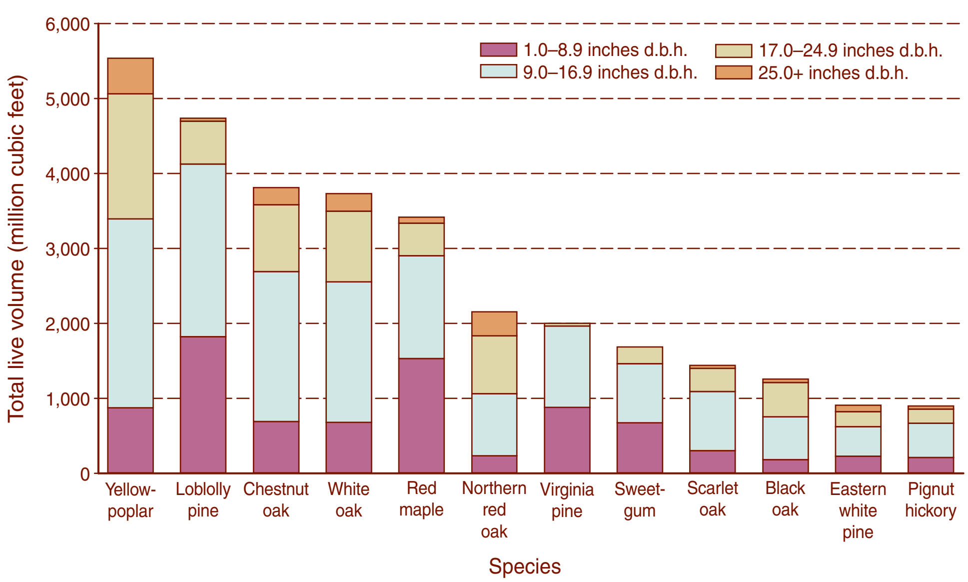


Figure 25—Top 12 tree species dominant for total live volume on forest land by diameter class, Virginia, 2001.

plantations, can have a much higher ranking than would naturally be expected due to the influence of plantings. Fifty-eight percent of the total live volume of loblolly pine was in stands classified as planted. This species accounted for 64 percent of all the live volume in planted stands.

Just as species dominance varied by physiographic province, so did the species composition of each forest-type group. Most of these variations were due to differences in soil type, elevation, and available moisture. For example, in the oak-hickory forest-type group, yellow-poplar and white oak were dominant for volume on the Coastal Plain and both Piedmont units. In contrast, yellow-poplar and chestnut oak were dominant in this group in the Southern Mountains while chestnut oak and northern red oak were dominant in the Northern Mountains (fig. 26).

(A) Loblolly-shortleaf pine forest-type group

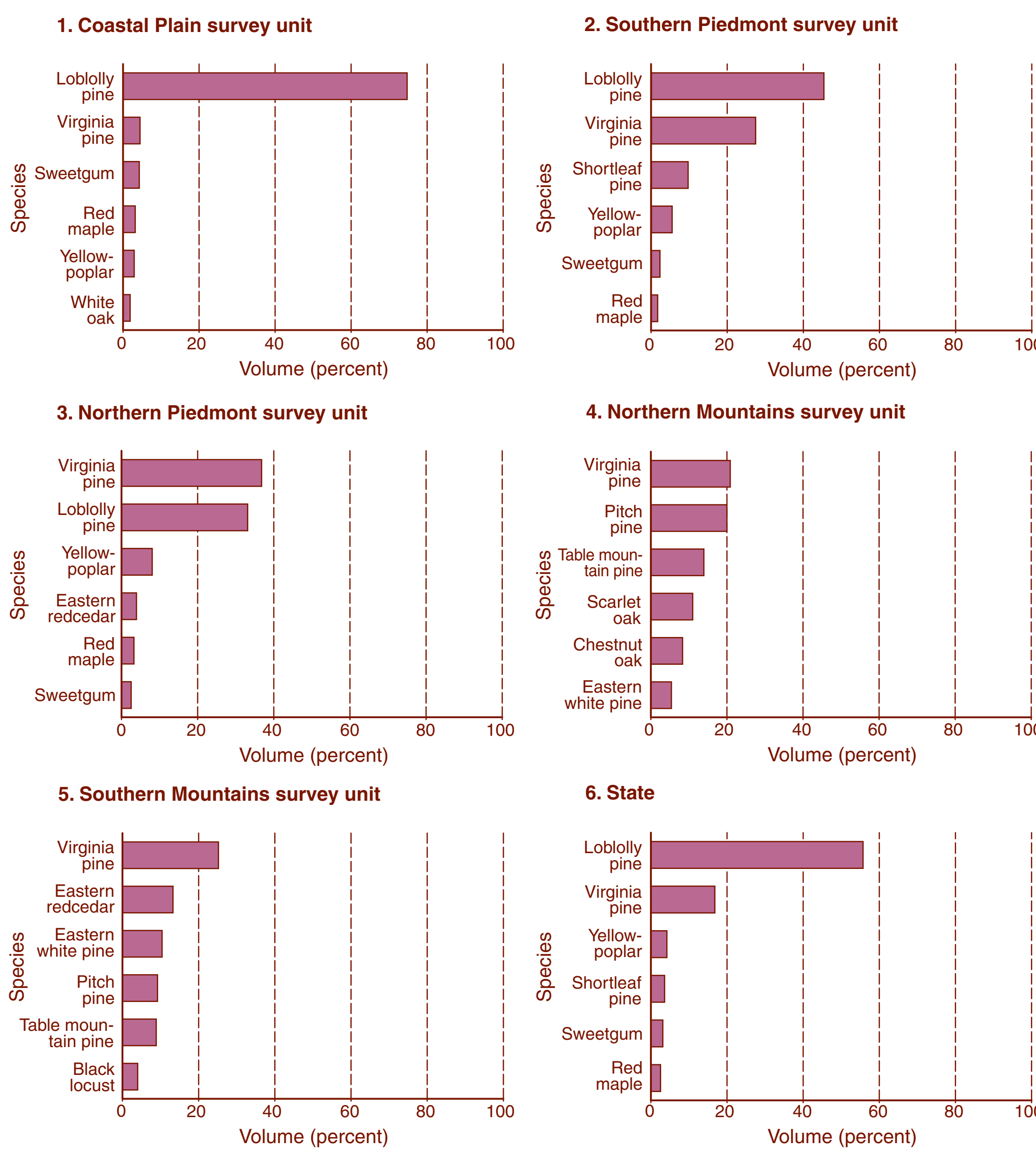


Figure 26—Species volume composition of (A) loblolly-shortleaf pine forest-type group, (B) oak-hickory forest-type group, and (C) oak-pine forest-type group on forest land by survey unit, Virginia, 2001 *(continued to next page).*

(B) Oak-hickory forest-type group

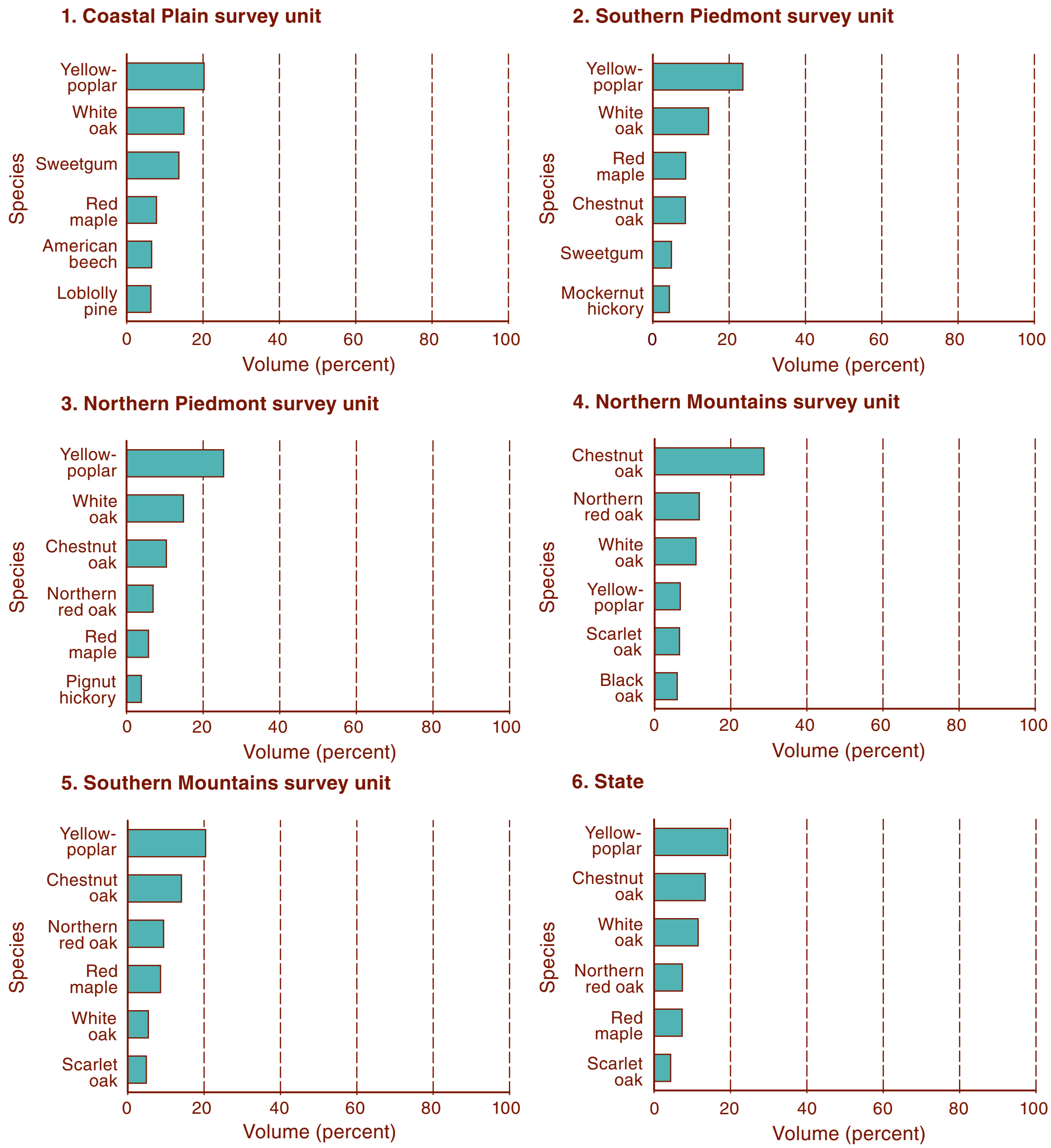


Figure 26—Species volume composition of (A) loblolly-shortleaf pine forest-type group, (B) oak-hickory forest-type group, and (C) oak-pine forest-type group on forest land by survey unit, Virginia, 2001 *(continued to next page)*.

(C) Oak-pine forest-type group

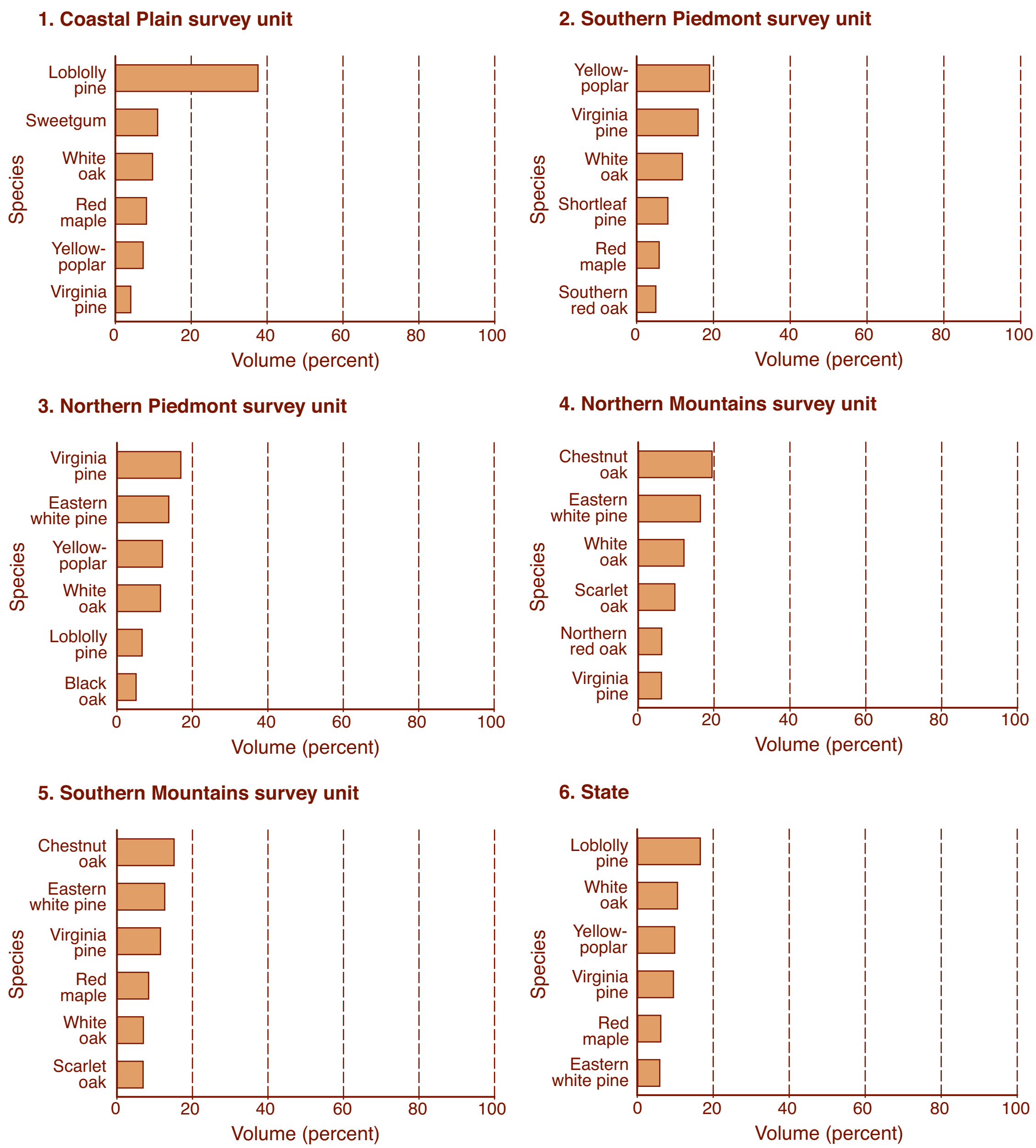


Figure 26—Species volume composition of (A) loblolly-shortleaf pine forest-type group, (B) oak-hickory forest-type group, and (C) oak-pine forest-type group on forest land by survey unit, Virginia, 2001.

Loblolly pine and Virginia pine dominated the loblolly-shortleaf pine forest-type group in the Coastal Plain and both Piedmont units. The relative order of importance for these two species was reversed in the Northern Piedmont. Virginia pine was the dominant species in the Southern and Northern Mountains for this group.

Chestnut oak and eastern white pine dominated the oak-pine forest-type group in both Southern and Northern Mountains units. Virginia pine, yellow-poplar, and loblolly pine dominated this group in the Northern Piedmont, Southern Piedmont, and Coastal Plain units, respectively.

Number of Trees

Another means of illustrating the importance of various species across the landscape is the analysis of the number of trees by species. Typically, the species that dominate volume also tend to dominate the number of trees. However, some very common species can be numerous, and may be considered dominant where this is the case, but because of their growth form are not dominant in terms of volume. Number of trees can be a measure of the successional status of a stand, as stands in an early stage of succession may have a high ratio of stems to biomass. For this reason, tree density is a good measure of regeneration and other lower canopy dynamics of established stands.

Red maple dominated the number of live stems with 1.5 billion stems, which represented 13 percent of the total number (table 21). Loblolly pine was second, with 958.8 million live stems, 72 percent of which were in stands classified as planted. Yellow-poplar, sweetgum, and blackgum were third, fourth, and fifth in number of stems. Yellow-poplar and sweetgum both accounted for 7 percent, and blackgum accounted for 6 percent of all live stems. These top five species represented 42 percent of all live stems.

Flowering dogwood and American holly were both in the top 10 for stem density. This illustrates the fact that species of relatively small stature can play an important role in a forested ecosystem.

Eighty-four percent of the red maple stems were < 5.0 inches d.b.h., as were 56 and 72 percent of the loblolly pine and yellow-poplar stems, respectively (fig. 27). Even though red maple regeneration numbers appear to portray a shifting of the species to a more dominant position in Virginia's forests, it remains to be seen if the numerous small red maple stems can maintain their relative position into maturity. High population numbers at the stand-establishment stage do not always mean that species importance will remain constant through the successional stages of development.

The oak-hickory forest-type group contained 60 percent of all live red maple

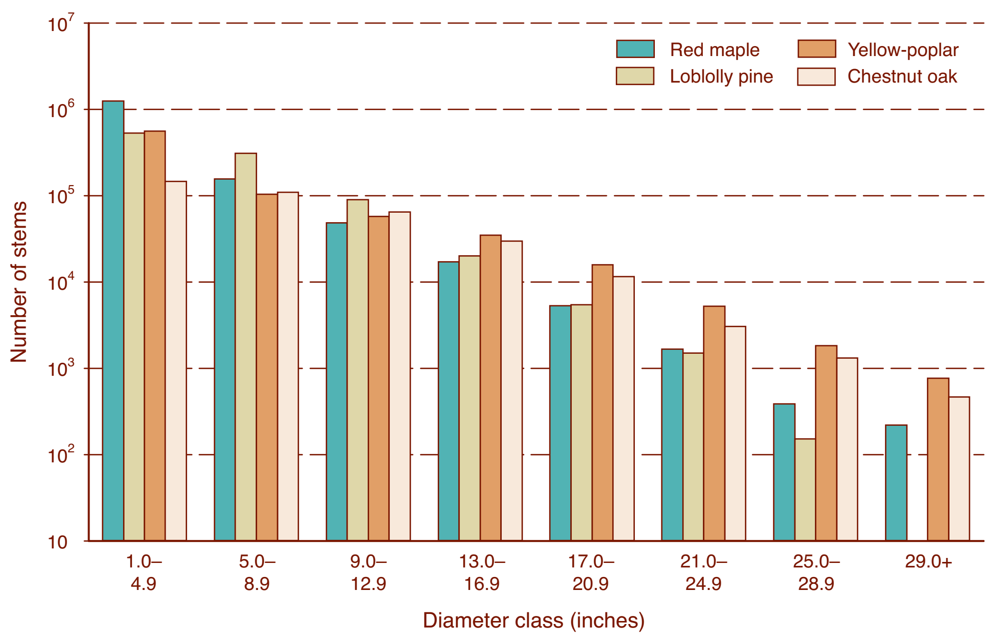


Figure 27—Number of live stems on forest land by diameter class for red maple, loblolly pine, yellow-poplar, and chestnut oak, Virginia, 2001.

stems. Loblolly pine and yellow-poplar densities were highest in the same forest-type groups (loblolly-shortleaf and oak-hickory, respectively) that contained the highest amounts of volume.

Red maple dominated number of live stems in both Piedmont units and the Southern Mountains, where it accounted for 12 to 15 percent of live stems. Red maple and blackgum each accounted for 15 percent of the live stems in the Northern Mountains. Loblolly pine was dominant in the Coastal Plain, where it accounted for 20 percent of the live stems.

Flowering dogwood ranked 7th in terms of number of stems on forest land in Virginia. *(photo by David J. Moorhead, University of Georgia, www.forestryimages.org)*

Trends in Species Importance on Timberland

Since the 1986 survey, volume of yellow-poplar has exceeded that of any other tree species in Virginia. Yellow-poplar volume on timberland increased by 11 percent between 1986 and 1992, and by 27 percent between 1992 and 2001 (table 22). There were increases in volume in all diameter classes along with a 13-percent increase in the number of live stems ≥ 5.0 inches d.b.h. Both live merchantable volume and number of stems increased in all survey units except the Northern Mountains.

Live merchantable volume of loblolly pine in planted stands increased substantially, from 3.0 billion cubic feet to 3.7 billion cubic feet. In stands classified as natural, loblolly volume decreased by 2 percent. Almost one-half of the 673.1-million-cubic-foot-increase for this species was in trees 9.0 to 12.9 inches d.b.h. There were not, however, increases in all size classes. There was a 6-percent volume decrease in trees 5.0 to 6.9 inches d.b.h. Additionally the number of live loblolly pine trees increased by 10 percent. This species increased in volume and number in all survey units except the Northern Piedmont.

Live merchantable volume of chestnut oak increased by 1 percent to 12 million cubic feet. This increase was not distributed across diameter classes evenly, however. Live merchantable volume decreased by about 20 percent for both trees < 7.0 inches d.b.h. and trees ≥ 29.0 inches d.b.h. Volume in trees 15.0 to 16.9 inches d.b.h. increased by 19 percent, or 54.9 million cubic feet. The total number of live chestnut oak trees also changed very little, decreasing by 2 percent. Trends in chestnut oak importance varied by unit. There was a decrease in volume in both Piedmont units, while the number of live stems decreased in all units except the Northern Mountains.

Virginia pine and shortleaf pine, both important softwood species in Virginia, showed decreases in volume and number of trees. The decrease in shortleaf pine importance reported here was a continuation of a downward trend that goes back several inventories. Live merchantable volume of Virginia pine decreased by 356 million cubic feet, or 19 percent. The number of live stems was down by 29 percent. Shortleaf pine live merchantable volume decreased by 23 percent, while number of stems decreased by 41 percent. Shortleaf volume increased slightly in the Southern Mountains but decreased in all other units, and Virginia pine volume decreased in all units. Virtually no shortleaf or Virginia pine tree had a d.b.h. ≥ 19.0 inches, and both volume and number of stems decreased for these species in more than half of the d.b.h. classes below 19.0 inches.

The distribution of most forest species is strongly influenced by the needs of individual species. Many requirements for survival are available only in certain habitats. Many species tend to have highly concentrated distributions, while others tend to be more widely spread and adaptable to a variety of conditions. Climate, topography, and soil are all important factors affecting where species and associations of species occur. It is important to note that vegetation and soil development are closely related and that both are controlled by climate (Oosting 1956).

Figures 28 and 29 illustrate the distribution of the four most dominant softwood and hardwood species on forest land by volume, respectively. For each species, a dot represents 2.0 million cubic feet of live-tree volume at the county level.

Loblolly pine had a fairly restricted range throughout Virginia. It occurred mainly in the Coastal Plain and Southern Piedmont, and these two units accounted for 94 percent of the total loblolly pine live-tree volume (table 20). This distribution correlates well with loblolly's natural range in Virginia, which is primarily in the Coastal Plain and Piedmont. Available moisture is a critical factor in the establishment and growth of this species (Burns and Honkala 1990). Artificial regeneration can increase both the abundance and range of a species. When a species is planted in an area in which it is not typically found, this increases its range, albeit artificially. About 58 percent of the volume of loblolly pine was found in stands that showed evidence of artificial regeneration.

Virginia pine was most concentrated in the Piedmont. Forty-seven percent of the total live-tree volume was in the Southern Piedmont and 24 percent in the Northern Piedmont (table 20). This species often grows in pure stands, usually as a pioneer species on disturbed sites (Braun 1950).

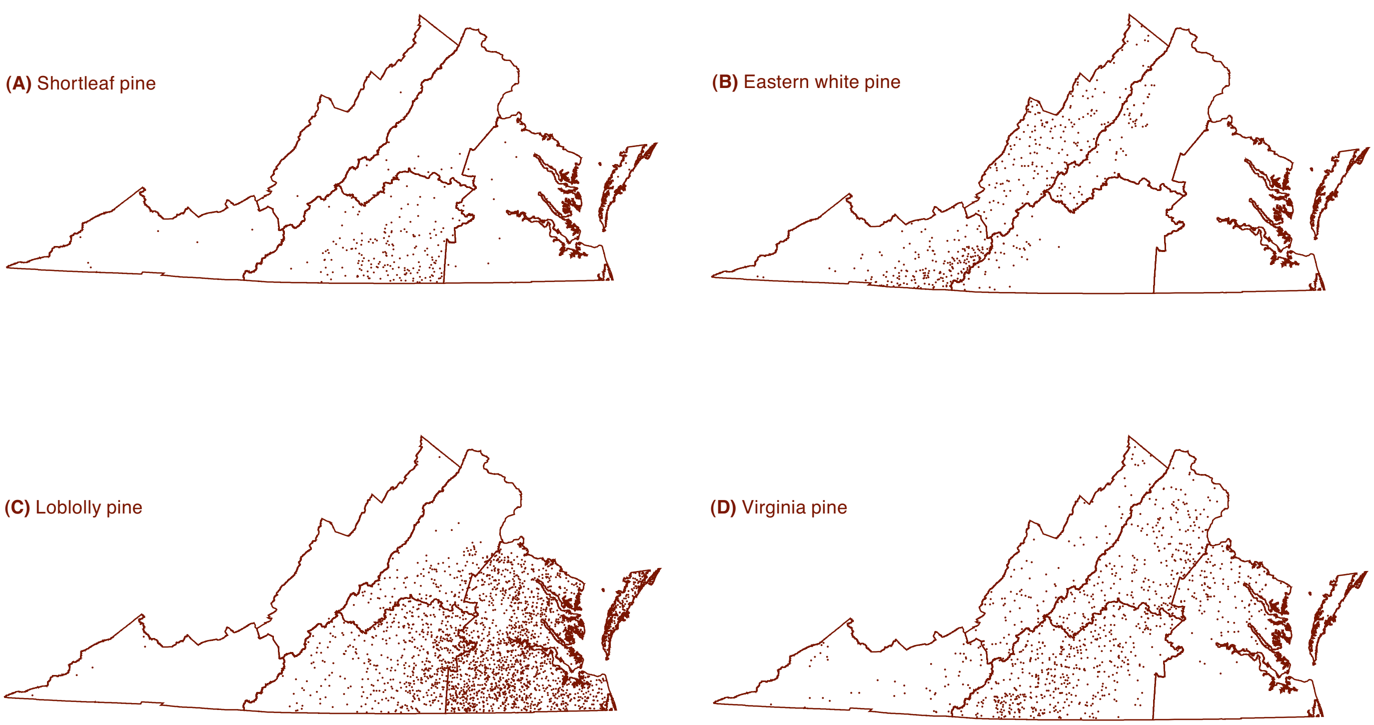


Figure 28—Distribution of four important softwood species on forest land, Virginia, 2001, (A) shortleaf pine, (B) eastern white pine, (C) loblolly pine, and (D) Virginia pine. Each dot represents 2 million cubic feet.

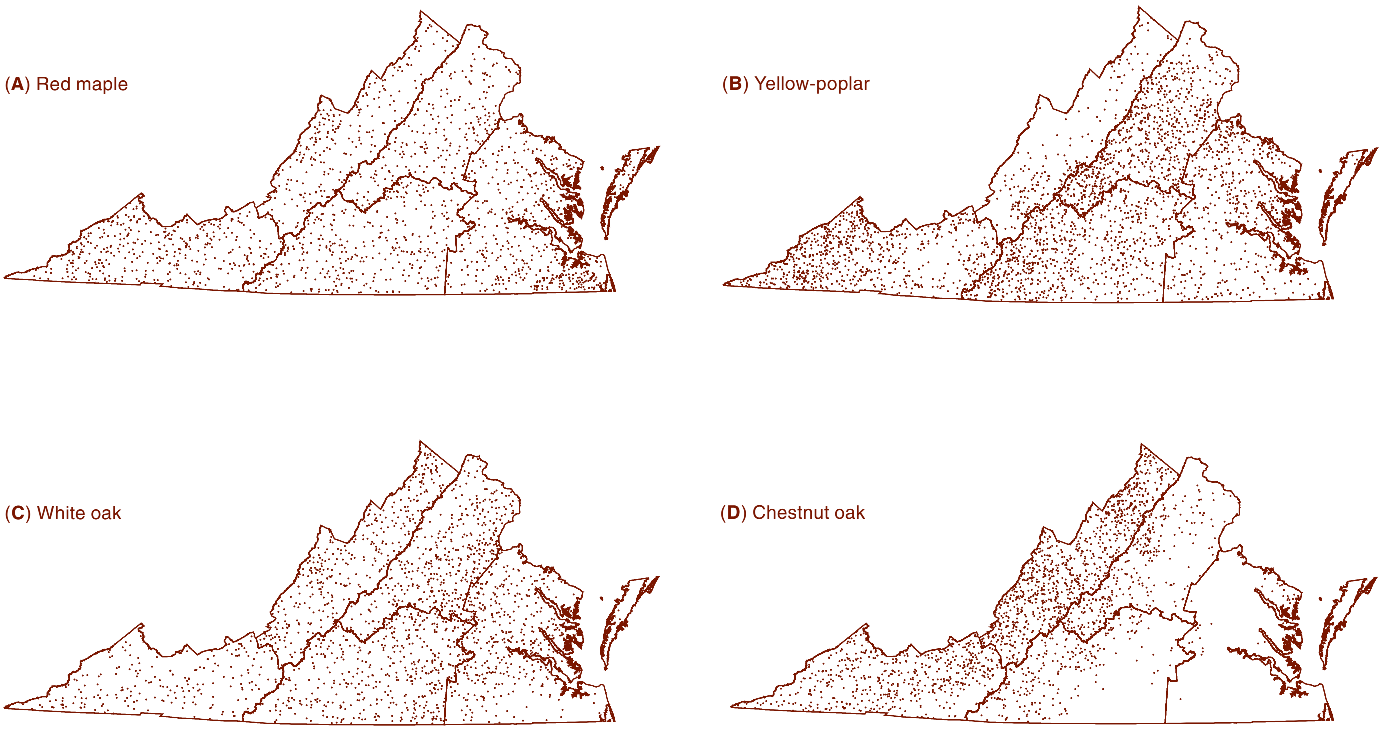


Figure 29—Distribution of four important hardwood species on forest land, Virginia, 2001, (A) red maple, (B) yellow-poplar, (C) white oak, and (D) chestnut oak. Each dot represents 2 million cubic feet.

As it is shade intolerant, it is often replaced by hardwoods as natural succession proceeds. In contrast to loblolly pine volume, only 7 percent of Virginia pine volume was found in stands with evidence of artificial regeneration.

The Southern and Northern Mountains accounted for 80 percent of total live-tree volume of eastern white pine. Eastern white pine is long lived, intermediate in shade tolerance, and has low tolerance for fire. Fire suppression during the 20th century, although unfavorable for many other softwood species, may be partially responsible for increases in white pine volume over the last few surveys.

Shortleaf pine was restricted almost exclusively to the Southern Piedmont, which has the well-drained soils it prefers. This early successional species was once a much more important part of Virginia's softwood component. However, due to many factors, which include but are not limited to fire suppression, limited regeneration efforts (only 3 percent of this species' volume was in planted stands), and old-field succession, this species has declined dramatically over the last 60 years.

Yellow-poplar was widely distributed within the State (fig. 29). Fifty-one percent of the volume of this species occurred in the Piedmont, primarily along the western edge. Twenty-five percent of the volume occurred in the Southern Mountains. Yellow-poplar is tolerant of a wide variety of soil and climatic conditions (Burns and Honkala 1990). Although considered shade intolerant, it grows very rapidly and can overcome much competition. Long lived and a prolific seed and sprout producer, this species is often found in old-growth stands as well as in young early successional stands.

Of the four hardwoods mapped, chestnut oak showed the most restricted distribution. This species is often found on dry upland sites (Eyre 1980). In the Appalachian region, it typically grows on intermediate-to-poor sites where it is considered to be the physiographic climax (Burns and Honkala 1990). Eighty-four percent of the chestnut oak live-tree volume was in stands > 60 years of age. Seventy-one percent of the volume of this species was in the Southern and Northern Mountains. It was one of the few species (which also included pitch pine and Table Mountain pine) that showed a strong affinity for the dry tops of ridges. Forty-seven percent of the chestnut oak live-tree volume occurred in areas in this physiographic class.

White oak and red maple resembled yellow-poplar in having fairly even distributions across Virginia. White oak and red maple have wide distributions across most of the Eastern United States. Each unit had from 11 to 24 percent of the total white oak volume (table 20). White oak usually becomes dominant in stands as a consequence of its shade tolerance and longevity and is often a climax species in central and southern hardwood forests. Like chestnut oak, white oak had a large fraction (67 percent) of its volume in stands > 60 years of age. There is currently some concern that white oak and other oak species are in decline. One possible reason for an oak decline is the change in disturbance regimes, including fire suppression, in the Eastern United States during the 20th century (Abrams 1992). One study conducted in the Piedmont of Virginia found that there was a shift in dominance away from white oak toward other species, and that this shift was consistent with the potential for other species to replace old-growth white oak in the mid-Atlantic region in the absence of fire (Abrams and Copenheaver 1999).

Chestnut oak occurred primarily in the Mountains. *(photo by Wendy VanDyk Evans, www.forestryimages.org)*

The distribution of red maple volume among units was similar to the distribution of white oak volume among units. Red maple showed a slight affinity for the Coastal Plain, where 30 percent of its volume occurred. Red maple is an early successional species that lives longer and is more shade tolerant than many other pioneer species and is, therefore, found in stands of various age.

> *Net growth of all live trees on timberland averaged 990.0 million cubic feet per year, an increase of 14.5 percent since the period 1986 to 1992.*

Three major components of change were monitored in the Virginia survey: growth, removals, and mortality. Complex interactions among these components can result in increases or decreases in the inventory. Estimates are given as an annual average and reflect the status of trees measured on the variable radius plots in the 1992 survey and then remeasured in the 2001 survey. During the remeasurement, trees were classified as survivor trees (live in the 1992 and 2001 surveys), ingrowth trees (new trees incorporated into the 2001 survey), removal trees (live in the 1992 survey and cut or removed by the 2001 survey), or mortality trees (live in the 1992 survey and dead in the 2001 survey). Gross growth minus mortality equals net growth, and net growth minus removals equals either a positive or negative net change in volume for the total forest resource.

Net growth for all live trees on timberland averaged 990.0 million cubic feet per year (table 23). This was an increase of 14.5 percent since the period 1986 to 1992, when it averaged 864.6 million cubic feet per year. The majority of this growth was in the hardwood component (662.9 million cubic feet per year) while about one-third (327.2 million cubic feet per year) was in the softwood component. Most of the softwood net growth (176.1 million cubic feet per year) was in the Coastal Plain. The Southern Piedmont ranked next, with 105.9 million cubic feet per year. These two survey units made up 86 percent of the softwood net growth. Softwoods in the Northern Mountains had negative net growth (-2.1 million cubic feet per year). Such a situation may arise when mortality exceeds gross growth.

Hardwood net growth was more evenly distributed among the survey units than softwood net growth. The Southern Piedmont had the greatest rate of hardwood net growth, 165.4 million cubic feet per year. Rates for the Southern Mountains and Coastal Plain were 150.6 and 149.8 million cubic feet per year, respectively. These three units accounted for 70 percent of Virginia's hardwood net growth.

Most of Virginia's timberland was in NIPF ownership, and the majority of the net growth was on these lands (table 24). A total of 818.8 million cubic feet per year (83 percent) of net growth occurred there. Seventy-nine percent of softwood net growth and 84 percent of hardwood net growth was on NIPF lands. Forest industry lands had 91.4 million cubic feet per year of net growth, of which 66 percent was in softwoods. This most likely reflects a tendency to emphasize softwood management where there are opportunities to do so. Softwood net growth was negative on national forest land (-2.9 million cubic feet per year), indicating that softwood mortality exceeded gross growth. Net growth was highest in the oak-hickory forest-type group, followed by loblolly-shortleaf (table 25). Fifty-two percent of the growth in the oak-hickory forest-type group was in the Southern Mountains and Southern Piedmont. Nearly 90 percent of the net growth in the loblolly-shortleaf forest-type group was in the Coastal Plain and Southern Piedmont.

Evaluation of growth on a per acre basis minimizes the effects of shifts in ownership that took place in Virginia since the last survey. Net growth of growing stock averaged 61.3 cubic feet per acre per year across the State (table 26). This was an increase of 12 percent since the last survey. At 88.0 cubic feet per acre per year, net growth of growing stock was highest on land controlled by forest industry. This was an increase of 10 cubic feet per acre per year since the last survey, and 66 percent of this increase was in the hardwood component. The high growth rate on industry land is a reflection of the large proportion of plantations in the most productive age classes on that land. There was a 20-percent increase in net growth on NIPF land, from 53.8 to 64.3 cubic feet per acre per year. In contrast, net growth on public land decreased from 44.0 to 34.2 cubic feet per acre per year. This is a reflection of the large proportion of land in the sawtimber-size class and the high mortality, particularly of softwoods, on public land.

Live-tree removals on timberland averaged 697.9 million cubic feet per year (table 23). This was an increase of 11.3 percent over the previous survey period, when removals averaged 627.1 million cubic feet per year. Over 60 percent of this increase was in softwood removals. In the current survey, 66 percent of the removals were on the Coastal Plain and Southern Piedmont (247.4 and 212.3 million cubic feet per year, respectively).

Live tree removals on timberland averaged 697.9 million cubic feet per year, an increase of 11.3 percent since the previous survey period.

Forty-three percent of live-tree removal volume consisted of softwoods and 57 percent of hardwoods, although 23 percent of inventory volume was in softwoods and 77 percent in hardwoods. Seventy-six percent of softwood removals and 58 percent of hardwood removals were in the Coastal Plain and Southern Piedmont.

Eighty-three percent (581.6 million cubic feet per year) of the live-tree removals were from NIPF lands (table 24). Removals from forest industry lands averaged 87.7 million cubic feet per year (13 percent of all removals). Sixty percent of removals from forest industry lands were softwoods and 40 percent hardwoods. The oak-hickory forest-type group accounted for 48 percent of all removals. The loblolly-shortleaf group ranked second, accounting for 37 percent of all removals.

Overall, the ratio of live net growth to live removals was 1.42:1. This indicates that net growth exceeded harvesting in Virginia. The softwood growth-to-removals ratio was 1.10:1, and the hardwood growth-to-removals ratio was 1.66:1. When ratios approach 1.00:1 there is a high likelihood that removals exceed growth in several areas in the State. Ideally, if harvesting is to be sustainable, removals should not exceed growth.

Overall, the ratio of live net growth to live removals was 1.42:1. The softwood growth to removals ratio was 1.10:1, and the hardwood growth to removals ratio was 1.66:1.

Growth exceeded removals in all units except in the case of softwoods in the Northern Piedmont, Northern Mountains, and Southern Mountains (fig. 30). However, in these three units, softwood growth was a minor component of overall growth (11 percent for the three units, combined). For softwoods on national forest lands and hardwoods on forest

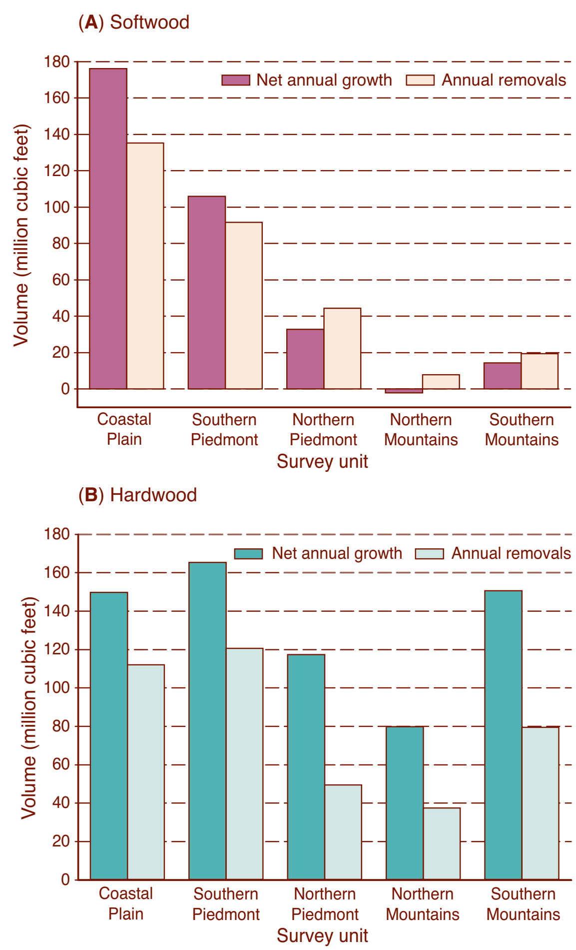


Figure 30—Average net annual growth and removals on timbearland by species group and survey unit, Virginia, 1992–2000, (A) softwood and (B) hardwood.

industry lands, removals exceeded growth by a slight margin (fig. 31). Annual softwood removals were higher in North Carolina than in Virginia or South Carolina (fig. 32). Additionally, softwood removals in North Carolina exceeded net growth. The softwood growth-to-removals ratio was higher in South Carolina than in Virginia or North Carolina.

On a per acre basis, removals of growing stock increased from 38.8 to 43.1 cubic feet per acre per year. Rates of removals, like rates of growth, were highest on lands controlled by forest industry, where the most significant increase in removals also occurred. Here rates of removals increased by 12.4 cubic feet per acre per year (18 percent) to 83.1 cubic feet per acre per year. Although removals did not exceed growth, the increase in removals per acre was more than the increase in growth per acre on industry lands. Removals decreased by 6.5

Planted pine.
(SRS photo)

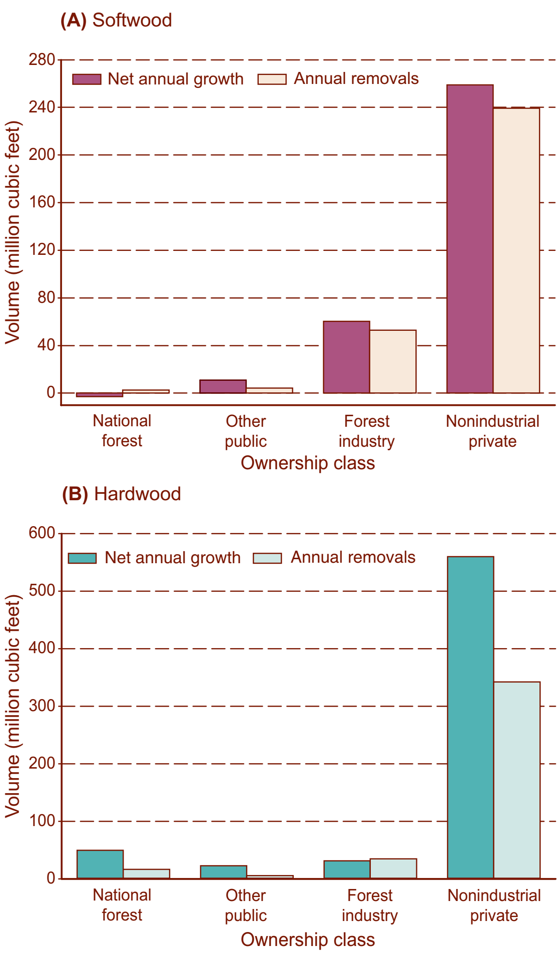


Figure 31—Average net annual growth and removals on timberland by species group and ownership class, Virginia, 1992–2000, (A) softwood and (B) hardwood.

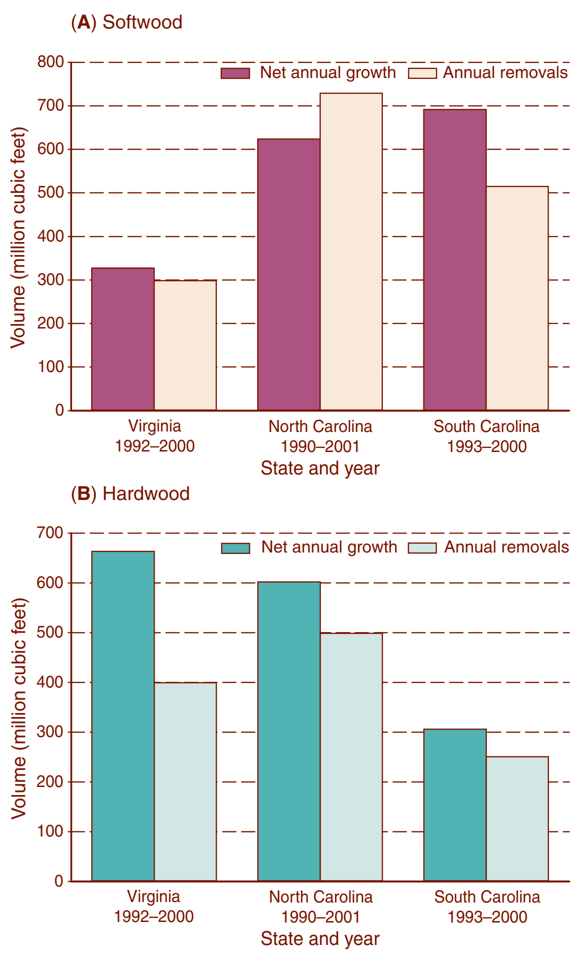


Figure 32—Average net annual growth and removals on timberland by species group, State, and year, (A) softwood and (B) hardwood.

cubic feet per acre per year (36 percent) on public lands, and increased by 7.8 cubic feet per acre per year (20 percent) on NIPF land.

Across the State, mortality averaged 333.6 million cubic feet per year (table 23). This represented a 46-percent increase since the previous survey, when mortality averaged 227.8 million cubic feet per year. Thirty-six percent of the current survey's mortality was in softwoods and 64 percent in hardwoods. This mortality was spread across the State with no specific survey unit showing substantially higher mortality volumes.

Across the State, mortality averaged 333.6 million cubic feet per year. This was a 46-percent increase since the previous survey.

Most (73 percent) of the average annual mortality was on NIPF lands (table 24). This would be expected as most of the timberland was in NIPF ownership. The oak-hickory forest-type group had the highest mortality volume, 192.1 million cubic feet per year. This was 58 percent of all annual mortality. However, this would be expected since about 60 percent of Virginia's timberland area and volume was in the oak-hickory group.

Per acre mortality of growing stock increased substantially across all ownerships, but most notably on public land. There, mortality increased from 14.5 to 27.8 cubic feet per acre per year (by 92 percent). On forest industry and NIPF land, mortality increased by 42 and 43 percent, respectively. Across all ownerships, mortality of softwoods accounted for the majority of the increase in mortality. Softwood mortality increased by 8.2 cubic feet per acre per year (295 percent) on public land, by 1.9 cubic feet per acre per year (61 percent) on forest industry land, and by 3.3 cubic feet per acre per year (87 percent) on NIPF land. Although softwoods accounted for only 20 percent of growing-stock volume on public land (fig. 33), they accounted for nearly 40 percent of average annual mortality of growing stock per acre (fig. 34). There are several possible explanations for the increase in mortality on public lands. Public lands were impacted more extensively by weather and insects than timberland in other ownerships. Also, natural succession may be a factor; softwoods tend to drop out as stands age and hardwoods begin to dominate. A confounding factor is that stands on public land tend to be older with bigger trees, and big trees contribute more volume to mortality calculations than small trees.

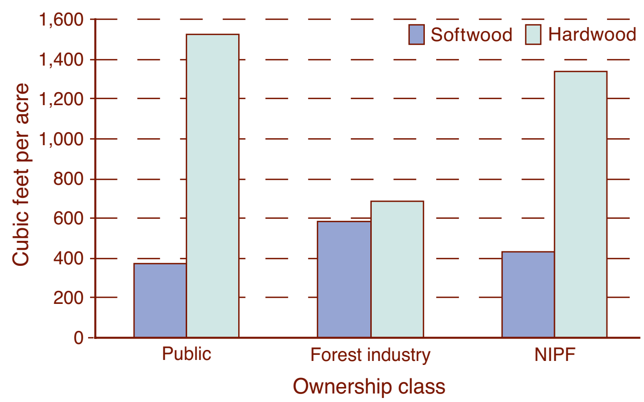


Figure 33—Volume of growing stock per acre on timberland by species group and ownership class, Virginia, 2001.

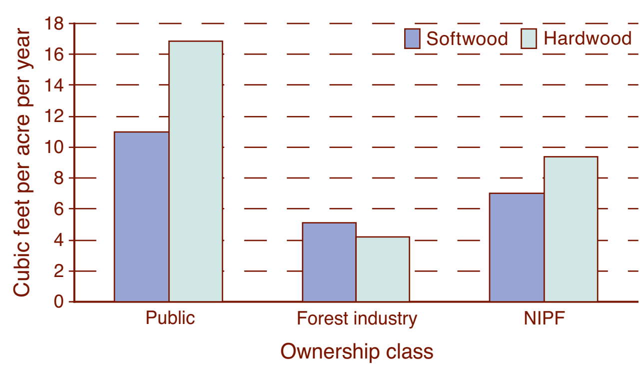


Figure 34—Average annual mortality of growing stock per acre on timberland by species group and ownership class, Virginia, 1992 to 2000.

Management Activities

Management activities, especially the establishment of plantations, can impact stand structure by altering forest type, species composition, stand age, stand density, and other stand attributes. In 2001, 2,118,000 acres of timberland in Virginia were classified as planted and 13,349,000 acres were classified as natural. Eighty-four percent (1,790,000 acres) of all plantation acreage was in the Coastal Plain and Southern Piedmont (fig. 35). Between 1992 and 2001, timberland area classified as planted increased by 21 percent (364,400 acres), and between 1986 and 1992 it increased by 25 percent (355,700 acres). Therefore, in < 20 years, the area in plantations increased from 1,397,900 to 2,118,000 acres, a 52-percent change.

Planted timberland area increased by 52 percent between 1986 and 2001. Eighty-four percent of all plantation acreage was in the Coastal Plain and Southern Piedmont.

Nearly all of the planted acreage was planted pine, with the remainder being mostly oak-pine and oak-hickory. Ninety-four percent of the planted pine acreage was in the loblolly-shortleaf forest-type group, and in this report the term planted pine refers to this forest-type group. Increases in acreage in this group accounted for the majority of the increase in planted acreage. The loblolly pine forest type, which occupied 1,767,000 acres, accounted for 99 percent of the planted loblolly-shortleaf group and 83 percent of all planted acreage. Ninety-one percent of the acreage in the planted loblolly pine forest type was in the Coastal Plain and Southern Piedmont. The loblolly pine-hardwood and the eastern white pine forest types occupied the majority of the remaining area classified as planted (fig. 36).

Harvesting activities can also substantially alter stand structure. The area of certain forest types, as well as the range, volume, and number of stems of certain species can be affected. This is more likely to be the case where stands are clearcut and sites then replanted with species other than the ones that were removed. However, harvesting is not always followed by artificial regeneration and the establishment of plantations.

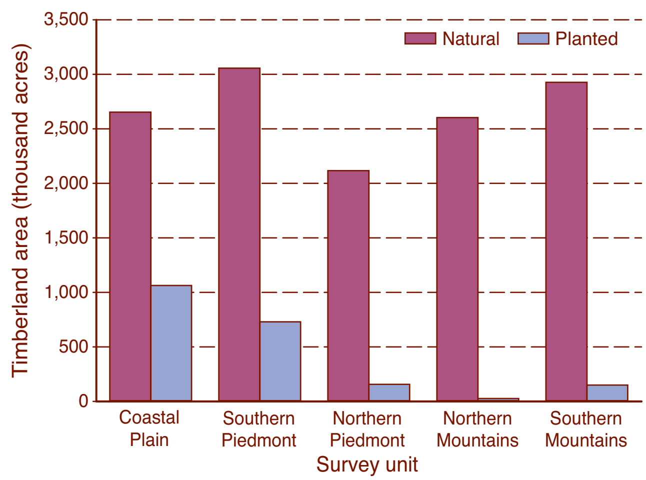


Figure 35—Area of timberland by stand origin and survey unit, Virginia, 2001.

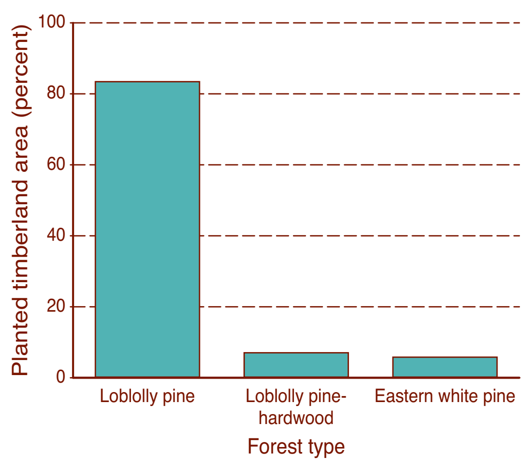


Figure 36—Percentage of total planted area (2.1 million acres) on timberland represented by loblolly pine, loblolly pine-hardwood, and eastern white pine forest types, Virginia, 2001.

A total of 2,992,800 acres, or 19 percent of all timberland, showed some evidence of cutting since 1992. This figure includes only land that remained timberland and was not cleared as a result of a land use change. Of this, a total of 1,245,000 acres had been clearcut. About two-thirds of the remaining acreage that displayed evidence of cutting was in stands that had partial cuts and one-third in stands that had other types of cutting, such as cutting for firewood.

Forty-four percent of the acreage that was clearcut was in the Coastal Plain and 34 percent in the Southern Piedmont. There was evidence of artificial regeneration on 36 percent of the acreage that had been clearcut, while 64 percent of clearcut acreage showed evidence of natural regeneration. Between 1986 and 1992 about 1,116,900 acres of timberland was clearcut.

The rate of clearcutting decreased by 21 percent, from 186,200 acres per year (between 1986 and 1992) to 146,900 acres per year (between 1992 and 2001). Also, partial harvesting increased by 148 percent, from 44,600 acres per year to 110,600 acres per year. However, these figures should be interpreted cautiously. Since the 1992 survey, definitions of some terms were modified, seed tree/shelterwood harvesting was added as a treatment category, and the sampling intensity in areas where cutting is more likely (the Coastal Plain and Southern Piedmont) was reduced by 47 percent.

Natural

Natural disturbance can take many forms. It can be the result of an insect infestation, or the damage caused by an ice storm. It can be the death of one overstory tree. At larger scales, disturbance in a forested ecosystem may be the result of fire or a hurricane. All forests experience some type of disturbance regime. In fact, disturbance is common to many systems, occurs at various spatial and temporal scales, and is continuous over all ecological levels of organization (Pickett and White 1985). At intermediate levels of intensity and frequency (relative to the system), disturbance may be so integral to the maintenance of a system (for example, maintenance of species richness) that it can be considered a part of the system, rather than a separate outside negative entity. Disturbance is now regarded as a natural part of the cycle and succession of forest ecosystems (Kohm and Franklin 1997).

Weather-caused disturbance affected an estimated 7 percent of Virginia's timberland between 1992 and 2002. Insect damage was the next most extensive natural disturbance, affecting 3 percent of the timberland.

Weather-caused disturbance, including disturbance resulting from weather-related events such as wind, ice, flooding, hurricanes, or tornadoes, affected an estimated 7 percent of Virginia's timberland between 1992 and 2002 (table 27). Between 4 and 9 percent of the timberland in each unit in Virginia experienced some form of weather damage. Twenty-nine percent of all weather-related damage occurred in the Southern Piedmont, where just under 300,000 acres of timberland were affected.

Insect damage was the next most extensive natural disturbance, affecting 3 percent of the timberland. Almost 50 percent of insect-related damage was in the Northern Mountains, where 9 percent of the timberland was affected. Data about damage, and especially data about damage caused by insects, should be interpreted cautiously because it is difficult to assess damage accurately in the field. (For example, field crews measure plots year-round, and a survey conducted during the dormant season could fail to detect defoliation damage.) Some of the insect damage noted in the Northern Mountains may have been caused by the gypsy moth (*Lymantria dispar* L.). This insect is a pest of hardwood trees and is native to Europe, Asia, and North Africa. The gypsy moth will feed on many tree species, but its preferred hosts include oak, aspen, willow, birch, apple, and basswood. The moth defoliated about 564,000 acres of forest land in Virginia between 1997 and 2002 (table 28) (Virginia Department of Forestry 2005). Gypsy moth infestations do not always result in tree mortality. If conditions are favorable, infested trees may be able to refoliate and survive.

The southern pine beetle (*Dendroctonus frontalis* Zimmerman) is a major pest of southern yellow pines and affects forests in Virginia. When the beetle invades a tree, the tree is almost certain to be killed. Infestations tend to be cyclical, with major outbreaks occurring in some years but not in others. There is evidence that major outbreaks tend to follow mild winters.

Many other influences have the potential to impact the forests of Virginia but are outside the scope of this report. These include but are not limited to strip mining, dogwood anthracnose, the hemlock woolly adelgid, and invasive exotic plant and animal species. However, Virginia's forests still support a wide variety of species in a wide range of situations. Forested ecosystems are very resilient, and only time will tell whether the offending agents cause the loss of species, species richness, forest health, or timber volume.

Southern pine beetle galleries. *(photo by Anita Rose)*

In order to address additional factors that affect forest ecosystem health, FIA assesses several forest health indicators. These include ozone-induced injury, crown condition, down woody material (DWM), lichen community composition, and soil condition. The phase 3 (P3) indicators are used to establish baselines, estimate biologically relevant thresholds, and detect potential forest health issues that warrant further evaluation. Readers should be aware that these indicators are based on a smaller plot population than the phase 2 (P2) sample, and that in some cases a full complement of data was not yet available for analyses.

Ozone

Ozone is the product of chemical reactions that take place in the air when volatile organic compounds (VOC) mix and react with nitrogen oxides (NO_x) in the presence of sunlight. A variety of NO_x compounds and their transformation products occur naturally and as a result of human activities. Anthropogenic emissions, primarily through the combustion of organic compounds, i.e., gasoline and coal, account for a large majority of NO_x inputs to the environment (fig. 37). In contrast, VOCs come primarily from natural sources, such as trees and other vegetation, although a sizable portion of the total input of VOCs does come from industrial and vehicular emissions. Weather plays a key role in the formation of ozone, with hot, dry, calm, cloudless days providing ideal conditions for VOCs and NO_x to combine and react to form ozone (U.S. Environmental Protection Agency 2004).

During the summer months, ozone concentrations at known phytotoxic levels can occur. A number of plants are sensitive to ozone exposures above normal background levels. These bioindicator species, such as yellow-poplar and sweetgum, exhibit an upper surface foliar injury symptom that can be distinguished from other foliar injuries. FIA tracks foliar injury with the goal of determining where negative impacts to forest trees may be occurring. In several controlled studies, tree seedlings have shown reductions in growth and biomass in response to elevated levels of ozone (McLaughlin and Downing 1996, Rebbeck 1996, Reinert and others 1996, Somers and others 1998). However, the effect of ozone on forest health is still poorly understood. Few studies show a direct relationship between foliar injury and physiological response to elevated levels of ozone (Fredericksen and others 1995, Somers and others 1998). Moreover, there are uncertainties about extrapolating

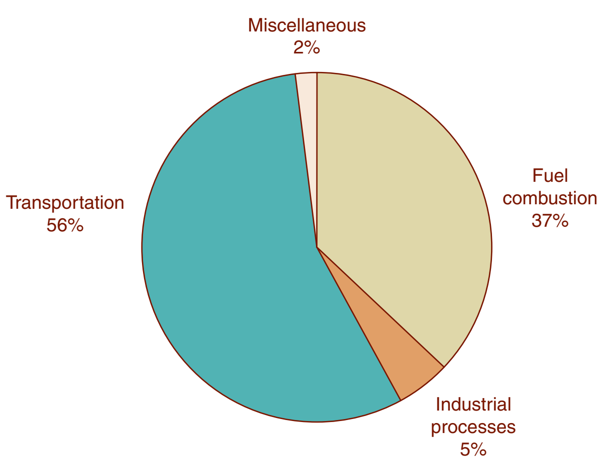


Figure 37—NO_x emissions by source category, 2002.

Ozone injury to a yellow-poplar leaf. *(photo by Robert L. Anderson, USDA Forest Service, www.forestryimages.org)* findings of ozone-induced responses from controlled seedling studies to large forest trees (Samuelson and Kelly 2001).

Ozone phytotoxicity is evaluated by field personnel statewide between late July and mid-August (U.S. Department of Agriculture 2004b). The amount and severity of ozone injury varies according to a complex set of factors including exposure, rates of stomatal uptake, and sensitivity to ozone. Ozone exposure can vary greatly across the landscape (fig. 38). For a given site, annual variations in humidity, temperature, and precipitation are perhaps the biggest source of variation in plant injury. Monitoring foliar injury of bioindicator plants does not identify specific levels of ozone present, but rather identifies whether conditions are favorable for ozone injury to occur (Coulston and others 2003). Although correlations between high levels of ozone exposure and foliar injury have been observed (Hildebrand and others 1996, Smith and others 2003), relationships between ozone exposure and tree responses have been difficult to confirm (Chappelka and Samuelson 1998). For example, some studies have shown that periods of drought offset the effects of ozone by causing stomatal conductance to be reduced (Patterson and others 2000). Variation in injury within a plant is largely determined by the position of foliage, exposure to air and sunlight, and the age of the leaves.

Between 1997 and 2002, 7,489 plants from various locations in Virginia (biosites) were evaluated, of which 94 percent showed no ozone injury (table 29). For each biosite,

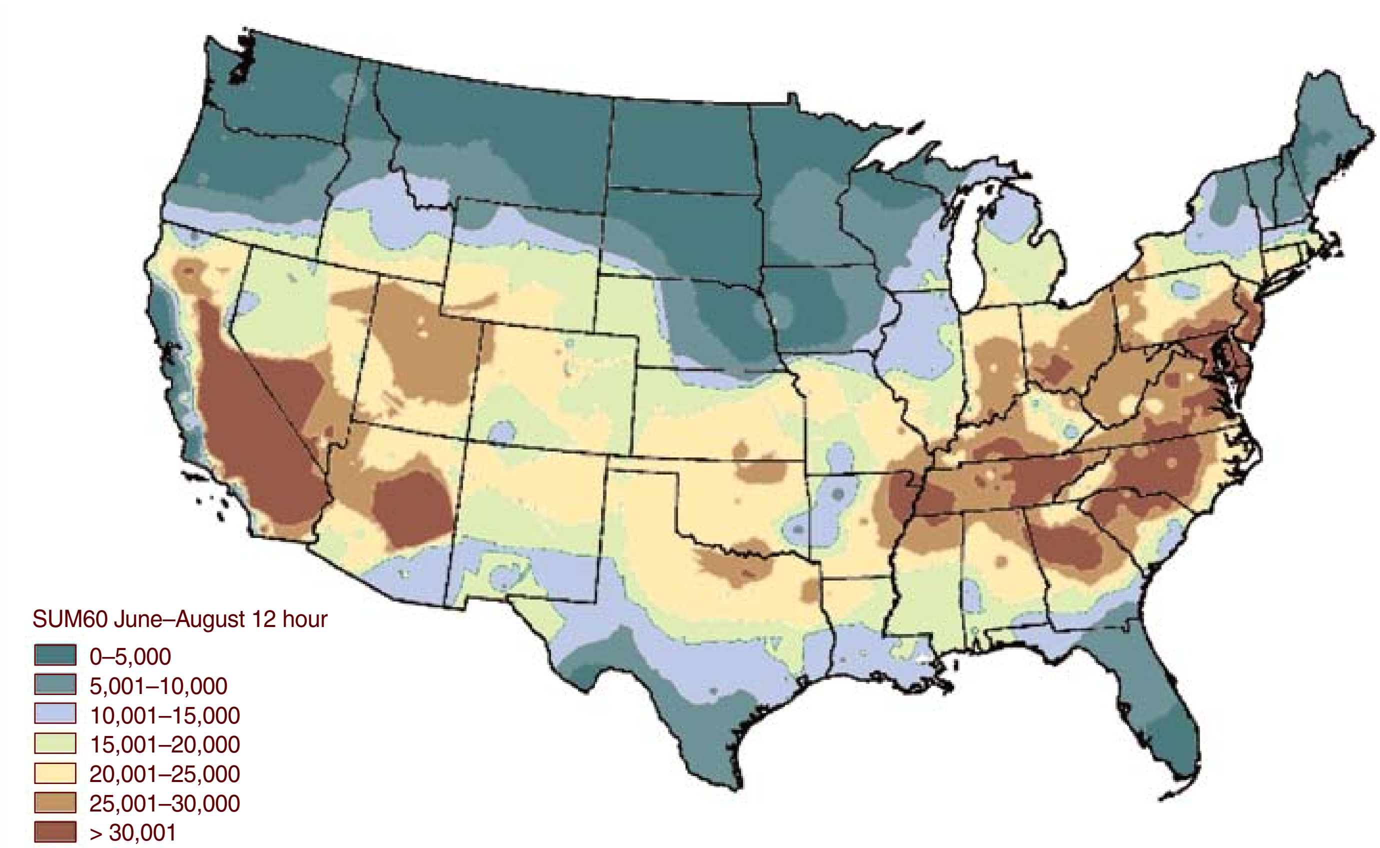


Figure 38—Average ozone exposures, 1998–2002; SUM60, June 1 to August 31, 8 a.m. to 8 p.m. *(Courtesy of Teague Pritchard)*

an index was calculated as the average score (amount x severity) for each species averaged across all species on the biosite. Biosite indices were spatially interpolated using kriging and a map of ozone risk to plants was created (fig. 39). Kriging is a standard interpolation technique by which ozone risk is modeled for all unmeasured locations utilizing weighted averages from measured locations (P3 plots). For a more detailed discussion of this technique as it applies to ozone, see Smith and others (2003). Averaging of biosite scores over a period of several years gives a clearer picture of the potential for foliar injury in a given location. The average biosite index was very low for 1999, a year of high ozone exposure (tables 30 and 31). This finding agrees well with those of Smith and others (2003), who found that average biosite indices were low across the Northeastern United States in 1999, when mild-to-severe drought conditions occurred across much of that region. Biosite indices were high in both Georgia and Virginia in 1998 and extremely high in South Carolina in 1999 (fig. 40) (Rose 2005).

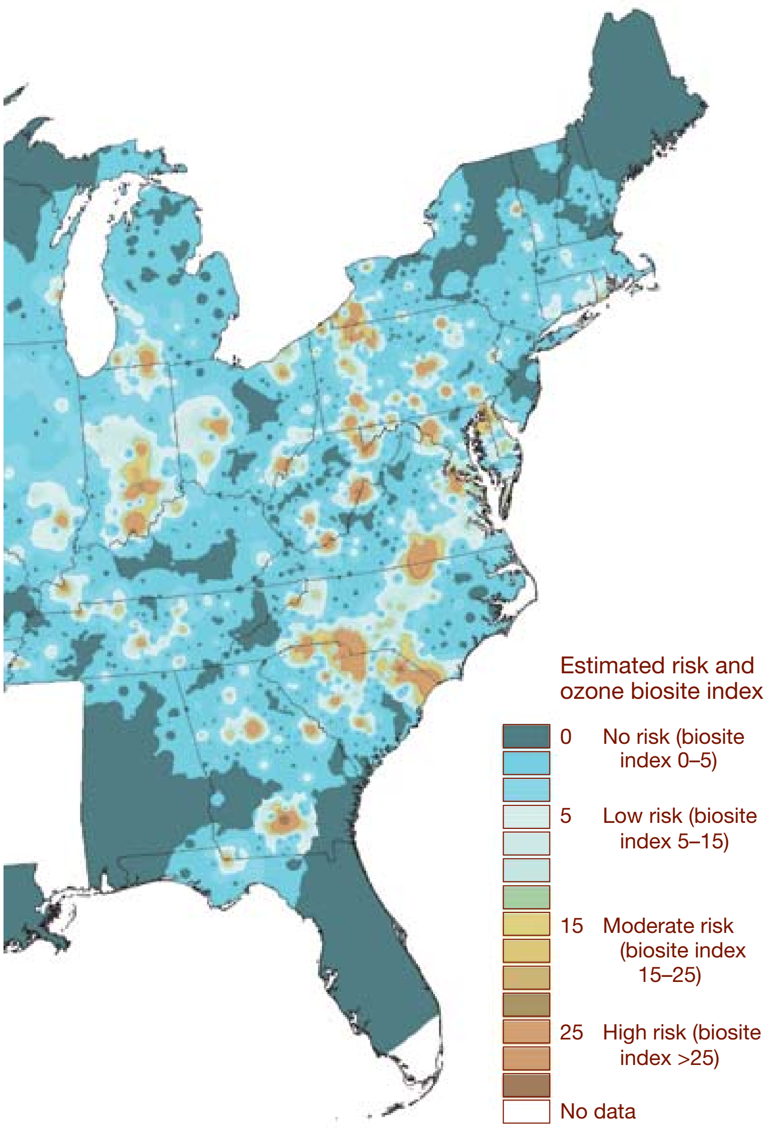


Figure 39—Estimated risk and ozone biosite index, 1999–2002. *(Courtesy of John Coulston)*

The Coastal Plain of Virginia had the highest average biosite index across all six measurement years (fig. 41). This result correlated well with those of Coulston and others (2003), who also found high biosite indices for the Coastal Plain of Virginia for the years 1994 to 1999. An analysis of variance showed a statistically significant affect of both year and unit on biosite index at the $p < 0.05$ level, and this illustrates the high temporal and spatial variability in ozone exposure and foliar injury. A study conducted in the Appalachian Mountains of Virginia found that between 1988 and 1999 ozone concentrations were typically not high enough to cause growth reductions. At all but one site (Big Meadows in the Shenandoah National Forest), when ozone concentrations were high, existing drought conditions probably overrode the more extreme negative growth responses (Edwards and others 2004).

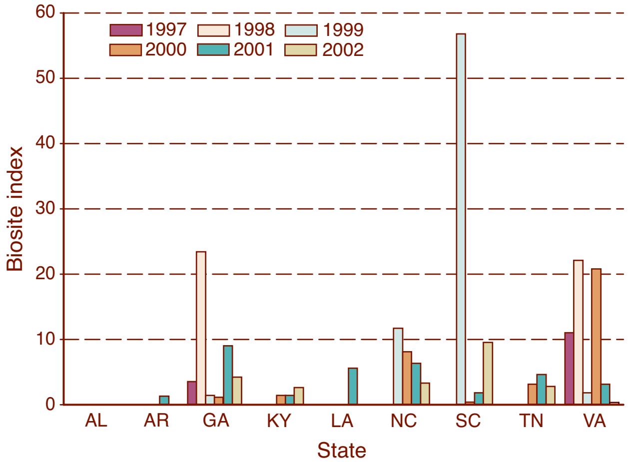


Figure 40—Ozone biosite index scores by year and State. [Scores for Alabama (1998, 1999, and 2002); Arkansas (2002); and Louisiana (2002) = 0. Otherwise, a missing bar = no data available.]

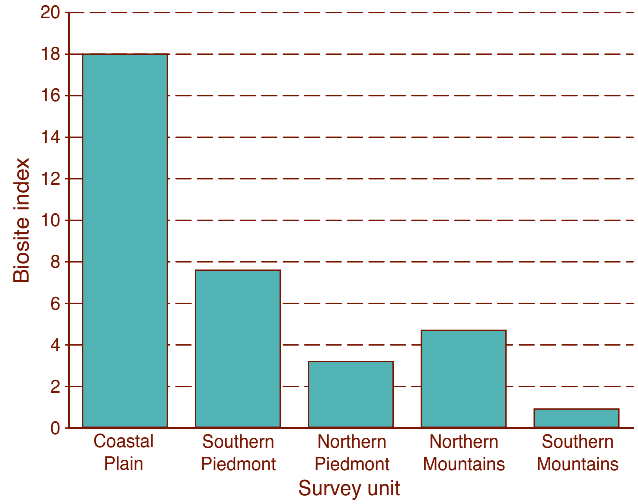


Figure 41—Ozone biosite index scores by survey unit, Virginia, 1997 to 2002.

Analysis of the data also showed that sensitivity varied among the indicator species. Blackberry had the highest species index, with sweetgum second (table 29). Bioindicator species were not sampled equally. Ultimately, this could mean that the distribution and selection of species could affect the biosite index.

These field studies indicate that foliar injury due to ozone occurred across the State of Virginia, particularly in the Coastal Plain, between 1997 and 2002. Tracking of this injury will establish a better baseline against which future detections of foliar injury can be measured. The high degree of injury noted in the Coastal Plain may be cause for more intensive monitoring and evaluation. Further research is needed in order to scale this foliar injury to responses at individual tree species, ecosystem, and regional levels.

Butterfly feeding on nectar of a native azalea (*Rhododendron* spp.). *(photo by Anita Rose)*

Crowns

When trees are under stress, visible changes often take place in the crown. Therefore, another potential indicator of natural or anthropogenic impacts on forests is tree crown condition. Tree crowns and tree crown health are affected by many biotic and abiotic factors such as tree age, soil conditions, precipitation, air pollution, insects, and disease. Tree age and climatic or site factors, such as drought and soil moisture are very commonly involved in tree decline (Manion 1981, Mueller-Dombois 1987). Tree senescence and death are a natural part of any forested ecosystem and are often the result of a complex set of factors. The complexity of these factors makes it difficult to determine exact causes. However, monitoring for relatively high levels of negative crown conditions, or changes in crown conditions through time,

Wind and harsh conditions can result in poor crown condition. (photo by Anita Rose) can indicate areas of concern that may warrant further investigation. Several indicators have been developed to assess crown condition and to detect various states of crown decline. These include crown dieback, foliage transparency, crown density, and sapling crown vigor. Only plots with at least five live trees ≥ 5.0 inches d.b.h. were included in the analysis.

Crown dieback is recorded as percent mortality of the terminal portion of branches that are < 1 inch in diameter, and are positioned in the upper portion of the crown (U.S. Department of Agriculture 2004b). High levels of dieback may indicate the presence of defoliating agents and a general loss of vigor. Increases in crown dieback are an indication of stress, possibly caused by root damage, stem damage that interferes with moisture and nutrient transport to the crown, or direct injury to the crown (Schomaker and others 2007). Crown dieback is considered an indication of recent stress because small dead twigs do not persist for long periods, and because trees typically replace lost twigs and foliage if the stress does not continue.

Across Virginia, 95 percent of all P3 plots had 0 to 7.5 percent crown dieback (table 32). Average crown dieback across all plots was 2.6 percent. By survey unit, average dieback ranged from a low of 1 percent in the Coastal Plain to a high of 4 percent in both the Northern Piedmont and Northern Mountains. The Southern Piedmont and the Northern Mountains had some plots with moderate crown dieback (7.6 to 15 percent) (Stolte 1997). The Northern Piedmont had one plot with > 15 percent average dieback (fig. 42). However, dieback averaged < 7.5 percent in all other plots in this unit.

Crown dieback varied by forest-type group, species, and stand age. In all likelihood, these three variables are correlated, since forest-type groups are composed of species, and occurrence of some species is correlated with stand age. The oak-hickory forest-type group showed the highest average percent dieback (4.3 percent) and loblolly-shortleaf had the lowest average percent dieback (0.3 percent) (fig. 43). Among species, scarlet oak, sourwood, and northern red oak had the highest percentage of trees with over 7.5 percent dieback (table 33). Average crown dieback for these three species was 8, 7, and 11 percent, respectively. Older stands had higher average percent dieback than younger stands (fig. 44).

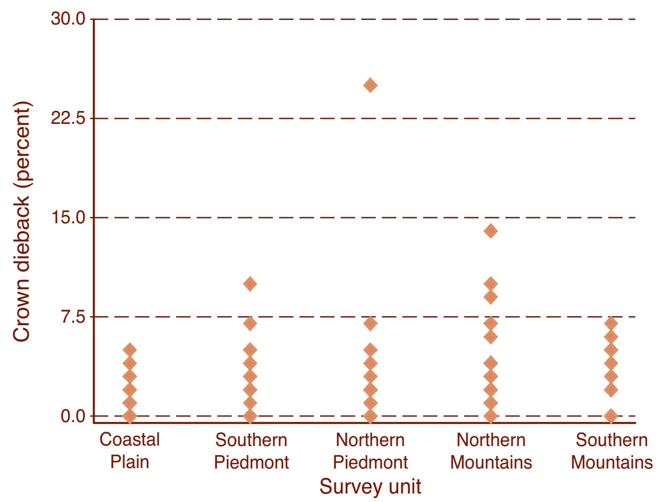


Figure 42—Average percent crown dieback by P3 plot and survey unit, Virginia, 1997 to 2001 (includes only plots with more than five live trees ≥ 5.0 inches d.b.h.).

Figure 43—Average percent crown dieback by forest-type group, P3 plots, Virginia, 1997 to 2001.

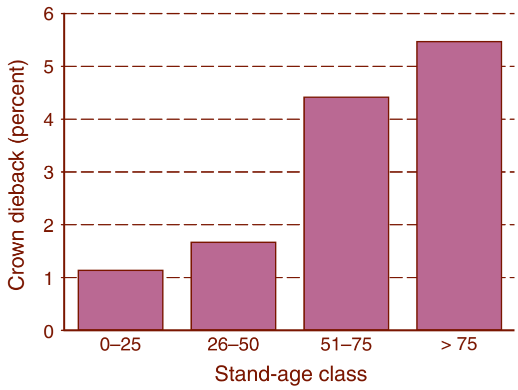


Figure 44—Average percent crown dieback by stand-age class, P3 plots, Virginia, 1997 to 2001.

Foliage transparency is the percentage of skylight that is visible through the live, normally foliated part of the crown (Zarnoch and others 2004). High foliage transparency may be related to insect damage. Ninety-nine percent of all plots had 0 to 30 percent foliage transparency (table 32). Average foliage transparency for all plots was 20 percent. By unit, averages ranged from a low of 17 percent in the Coastal Plain to a high of 22 percent in the Southern and Northern Mountains. Only one plot in the Southern Mountains had 31 to 50 percent foliage transparency, and no plot in any survey unit had > 50 percent transparency. Foliage transparency varied by species. Virginia pine, eastern white pine, and black locust had 21, 17, and 13 percent, respectively, of trees with > 30 percent transparency (table 33). Average foliage transparency was 27 percent for both Virginia and eastern white pine, and 25 percent for black locust.

Crown density is the percentage of light blocked by branches, foliage, and reproductive structures, relative to the total symmetrical crown outline (Zarnoch and others 2004). Over one-half of all plots had 21 to 50 percent average crown density (table 32). Average crown density for all plots was 48 percent, with survey unit averages ranging from 46 to 50 percent. Loblolly pine, Virginia pine, and shortleaf pine had the lowest percentage of trees with > 50 percent crown densities (table 33). Softwood trees frequently had crown densities around 35 to 40 percent, while hardwood trees frequently had crown densities in the 50 to 55 percent range (fig. 45).

Crown vigor class is used to rate the crown condition of saplings (trees 1.0 to 4.9 inches d.b.h.). Factors that can impact crown vigor in saplings include overhead competition and stand density. Separating natural stand competition functions from insect damage and disease damage is difficult. About 70 percent of all saplings were in vigor class 1 (good), 25 percent were in vigor class 2 (average), and only 4 percent were in vigor class 3 (poor). Among species (those with at least 15 stems tallied), flowering dogwood had the lowest percentage of saplings in vigor class 1 (47 percent) (table 34). Other species had from 62 to 100 percent of saplings in vigor class 1.

The interpretation of forest health measurements relies upon established baselines and thresholds. Ideally, comparison of field conditions with biological thresholds indicates when a tree, group of trees, or forest moves from healthy to unhealthy. There is some evidence that crown dieback > 20 to 30 percent or crown density < 30 percent, or both, can be used to estimate the probability of tree mortality (Steinman 2000). Nine plots had three or more trees with ≥ 20 percent crown dieback (fig. 46). All nine of these plots were in the Southern and Northern Mountains and the Northern Piedmont. The majority of plots with three or more trees with a crown density of < 30 percent were also in the Southern and Northern Mountains and Northern Piedmont.

The P3 field measurements were originally designed to track forest health through time to detect potentially serious changes taking place across the landscape. Across Virginia, 79 plots were measured six times between 1991 and 2001. Each plot included in this analysis maintained at least five live trees ≥ 5.0 inches d.b.h. Plots that were diverted to a nonforest use or clearcut were not included.

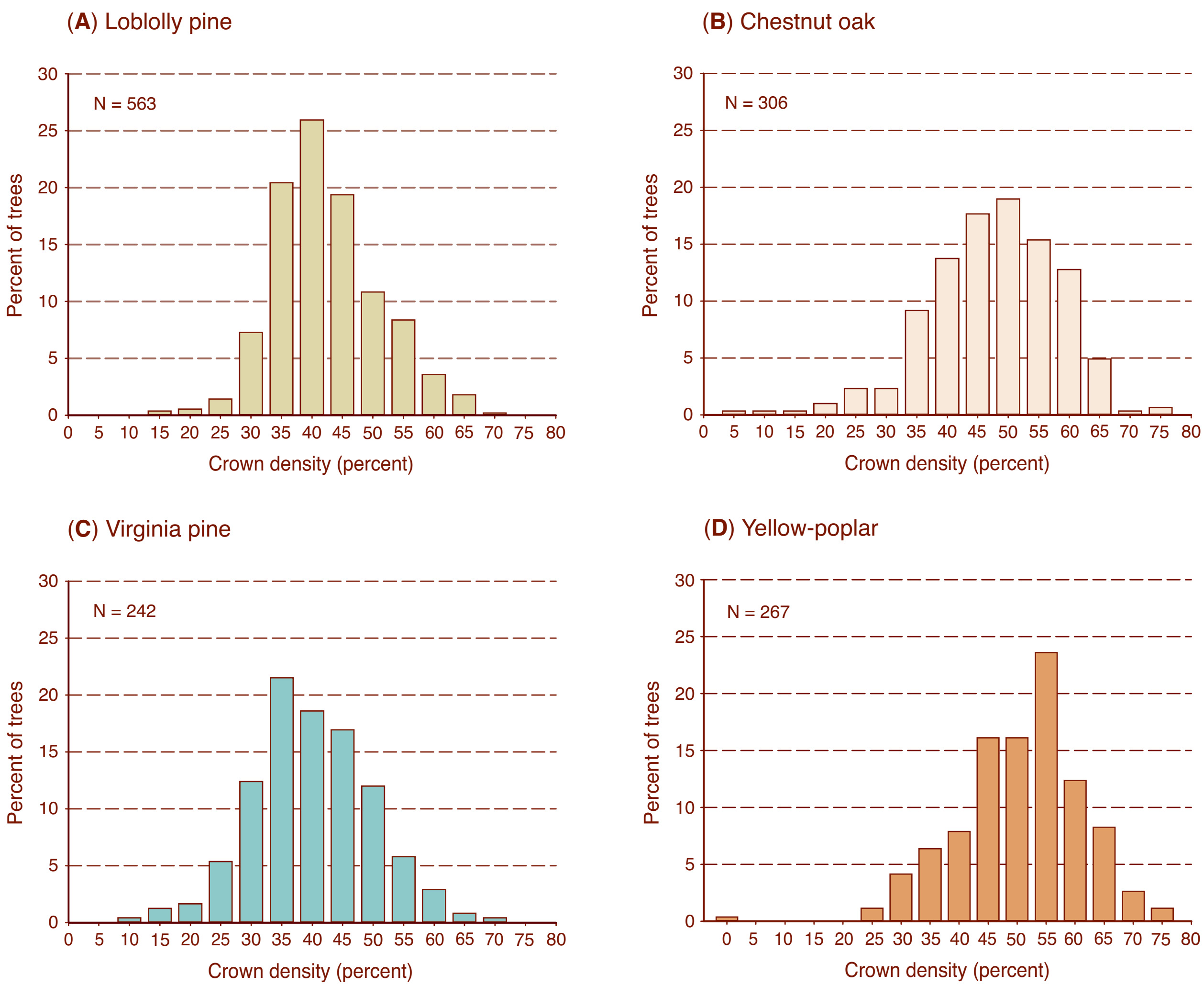


Figure 45—Crown density for top four tree species on P3 plots, Virginia, 1997 to 2001, (A) loblolly pine, (B) chestnut oak, (C) Virginia pine, and (D) yellow-poplar.

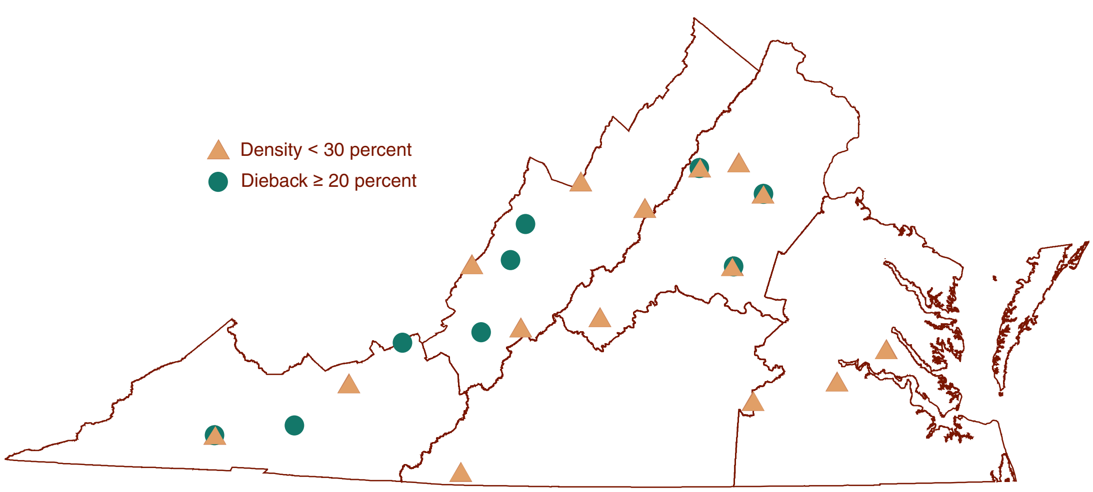


Figure 46—Plots with three or more trees having ≥ 20 percent crown dieback and plots having three or more trees with crown density < 30 percent, Virginia, 1997 to 2001.

On average, there was a slight decrease in crown dieback between 1991 and 2001 (table 35). Average plot-level dieback was highest in 1992 (6 percent) and lowest in 1994 (2 percent). There were no plots with average dieback > 15 percent in 1994, but the number of plots with average dieback > 7.5 percent was lowest in 2001. Tracking of crown dieback is somewhat problematic because the small branches used in rating this variable fall off the trees in a relatively short time and, thus, are not included in subsequent measurements. Other factors can affect and potentially hinder field assessment. These include but are not limited to weather, stand density, tree height, and visibility.

Average foliage transparency increased over the 10-year period and was highest in 2001 (20 percent). Average transparency was lowest in 1994. Average crown density varied only between 47 and 51 percent over the 10 years. Values of all three variables—crown dieback, crown density, and foliage transparency—varied from year to year.

Damage

The incidence of damage, whether natural or anthropogenic, was recorded on P3 plots for live trees ≥ 5.0 inches d.b.h. Where damage was considered serious enough to potentially affect a tree's chances of survival, its type, location, and severity were noted. Trees with damage may be more likely to succumb to additional stresses such as drought or disease. The type of damage most commonly noted was the presence of conks, fruiting bodies, or decay (table 36). This type of damage was recorded for 226 trees (8 percent of sample trees), and represented 52 percent of all damages noted. Conks are the fruiting bodies of fungi, often of the genus *Polyporus*, which attack and rot wood. In living trees, most of the rotting is confined to the heartwood (Agrios 1988). Forty-five percent of all conks, fruiting bodies, and instances of decay affected chestnut oak, red maple, white oak, or yellow-poplar.

The next most common forms of damage were loss of apical dominance, canker or gall, and vines in crown, which affected 54, 46, and 43 trees, respectively. Many pathogens cause cankers on trees, the most common being Ascomycetous fungi. Depending on the tree and the pathogen, and environmental conditions, a tree may survive the disease by producing callus tissue around the dead areas. However, trees may be killed by girdling if the disease is serious enough (Agrios 1988). Virginia pine accounted for 33 percent of cankers or galls recorded.

The oyster mushroom of the fungus Pleurotus spp. (Fr.) P. Kumm. *(photo by U.S. Forest Service, North Central Research Station Archives, www.forestryimages.org)*

On average, 15 percent of trees on plots with at least five live trees that were ≥ 5.0 inches d.b.h. had damage. Most plots (n = 78) had a low percentage (< 20 percent) of trees with damage (fig. 47). Twenty to forty percent of trees were damaged on 26 plots, and > 40 percent of trees were damaged on 6 plots. The Southern Piedmont had the most plots (10) with either a moderate or high percentage of damaged trees.

By species, shortleaf pine had the lowest percentage of trees with damage (3 percent) (table 37). The percentage of sourwood, northern red oak, and black oak trees with damage was 37, 27, and 26 percent, respectively. Both northern red oak and sourwood also had a relatively high percentage of trees showing moderate-to-high crown dieback. Species-level damage may be related in part to differences in tree or stand age, site characteristics, and other factors that are not necessarily species related.

Deadwood

An important part of any ecosystem is the return of nutrients to the system via decomposition. In forested ecosystems deadwood can be a significant store of nutrients (Harmon and others 1987, Keenan and others 1993). While senescence and death of trees is a normal part of the cycle of life within a forest, the proportion of trees in a system that are dead, and the rate at which they die can vary substantially over space and time. Episodic events or stand replacement disturbances, such as insect infestation and changing environmental conditions, can create large amounts of deadwood and have a substantial impact on nutrient cycling in the affected area. An insufficient amount of deadwood present, such as in heavily managed stands, can negatively impact nutrient cycling (Arthur and Fahey 1990, Harmon and others 1986). Across Virginia, about 7 percent of the standing trees ≥ 5.0 inches d.b.h. were dead. Tree mortality rates averaged 2.4 percent per year between 1992 and 2001 (Rose 2005).

Deadwood can be a significant store of nutrients, but large amounts of deadwood can present a fire hazard.

Standing and down-dead trees are also important habitats for a wide variety of organisms, including microbes, invertebrates, fungi, and small mammals.

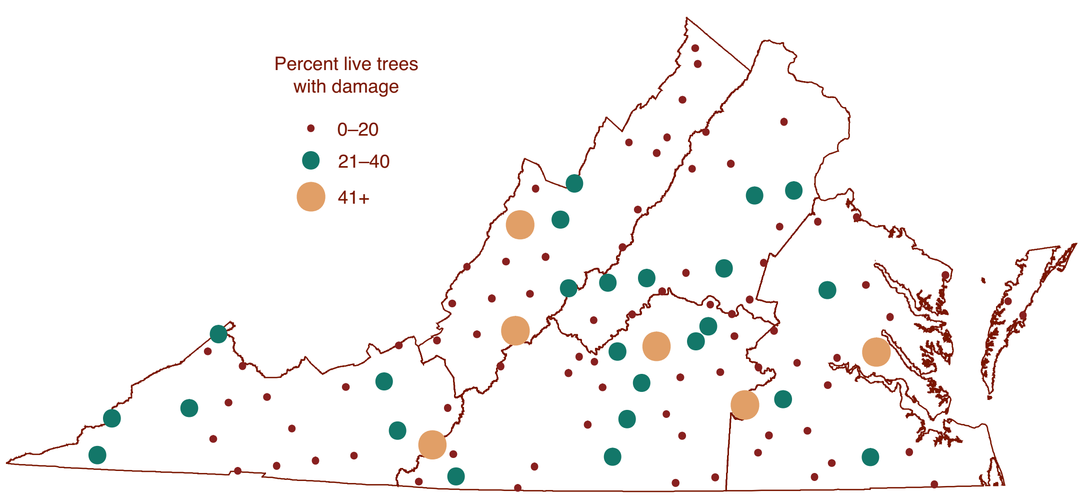


Figure 47—Percentage of live trees with damage by P3 plot, Virginia, 1997 to 2001.

Additionally, a wide range of birds, reptiles, and amphibians depend on deadwood. Where inadequate amounts of coarse woody debris (CWD) (down-dead logs ≥ 3.0 inches in diameter and ≥ 3.0 feet in length) are present, usually as a result of intensive stand management, this can negatively impact small vertebrates in forest ecosystems (Butts and McComb 2000). However, it should be noted that the presence of large amounts of deadwood can constitute a fire hazard.

Deadwood goes through a number of physical, biological, and chemical changes during the decay process. Decomposition leads to the release of carbon dioxide, water, and nutrients, and to the production of stable organic compounds known as humus (Schlesinger 1991). Boles begin to collapse, lose mass, and settle to the ground as they become unable to support their own weight. Loss of mass can be caused by leaching, fragmentation, and the respiration of carbon by microbes (Harmon and others 1986). Moisture content (based on dry weight) may increase from about 100 percent in living tissue to 300 percent in highly decayed wood (Hope 1987, Jurgensen and others 1984, Rose 2000).

Climate, tree species, and size of woody debris can affect rates of decomposition and, therefore, the rate of mass and nutrient loss. Most wood-decaying fungi have a temperature optimum of 77 to 86 °F and a moisture optimum of 30 to 200 percent. Extremely low or high moisture content or temperature extremes can limit the activity of organisms essential to decomposition (Harmon and others 1986, Hedges and others 1988).

Coarse woody debris at the Thunder Ridge Overlook on the Blue Ridge Parkway. *(photo by Anita Rose)*

DWM, including CWD and fine woody debris (FWD) (diameter < 3.0 inches), as well as duff, litter, and slash, was measured on 103 P3 plots in Virginia between 2001 and 2003. Volume of CWD ranged from an average of 242 cubic feet per acre in the Northern Piedmont to an average of 856 cubic feet per acre in the Northern Mountains. The average for the State was 407 cubic feet per acre. Individual plot values ranged from 0 to 5,498 cubic feet per acre. CWD accounted for about 13 percent of the volume per acre (live + standing dead + CWD) of wood in Virginia (table 38).

Biomass of CWD averaged 2.5 tons per acre statewide, with plot values ranging between 0 and 17.5 tons per acre. The Northern Mountains had the most CWD per acre (3.2 tons per acre), and the Northern Piedmont the least (2.05 tons per acre) (table 39). CWD is classified as a 1,000-hour fuel, while FWD is classified into 1-, 10-, and 100-hour fuel categories. These fuel class numbers correspond to the approximate amount of time required for the moisture content to fluctuate within a given piece of deadwood (Brown 1974). Consequently, FWD is an important factor in fire hazard prediction. The 100-hour class FWD, the FWD that dries out slowest and is least hazardous, accounted for 67 percent of the total FWD biomass (table 39). Overall, FWD biomass averaged 2.3 tons per acre. While plot values ranged from 0 to 11.5 tons per acre, 50 percent of plots had ≤ 1.8 tons per acre. Biomass of duff, litter, and slash averaged 10.4, 3.6, and 1.8 tons per acre, respectively. The values for CWD, FWD, and litter were comparable to those in other States in the region (fig. 48). Average CWD for all the States analyzed was below the range of 3.1 to 43.3 tons per acre reported in other studies (Harmon and others 1986).

Statewide, the density of CWD averaged 138 logs per acre (table 40). The density of CWD was lowest in the Northern Mountains and highest in the Southern Mountains. CWD accounted for 29 percent of stems per acre (live + standing dead + CWD). Just over one-half of all CWD was moderately decayed (decay class 3) (fig. 49). More than 90 percent of CWD boles were between 3.0 and 7.9 inches in diameter. Not only did the Northern Mountains have the highest average number of decay class

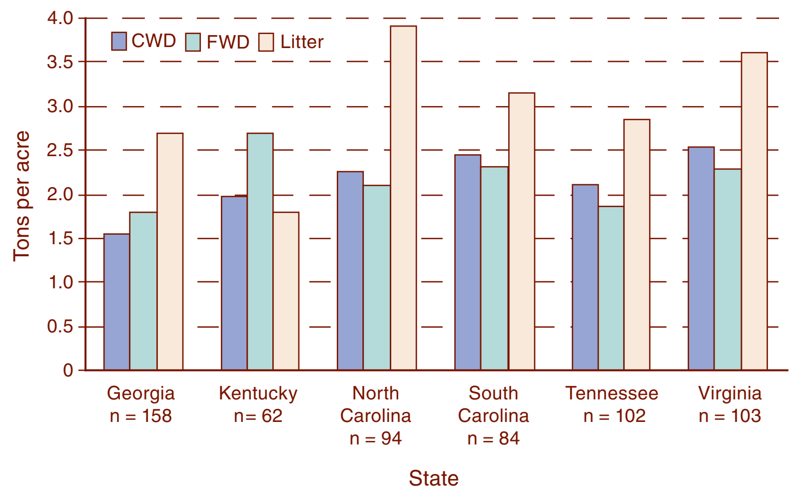


Figure 48—Biomass of coarse woody debris (CWD), fine woody debris (FWD), and litter on P3 plots by State, 2001 to 2003.

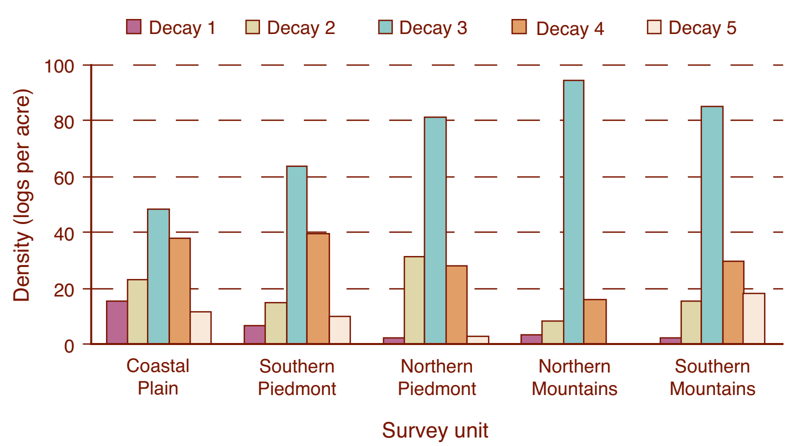


Figure 49—Density of coarse woody debris by decay class and survey unit on P3 plots, Virginia, 2001 to 2003.

3 logs per acre, they also had by far the highest proportion of CWD in this decay class (78 percent). One possible explanation for this is that boles may spend significantly more time in decay class 3 than in the other decay classes. Boles in decay classes 4 and 5 decay more rapidly than those in decay class 3. Lambert and others (1980) found that in fir waves in New Hampshire, it took 15 to 20 years for the down bole cohort to move into the moderate decay stage, while it took about 40 years for fir boles to reach an advanced state of decay. The relatively small number of CWD sample plots in the Northern Mountains (n = 16) could also have affected the accuracy of this estimate.

While alive, trees sequester carbon, with carbon-to-nitrogen ratios approaching 1,000:1. Once a tree dies it is considered a temporary sink for carbon. As decay proceeds, carbon-to-nitrogen ratios typically decrease to about 100:1 in decayed material, as the wood becomes a source of carbon and nitrogen to the system, rather than a sink (Foster and Lang 1982, MacMillan 1988). Likewise, litter is a source of nutrients to the system, with a much faster turnover rate. The amount of carbon tied up in CWD and FWD averaged 1.3 and 1.2 tons per acre, respectively. The forest floor (duff + litter) averaged 8.2 tons of carbon per acre.

The amount of CWD, which is especially important as habitat and as a long-term source of nutrients, was similar to that reported in other published studies only for a few plots. CWD was extremely low or totally missing for nearly one-half of the plots in which it was measured (fig. 50). This may have negative implications for wildlife and nutrient cycling, and positive implications for fire hazard.

Lichens

Lichen is a composite of a fungus and a green alga, or cyanobacteria, or sometimes both, functioning in a symbiotic relationship. The lichen body, or thallus, consists mainly of fungal tissue, with the alga providing the photosynthetic capability. Because lichens have no root system, they absorb the minerals and water they need from rain or the atmosphere (Brodo and others 2001). They are efficient at acquiring nutrients from the atmosphere, and this efficiency can prove disadvantageous if high concentrations of toxins are present. Lichens are especially sensitive to sulfur dioxide (SO_2), with sensitivities varying among species, and among regions for any given species (Haffner and others 2001, Hutchinson and others 1996, Van Dobben

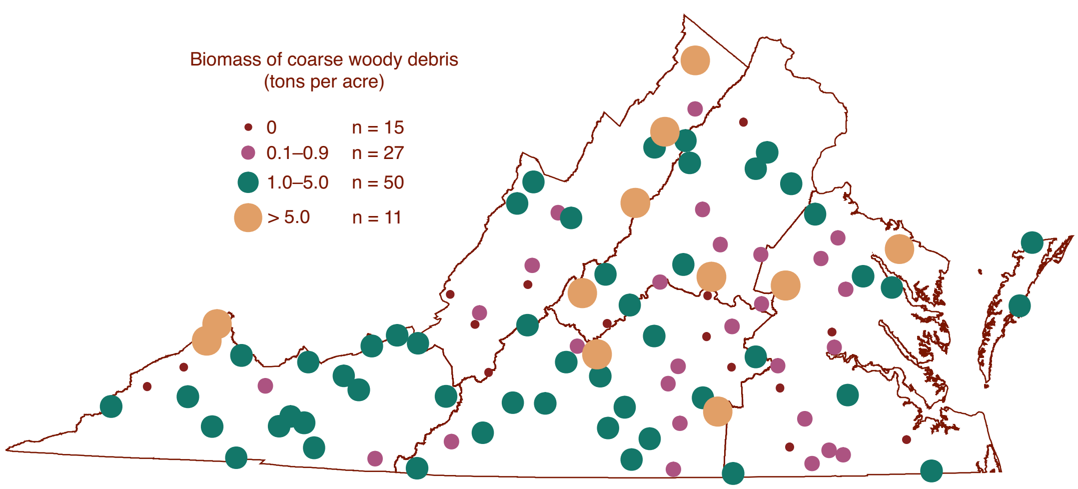


Figure 50—Biomass of coarse woody debris on each P3 plot, Virginia, 2001 to 2003.

and Ter Braak 1999). SO_2 sensitivity also varies with lichen morphology: fruticose lichens are more sensitive than foliose lichens, which are more sensitive than crustose lichens (Haffner and others 2001, Hutchinson and others 1996).

Data about lichen occurrence can reflect changes in forest biodiversity and may provide early warnings when serious conditions are developing.

As biomonitors, lichens can be collected and analyzed for accumulations of specific compounds, such as lead, in their tissues. Lichen communities can also be assessed for species richness and diversity. Existing lichen community parameters and changes in these communities over time may be correlated with climate and air quality data, with the goal of using lichens as early warning indicators of potential forest health degradation (McCune 2000). McCune and others (1997) found that in the Southeastern United States, climate and air quality explained 59 percent of the variation in lichen communities. Generally, species richness was greatest in the Southern and Northern Mountains and decreased across the Piedmont and onto the Coastal Plain. Species richness and the number of sensitive species also decreased as air quality declined. Two separate lichen gradients were calculated, one for climate and one for air quality, for the southeastern region, including Virginia, North Carolina, South Carolina, Georgia, and Alabama. The climate gradient was based on long-term average temperature and precipitation data from weather stations in the region. The air quality gradient was not based on actual monitoring data, but was instead inferred from the literature.

Across Virginia, lichens were tallied on 53 plots in 1994, 1995, 1998, and 1999. A total of 123 species were encountered on these 53 plots (appendix table C.2). This number includes six specimens identified only to genus, and two unknowns that were counted as one species. The highest count for a single plot was 35 and the lowest 3 (fig. 51). The average number of species across all plots and years was 15.4. In 1994, lichens were tallied in 13 plots, with an average of 10.5 species per plot. Averages for 1995, 1998, and 1999 were 14.7, 10.2, and 7.7, respectively (table 41). In comparison, in South Carolina in 1999, 67 species were found on 27 plots, with an average of 11.3 species found per plot (Conner and others 2004). Over the years

Lichens are considered biomonitors of air quality. *(photo by Anita Rose)*

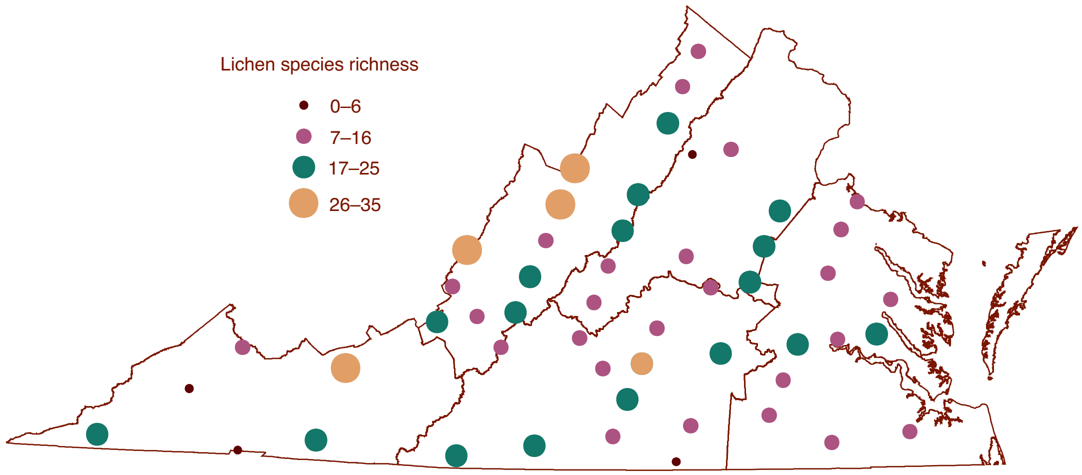


Figure 51—Cumulative lichen species richness by P3 plot, Virginia.

1994, 1995, 1998, and 1999, multiple tallies of lichens were conducted in 38 Virginia plots (1994/1998, n = 8; 1995/1999, n = 22; 1998/1999, n = 3; 1994/1998/1999, n = 5).

In Virginia, the lichen genera that were found most often were *Flavoparmelia*, *Punctelia*, and *Parmotrema*. The first two occurred on 52 plots and the third on 48 plots. The species that were sampled most frequently were *Flavoparmelia caperata* (L.) Hale, *Parmotrema hypotropum* (Nyl.) Hale, and *Punctelia rudecta* (Ach.) Krog, a lichen known to be fairly tolerant of pollution (Brodo 2001). Out of the 123 species tallied, 35 (28 percent) were found on only 1 plot. This local rarity phenomenon has been observed by other researchers and emphasizes the overall complexity of lichen communities and their distribution (Humphrey and others 2002).

Data from plots that are sampled repeatedly are important in portraying trends that may be correlated with changing environmental conditions. There did not seem to be any significant changes in species richness or climate and air quality gradient scores on plots with a repeated measure, but an analysis of species similarity showed that the lichen communities changed markedly between measurements. On plots measured twice, only 25 percent of the species were measured both times. Similarly, on plots measured three times, only 32 percent of species were tallied twice, and only 7 percent were tallied all three times. This may indicate that the composition of lichen communities is changing rapidly across Virginia. However, lichen dispersal (1 to 2 years for recolonization) and growth (0.05 to 5 mm/year) are slow, that it seems more likely that a one-time measurement may not give a clear picture of the true species richness and diversity on individual plots (Richardson 1974).

The Coastal Plain and the Northern Piedmont had the lowest average number of lichen species per plot (13), and the Northern Mountains had the highest (20). This seems consistent with the climatic gradient described by McCune and others (1997), who found that there were fewer species on the Coastal Plain than in the Southern and Northern Mountains. It is also possible that the amount of SO_2 in the atmosphere affected the lichen communities. Based on U.S. Environmental Protection Agency monitoring data, the Northern Piedmont, around the Washington, DC, area, and the Southern Mountains, along the border with Tennessee (represented by a monitor in Sullivan County, TN) had the highest average annual SO_2 amounts (fig. 52) (U.S. Environmental Protection Agency 2005). In the Northern Piedmont, the lichen plot that was closest

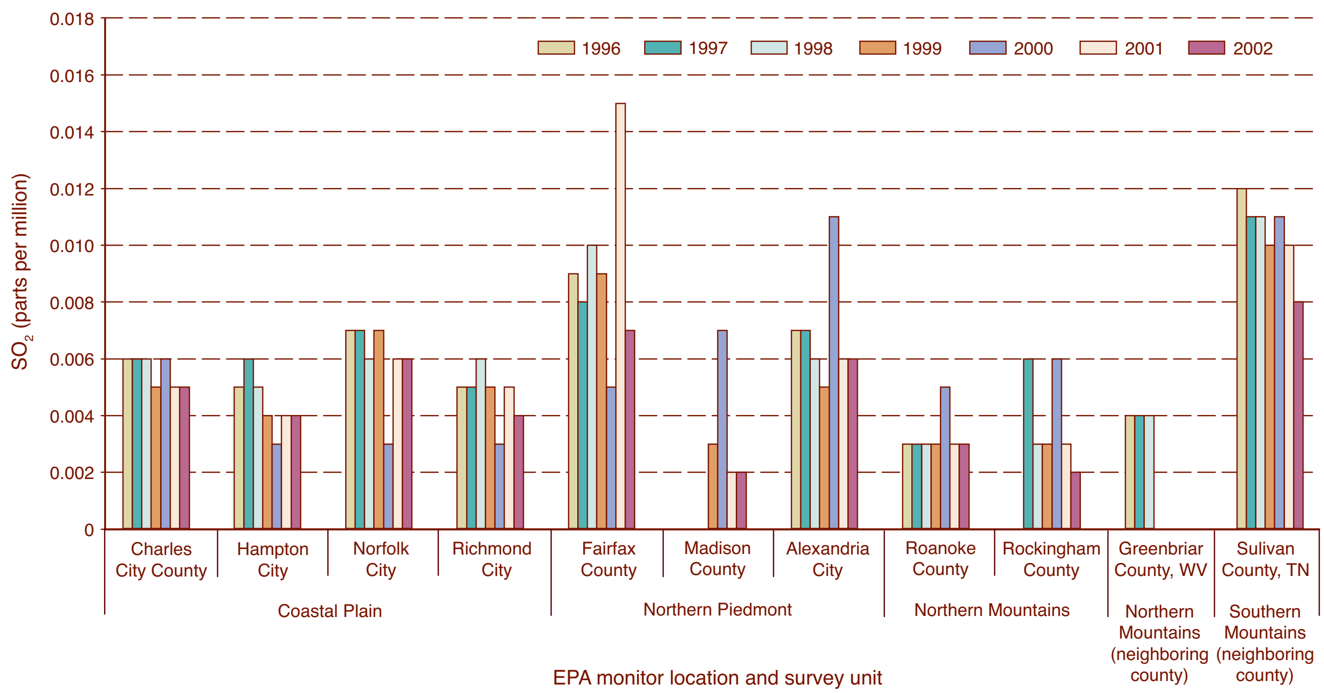


Figure 52—Average annual SO_2 levels measured by the U.S. Environmental Protection Agency (EPA) across Virginia, 1996 to 2002 (data from www.epa.gov).

to Fairfax and Alexandria Counties was three counties away and there were no monitors in the Southern Piedmont, further complicating the correlation. The average climate gradient score for Virginia, based on lichen species and climate data, was 72.7, as compared to 48.1 for the southeastern region (table 42). This indicates that plots in Virginia tend to be cooler than those in the rest of the region. The average air quality gradient score, based on lichen species composition and richness and inferred air quality, was 40.0 for Virginia and 52.6 for the region (table 43). This suggests that air quality may be poorer in Virginia than elsewhere in the region.

Although species richness seemed to decrease from the Southern and Northern Mountains to the Coastal Plain, species known to be sensitive to pollution or sensitive to SO_2 in particular occurred in all units. The pollution sensitive species *Leptogium cyanescens* (Rabenh.) Korber was found in the Coastal Plain as well as in the Northern Mountains. *Normandina pulchella* (Borrer) Nyl., *Ramalina americana* Hale, and *Parmelia squarrosa* Hale are all considered SO_2 sensitive species (U.S. Department of Agriculture 2004c; Wetmore 1987, 1995). *N. pulchella* occurred in both the Northern Piedmont and the Northern Mountains, *R. americana* was found in all units except the Coastal Plain, and *P. squarrosa* was found in the Southern Piedmont and both Southern and Northern Mountains units. The genus *Lobaria*, which is generally considered pollution sensitive and is typically found only in mature forests (Brodo 2001, Haffner and others 2001), was found on four plots in the Northern Mountains. Species that are considered sensitive to pollution or to SO_2 in particular were found in 3 out of 11 plots (27 percent) in the Coastal Plain, 6 out of 14 plots (43 percent) in the Southern Piedmont, 2 out of 8 plots (25 percent) in the Northern Piedmont, 9 out of 14 plots (64 percent) in the Northern Mountains, and 4 out of 6 plots (67 percent) in the Southern Mountains.

Factors other than climate and air quality are known to affect lichens. These include but are not limited to tree species, stand age, site history (natural versus planted stands), and the amount of deadwood (standing or down) present (Crites and Dale 1998, Holien 1996, Humphrey and others 2002, Schmull and others 2002). Of the 53 plots sampled for lichens, 6 were at least 50 percent artificially regenerated, 6 had at least 50 percent of the stocking removed on at least 25 percent of the plot, and another 6 had evidence of partial harvesting on at least 25 percent of the plot area. Another factor that may have affected lichen analysis is that 18 of the plots were < 100 percent forested. All of the condition level variables mentioned above have the potential to impact analysis of lichen data, but unfortunately lichens were not tallied on the subplots, or by condition (U.S. Department of Agriculture 2004b), thereby precluding any rigorous analyses of these issues. The lichen indicator can be useful in detecting changes in ecosystem health, whether these are due to changes in air quality or to changes in climate. Data about lichen occurrence can reflect changes in forest biodiversity and may provide early indications when more serious conditions are developing. So far, no direct links or correlations have been demonstrated among lichen community gradients, species trends, and change in forest functions. In addition, links to more direct forest change such as greater tree mortality, lower productivity (growth reductions), shifts in tree species composition, and degradation of regeneration capacities have not been shown.

Soils

Soil is a key element of forest ecosystems. The varying characteristics of parent materials, from which soil is derived, partly determines what kind of plant life ecosystems will support (Pritchett and Fisher 1987). Likewise, the modification of soils by natural means or human action can affect vegetation. Weathering is the primary means by which soils are formed. Over time, parent material is broken down into soil by precipitation, wind, and the freeze-thaw cycle. Soil properties are also modified by microbial activity and vegetation. Human-related processes that affect soil properties include acidic deposition, soil compaction (caused by operation of heavy equipment), and erosion of topsoil (resulting from harvesting or grazing activity). Acidic deposition, either to soil or vegetation, occurs via three main pathways: (1) precipitation or wet deposition, where material is dissolved in rain or snow; (2) dry deposition, involving direct deposition of gases and particles (aerosols) onto surfaces; and (3) cloud-water deposition, involving material dissolved in cloud droplets, which is deposited when cloud or fog droplets are intercepted by vegetation (Mohnen 1992).

Soil erosion and compaction levels seem low at this time, but high bulk densities may be a cause for concern. Low soil pH and high exchangeable aluminum are potential issues.

Erosion of soil is a primary concern due to the potential for loss of nutrients from the upper layers of soil. Risk of significant erosion is greatest in areas with large amounts of bare soil, steep slopes, and high precipitation, especially where logging or grazing may have occurred. Most P3 plots in Virginia (72 percent, n = 92) had ≤ 10 percent bare soil, while only 2 percent of plots had > 50 percent bare soil. The Northern Mountains had the lowest percentage (17 percent) of plots with 1 percent or less of bare soil, and the Coastal Plain had the highest (65 percent).

Soil compaction reduces pore space and decreases air in the soil. The severity of compaction can vary by soil texture and percent moisture in the soil. Soils with multiple particle sizes, such as fine sandy loam, or high moisture content have a greater potential for damage (O'Neill and others 2005). The percentage of plot area compacted was determined on 129 plots between 1999 and 2002. In the majority of these plots (68 percent), ≤ 1 percent of the plot area was compacted (fig. 53). Eleven percent or more of the plot area was compacted in only 17 percent of plots. Compaction caused by passage of heavy machinery or equipment was noted on 73 percent of the plots with compaction.

Soil samples were also collected from P3 plots and analyzed in a laboratory for various physical and chemical properties to further clarify the status of forest soils. The forest floor layer (litter + duff) was analyzed for percent moisture, carbon, and nitrogen. Mineral soil was collected in two layers, 0 to 4 inches (M1) and 4 to 8 inches (M2), and analyzed for the same information plus pH and a variety of exchangeable cations. Due to changes in methods, only the data from 2000 to 2002 is included in this analysis. For a description of these changes, see O'Neill and others (2005).

Bulk density, or the weight of a unit volume of dry soil, varies by soil texture. Clay soils tend to have lower bulk densities than do sandy soils (Brady and Weil 1996). About 50 percent (n = 36) of the M1 samples were loamy, while 44 percent (n = 31) of the M2 samples were clayey. Bulk density can range from 0.1 g/cm³ for histosols to 2.2 g/cm³ for compacted glacial tills. The threshold value for bulk density is typically considered 1.6 g/cm³. At or above this threshold, root growth is impaired. Bulk density averaged 1.10 g/cm³ for all M1 samples, while that for the M2 layer averaged 1.45 g/cm³. The majority (57 percent) of M1 samples had bulk densities in the range of 0.88 to 1.37 g/cm³. Sixty-eight percent of M2 samples were in the range of 1.12 to 1.62 g/cm³ (fig. 54). Average bulk densities for both layers were highest in the Coastal Plain and lowest in the Northern Mountains. Overall, 21 plots (31 percent) had bulk densities at or above 1.6 g/cm³ for either the M1 or the M2 layer. Over one-half of these were on the Coastal Plain. Additionally, 38 percent (n = 8) of plots with high bulk densities had compaction on 10 percent or more of the plot area, which suggests that compaction may have contributed to high bulk density values of the mineral soil on these plots.

The amount of water present in the soil varies by soil texture and by the amount of water available to the system, i.e., precipitation. In general, finer textured soils have a higher water retention capacity than

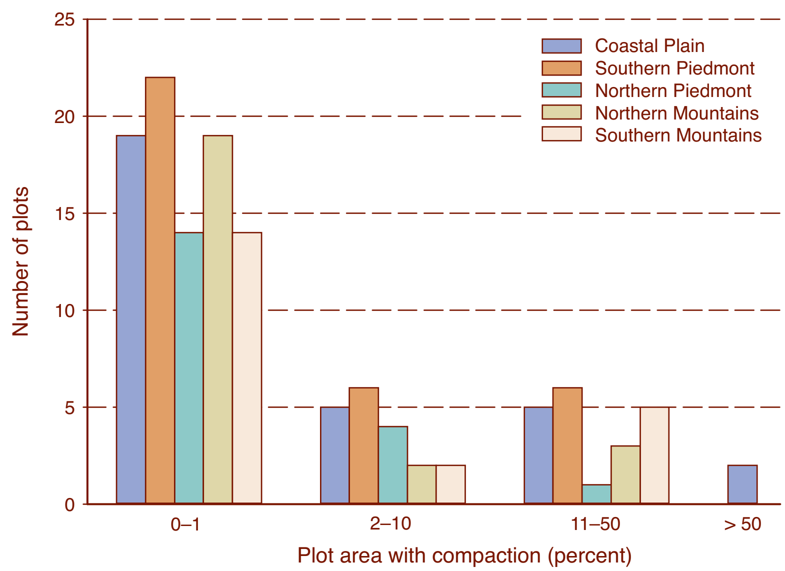


Figure 53—Distribution of soil compaction on P3 plots by survey unit, Virginia, 1999 to 2002.

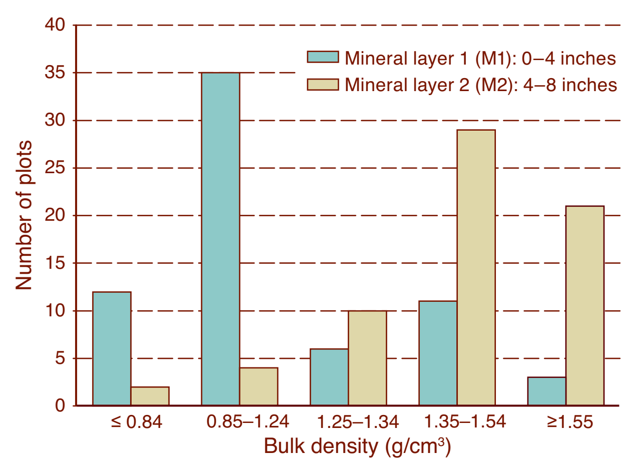


Figure 54—Distribution of bulk density values for mineral soils on P3 plots, Virginia, 2000 to 2002.

do coarsely textured soils. Soil moisture affects everything from productivity of vegetation to potential for damage from compaction. Percent moisture averaged 168 percent for the forest floor layer. The M1 layer averaged 41 percent moisture, while the M2 layer averaged 32 percent (table 44). For all three layers, percent moisture was lowest in the Coastal Plain and highest in the Southern and Northern Mountains.

Soil pH, or the negative logarithm of the activity of hydrogen ions, affects all physical, chemical, and biological properties of a soil. Like soil moisture, it is a major factor determining what types of vegetation will dominate a natural landscape (Brady and Weil 1996). Most soils have a pH between 4.0 and 8.5 (Black 1957). Average pH for the M1 layer was 4.8 (table 44). The minimum and maximum pH values recorded in this layer (3.4 and 6.7, respectively) were both for soils collected in the Southern Mountains. The average pH for the M2 layer was slightly higher, at 4.9. Again, the lowest and highest values for this layer were for soils collected in the Southern Mountains. The majority of the M1 and M2 samples had a pH < 5.0 (fig. 55). At these levels of pH, enough exchangeable aluminum may be present to reduce plant growth. Additionally, a low percentage of base saturation would be expected (Buol and others 1980). Low soil pH may occur naturally or may be related to acidic deposition associated with the combustion of fossil fuels (Bailey and others 2005, Joslin and others 1992).

Soil pH, base-forming cations such as calcium, and exchangeable aluminum are intricately related. As base-forming cations are leached from the soil, aluminum and hydrogen replace these much needed nutrients on the soil complex, and pH decreases. Exchangeable aluminum averaged 148.5 and 144.6 mg/kg for the M1 and M2 layers, respectively (table 45). Aluminum was highest in the Southern and Northern Mountains for both layers, and lowest in the Southern Piedmont for both layers. Soils with lower pH tended to have more exchangeable aluminum than soils with a higher pH. Soils with lower pH values and higher levels of exchangeable aluminum had lower proportions of exchangeable base-forming cations (fig. 56). Exchangeable calcium averaged 447.4 mg/kg for the M1 layer and 165.3 mg/kg for the M2 layer. Given the low pH values and high proportion of exchangeable aluminum in about 30 percent of the samples, very low calcium-to-aluminum ratios in the soil solution are very possible. Consequently, plant growth may be reduced where the ratio of calcium to aluminum in the soil solution is < 1.0 (Brady and Weil 1996).

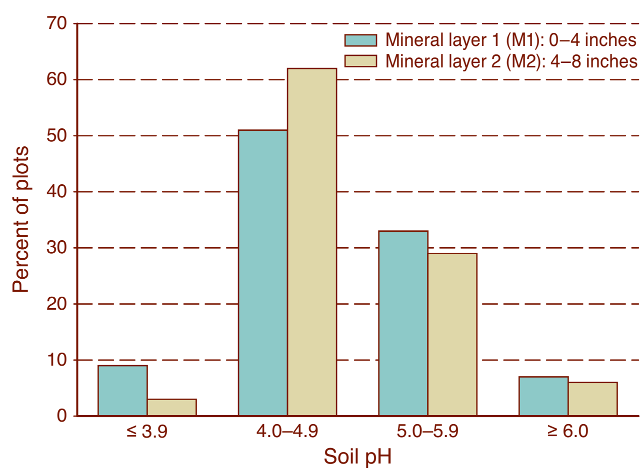
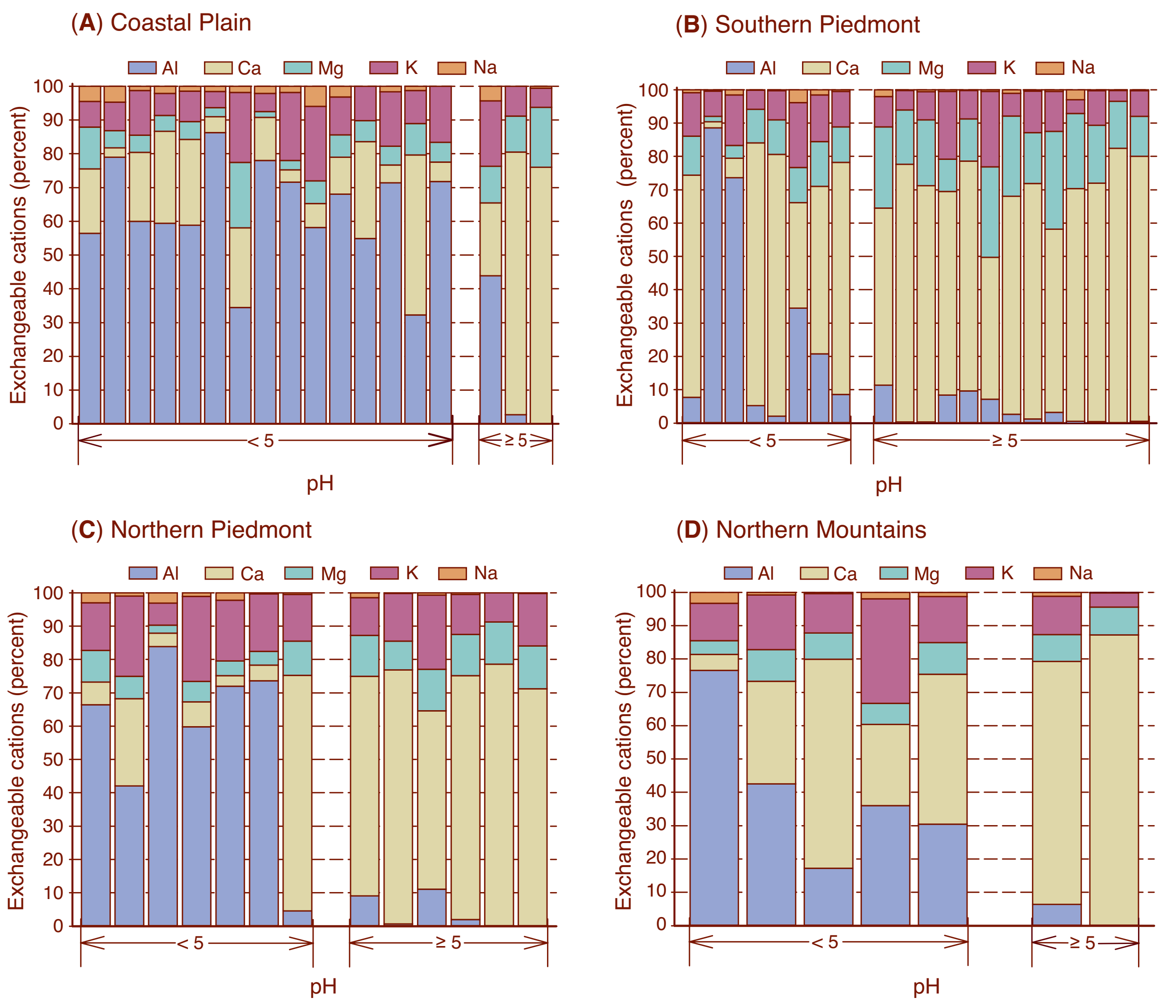


Figure 55—Distribution of pH values for mineral soils on P3 plots, Virginia, 2000 to 2002.



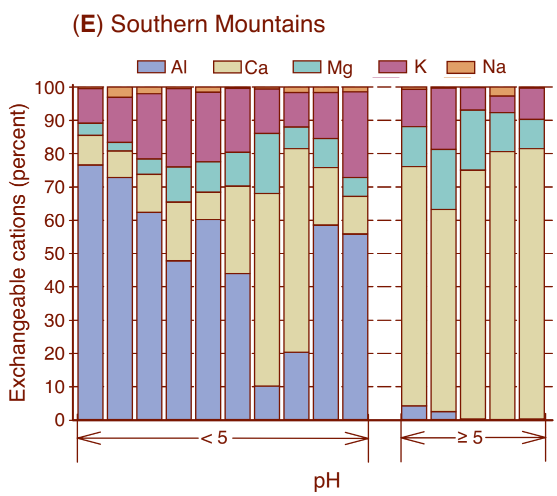


Figure 56—The proportion of exchangeable cations per mineral soil sample (0–4 inches) by survey unit, P3 plots, Virginia, 2000 to 2002, (A) Coastal Plain, (B) Southern Piedmont, (C) Northern Piedmont, (D) Northern Mountains, and (E) Southern Mountains. (Al = aluminum, Ca = calcium, Mg = magnesium, K = potassium, Na = sodium.)

In terrestrial systems, the amount of carbon and nitrogen in the soil often exceeds the amount found in the aboveground biomass. Each of these elements occurs in organic and inorganic forms in soil. The organic carbon includes decomposing material from plants and animals (Post and Kwon 2000, Schlesinger 1991). The forest floor averaged 35 percent organic carbon. The mineral soil had a much lower concentration of organic carbon. The M1 and M2 layers averaged 2.8 and 1.1 percent carbon, respectively (table 44). This, however, does not necessarily translate to a lower mass of carbon in the mineral layers. An estimate of the mass of organic carbon per acre was calculated using the percent carbon of the sample and the bulk density. It was estimated that the forest floor accounted for 5.3 tons per acre of organic carbon, and that the M1 and M2 layers accounted for 11.4 and 5.8 tons per acre, respectively. Together, these three layers contained about nine times the mass of carbon in the DWM (table 46).

Nitrogen is an integral component of many essential plant compounds, including amino acids, and is usually the limiting nutrient in terrestrial ecosystems (Brady and Weil 1996). However, some forests in the Eastern United States are becoming nitrogen saturated. These forests receive high levels of atmospheric nitrogen inputs and have high nitrate levels in soil solution and streamwater (Nodvin and others 1995). Several factors predispose forested watersheds to nitrogen saturation, including chronically high rates of nitrogen deposition, advanced stand age, and the presence of large pools of soil nitrogen (Stoddard 1994). The presence of excess nitrogen, especially in the form of nitrate (NO_3^-), can result in the leaching of base-forming cations, reductions in soil pH, and the mobilization of aluminum; all of which can have negative impacts on vegetation. Nitrogen in precipitation might be considered beneficial in areas of limited nitrogen availability, i.e., farmland, but it can be a serious pollutant when added to soil supporting a mature forest. Nitrogen concentration in the forest floor averaged 1.3 percent across the State. The nitrogen concentration of the M1 layer averaged 0.16 percent and that of the M2 layer averaged 0.07 percent (table 44). Percent total nitrogen, for all three layers, was highest in the Southern and Northern Mountains. These values translate to roughly 1.2 tons per acre of nitrogen in the forest floor and mineral soil (0 to 8 inches). Plot-level values ranged from 0.1 to 3.4 tons per acre of nitrogen.

The status of soil on P3 plots in Virginia varied by unit and by the parameter considered. While soil erosion and compaction levels seem low at this time, high bulk densities may be cause for concern. Likewise, low soil pH and high exchangeable aluminum are potential issues. Losses of base cations, such as calcium, from soils and the immobilization of soil aluminum may contribute to nutritional imbalances and ultimately to forest decline (Agren and Bosatta 1988, Garten and Van Miegroet 1994). Additionally, high nitrate levels have been implicated in soil acidification and water-quality deterioration (Aber and others 1998, Joslin and Wolfe 1992). Complexities related to connections among soil properties and the fact that soil properties are intrinsically tied to deposition and site history make it difficult to focus on just one variable and relate it to forest health. Furthermore, due to changes in methodology, this analysis represents only a portion of the data that will eventually be available. With a full set of data, some issues will be clarified, while some may warrant further investigation.

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Violet (*Viola* spp.) on Blue Ridge Parkway in Virginia. *(photo by Anita Rose)*

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Afforestation. Area of land previously classified as nonforest that is converted to forest by planting of trees or by natural reversion to forest.

Average annual mortality. Average annual volume of trees 5.0 inches d.b.h. and larger that died from natural causes during the intersurvey period.

Average annual removals. Average annual volume of trees 5.0 inches d.b.h. and larger removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

Average net annual growth. Average annual net change in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting (gross growth minus mortality) during the intersurvey period.

Basal area. The area in square feet of the cross section at breast height of a single tree or of all the trees in a stand, usually expressed in square feet per acre.

Bioindicator species. A tree, woody shrub, or nonwoody herb species that responds to ambient levels of ozone pollution with distinctive visible foliar symptoms.

Biomass. The aboveground fresh weight of solid wood and bark in live trees 1.0 inch d.b.h. and larger from the ground to the tip of the tree. All foliage is excluded. The weight of wood and bark in lateral limbs, secondary limbs, and twigs under 0.5 inch diameter at the point of occurrence on sapling-size trees is included but is excluded on poletimber and sawtimber-size trees.

Blind check. A reinstallation done by a qualified inspection crew without production crew data on hand; a full reinstallation of the plot is recommended for the purpose of obtaining a measure of data quality. If a full plot reinstallation is not possible, then it is strongly recommended that at least two full subplots be completely remeasured along with all the plot-level information. The two datasets are maintained separately. Discrepancies between the two sets of data are not reconciled. Blind checks are done on production plots only. This procedure provides a quality assessment and evaluation function.

Bole. That portion of a tree between a 1-foot stump and a 4-inch top d.o.b. in trees 5.0 inches d.b.h. and larger.

Census water. Streams, sloughs, estuaries, canals, and other moving bodies of water 200 feet wide and greater, and lakes, reservoirs, ponds, and other permanent bodies of water 4.5 acres in area and greater.

Coarse woody debris. Down pieces of wood leaning more than 45 degrees from vertical with a diameter of at least 3.0 inches and a length of at least 3.0 feet (decay classes 1 through 4). Decay class 5 pieces must be at least 5.0 inches in diameter, at least 5.0 inches high from the ground, and at least 3.0 feet in length.

Cold check. An inspection done either as part of the training process, or as part of the ongoing quality control program. Normally the installation crew is not present at the time of inspection. The inspector has the completed data in-hand at the time of inspection. The inspection can include the whole plot or a subset of the plot. Data errors are corrected. Cold checks are done on production plots only. This type of quality control measurement is a "blind" measurement in that the crews do not know when or which of their plots will be remeasured by the inspection crew.

Compacted area. Type of compaction measured as part of the soil indicator. Examples include the junction areas of skid trails, landing areas, work areas, etc.

Condition class. The combination of discrete landscape and forest attributes that identify and define, and stratify the area associated with a plot. Examples of such attributes include condition status, forest type, stand origin, stand size, owner group, reserve status, and stand density.

Crown. The part of a tree or woody plant bearing live branches or foliage.

Crown density. The amount of crown stem, branches, twigs, shoots, buds, foliage, and reproductive structures that block light penetration through the visible crown. Dead branches and dead tops are part of the crown. Live and dead branches below the live crown base are excluded. Broken or missing tops are visually reconstructed when forming this crown outline by comparing outlines of adjacent healthy trees of the same species and d.b.h.

Crown dieback. This is recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is only considered when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, it is assumed that the branches died from the terminal portion of the branch. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading. Dead branches in the lower live crown are not considered as part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches.

D.b.h. Tree diameter in inches (outside bark) at breast height (4.5 feet aboveground).

Decay class. Qualitative assessment of stage of decay (five classes) of coarse woody debris based on visual assessments of color of wood, presence/absence of twigs and branches, texture of rotten portions, and structural integrity.

Diameter class. A classification of trees based on tree d.b.h. Two-inch diameter classes are commonly used by FIA, with the even inch as the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

D.o.b. (diameter outside bark). Stem diameter including bark.

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

Duff. A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material, e.g., individual plant parts, can no longer be identified.

Effective cation exchange capacity (ECEC). The sum of cations that a soil can adsorb in its natural pH. Expressed in units of centimoles of positive charge per kilogram of soil.

Erosion. The wearing away of the land surface by running water, wind, ice, or other geological agents.

Fine woody debris. Down pieces of wood with a diameter < 3.0 inches, not including foliage or bark fragments.

Foliage transparency. The amount of skylight visible through microholes in the live portion of the crown, i.e. where you see foliage, normal or damaged, or remnants of its recent presence. Recently defoliated branches are included in foliage transparency measurements. Macroholes are excluded unless they are the result of recent defoliation. Dieback and dead branches are always excluded from the estimate. Foliage transparency is different from crown density because it emphasizes foliage and ignores stems, branches, fruits, and holes in the crown.

Forest floor. The entire thickness of organic material overlying the mineral soil, consisting of the litter and the duff (humus).

Forest land. Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120 feet wide.

Forest management type. A classification of timberland based on forest type and stand origin.

Pine plantation. Stands that (1) have been artificially regenerated by planting or direct seeding, (2) are classed as a pine or other softwood forest type, and (3) have at least 10 percent stocking.

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

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

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

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

Nonstocked stands. Stands < 10 percent stocked with live trees.

Forest type. A classification of forest land based on the species forming a plurality of live-tree stocking. Major eastern forest-type groups are:

White-red-jack pine. Forests in which eastern white pine, red pine, or jack pine, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, birch, and maple.)

Spruce-fir. Forests in which spruce or true firs, singly or in combination, constitute a plurality of the stocking. (Common associates include maple, birch, and hemlock.)

Longleaf-slash pine. Forests in which longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Loblolly-shortleaf pine. Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Oak-pine. Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Oak-hickory. Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-gum-cypress. Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent of stocking, in which case the stand would be classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Elm-ash-cottonwood. Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

Maple-beech-birch. Forests in which maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, elm, basswood, and white pine.)

Nonstocked stands. Stands < 10 percent stocked with live trees.

Forested tract size. The area of forest within the contiguous tract containing each FIA sample plot.

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

Gross growth. Annual increase in volume of trees 5.0 inches d.b.h. and larger in the absence of cutting and mortality. (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

Growing-stock trees. Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Trees must contain at least one 12-foot or two 8-foot logs in the saw-log portion, currently or potentially (if too small to qualify), to be classed as growing stock. The log(s) must meet dimension and merchantability standards to qualify. Trees must also have, currently or potentially, one-third of the gross board-foot volume in sound wood.

Growing-stock volume. The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Hardwoods. Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods. Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods. Hardwood species with an average specific gravity > 0.50 such as oaks, hard maples, hickories, and beech.

Hexagonal grid (Hex). A hexagonal grid formed from equilateral triangles for the purpose of tessellating the FIA inventory sample. Each hexagon in the base grid has an area of 5,937 acres (2,403.6 ha) and contains one inventory plot. The base grid can be subdivided into smaller hexagons to intensify the sample.

Humus. A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material, e.g., individual plant parts, can no longer be identified.

Land area. The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals < 200 feet wide, and lakes, reservoirs, and ponds < 4.5 acres in area.

Lichen. An organism generally appearing to be a single small leafy, tufted or crustlike plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association.

Lichen community indicator. The set of macrolichen species collected on a FIA lichen plot using standard protocols, which serves as an indicator of ecological condition, e.g., air quality or climate of the plot.

Lichen plot. The FIA lichen plot is a circular area, total 0.935 acre (0.4 ha), with a 120-foot (36.6 m) radius centered on subplot 1, and excluding the four subplots.

Litter. Undecomposed or only partially decomposed organic material that can be readily identified, e.g., plant leaves, twigs, etc.

Live trees. All living trees. All size classes, all tree classes, and both commercial and noncommercial species are included.

Measurement quality objective (MQO). A data user's estimate of the precision, bias, and completeness of data necessary to satisfy a prescribed application, e.g., Resource Planning Act, assessments by State foresters, forest planning, forest health analyses. Describes the acceptable tolerance for each data element. MQOs consist of two parts: (1) a statement of the tolerance and (2) a percentage of time when the collected data are required to be within tolerance. MQOs can only be assigned where standard methods of sampling or field measurements exist, or where experience has established upper or lower bounds on precision or bias. MQOs can be set for measured data elements, observed data elements, and derived data elements.

Mineral soil. A soil consisting predominantly of products derived from the weathering of rocks, e.g., sands, silts, and clays.

Net annual change. Increase or decrease in volume of live trees at least 5.0 inches d.b.h. Net annual change is equal to net annual growth minus average annual removals.

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

Nonforest land. Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.

Nonstocked stands. Stands < 10 percent stocked with live trees.

Other forest land. Forest land other than timberland and productive reserved forest land. It includes available and reserved forest land which is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions, because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other removals. The growing-stock volume of trees removed from the inventory by cultural operations such as timber stand improvement, land clearing, and other changes in land use, resulting in the removal of the trees from timberland.

Ozone (O_3). A regional, gaseous air pollutant produced primarily through sunlight-driven chemical reactions of NO_2 and hydrocarbons in the atmosphere and causing foliar injury to deciduous trees, conifers, shrubs, and herbaceous species.

Ozone bioindicator site. An open area in which ozone injury to ozone-sensitive species is evaluated. The area must meet certain site selection guidelines regarding size, condition, and plant counts to be used for ozone-injury evaluations in FIA.

Ownership. The property owned by one ownership unit, including all parcels of land in the United States.

National forest land. Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III land.

Forest industry land. Land owned by companies or individuals operating primary wood-using plants.

Nonindustrial private forest land. Privately owned land excluding forest industry land.

Corporate. Owned by corporations, including incorporated farm ownerships.

Individual. All lands owned by individuals, including farm operators.

Other public. An ownership class that includes all public lands except national forests.

Miscellaneous Federal land. Federal land other than national forests.

State, county, and municipal land. Land owned by States, counties, and local public agencies or municipalities or land leased to these governmental units for 50 years or more.

Phase 1 (P1). FIA activities related to forest area estimation, the primary purpose of which is to label plots and obtain stratum weights for population estimates.

Phase 2 (P2). FIA activities conducted on the network of ground plots. The primary purpose is to obtain field data that enable classification and summarization of area, tree, and other attributes associated with forest land uses.

Phase 3 (P3). FIA activities conducted on a subset of phase 2 plots. Additional attributes related to forest health are measured on phase 3 plots.

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

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

Quality assurance (QA). The total integrated program for ensuring that the uncertainties inherent in FIA data are known and do not exceed acceptable magnitudes, within a stated level of confidence. QA encompasses the plans, specifications, and policies affecting the collection, processing, and reporting of data. It is the system of activities designed to provide program managers and project leaders with independent assurance that total system quality control is being effectively implemented.

Quality control (QC). The routine application of prescribed field and laboratory procedures, e.g., random check cruising, periodic calibration, instrument maintenance, use of certified standards, etc., in order to reduce random and systematic errors and ensure that data are generated within known and acceptable performance limits. QC also ensures the use of qualified personnel, reliable equipment and supplies, training of personnel, good field and laboratory practices, and strict adherence to standard operating procedures.

Reforestation. Area of land previously classified as forest that is regenerated by tree planting or natural regeneration.

Rotten trees. Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, now or prospectively, primarily because of rot or missing sections, and with less than one-third of the gross board-foot tree volume in sound material.

Rough trees. Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, now or prospectively, primarily because of roughness, poor form, splits, and cracks, and with less than one-third of the gross board-foot tree volume in sound material; and live trees of noncommercial species.

Sapling. Live trees 1.0 to 4.9 inches (2.5 to 12.5 cm) in diameter (d.b.h. or d.r.c.).

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

Saw-log portion. The part of the bole of sawtimber trees between a 1-foot stump and the saw-log top.

Saw-log top. The point on the bole of sawtimber trees above which a conventional saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber-size trees. Softwoods 9.0 inches d.b.h. and larger and hardwoods 11.0 inches d.b.h. and larger.

Sawtimber volume. Growing-stock volume in the saw-log portion of sawtimber-size trees in board feet (International 1/4-inch rule).

Seedlings. Trees < 1.0 inch d.b.h. and > 1 foot tall for hardwoods, > 6 inches tall for softwoods, and > 0.5 inch in diameter at ground level for longleaf pine.

Select red oaks. A group of several red oak species composed of cherrybark, Shumard, and northern red oaks. Other red oak species are included in the "other red oaks" group.

Select white oaks. A group of several white oak species composed of white, swamp chestnut, swamp white, chinkapin, Durand, and bur oaks. Other white oak species are included in the "other white oaks" group.

Site class. A classification of forest land in terms of potential capacity to grow crops of industrial wood based on fully stocked natural stands.

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

Yellow pines. Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

Other softwoods. Cypress, eastern redcedar, white-cedar, eastern white pine, eastern hemlock, spruce, and fir.

Soil bulk density. The mass of soil per unit volume. A measure of the ratio of pore space to solid materials in a given soil. Expressed in grams per cubic centimeter of oven dry soil.

Soil compaction. A reduction in soil pore space caused by heavy equipment or by repeated passes of light equipment that compress the soil and break down soil aggregates. Compaction disturbs the soil structure and can cause decreased tree growth, increased water runoff, and soil erosion.

Soil texture. The relative proportions of sand, silt, and clay in a soil.

Stand age. The average age of dominant and codominant trees in the stand.

Stand origin. A classification of forest stands describing their means of origin.

Planted. Planted or artificially seeded.

Natural. No evidence of artificial regeneration.

Stand-size class. A classification of forest land based on the diameter class distribution of live trees in the stand.

Sawtimber stands. Stands at least 10 percent stocked with live trees, with half or more of total stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Poletimber stands. Stands at least 10 percent stocked with live trees, with half or more of total stocking in poletimber and sawtimber trees, and with poletimber stocking exceeding sawtimber stocking.

Sapling-seedling stands. Stands at least 10 percent stocked with live trees, in which saplings and seedlings account for more than half of total stocking.

Nonstocked stands. Stands < 10 percent stocked with live trees.

Stocking. The degree of occupancy of land by trees, measured by basal area or the number of trees in a stand and spacing in the stand, compared with a minimum standard, depending on tree size, required to fully utilize the growth potential of the land.

Density of trees and basal area per acre required for full stocking

D.b.h. class	Trees per acre for full stocking	Basal area (square feet per acre)
Seedlings	600	—
2	560	—
4	460	—
6	340	67
8	240	84
10	155	85
12	115	90
14	90	96
16	72	101
18	60	106
20	51	111

Timberland. Forest land capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

Tree. Woody plant having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

Tree grade. A classification of the saw-log portion of sawtimber trees based on: (1) the grade of the butt log or (2) the ability to produce at least one 12-foot or two 8-foot logs in the upper section of the saw-log portion. Tree grade is an indicator of quality; grade 1 is the best quality.

Upper-stem portion. The part of the main stem or fork of sawtimber trees above the saw-log top to a minimum top diameter of 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Vigor class. A visual assessment of the apparent crown vigor of saplings. The purpose is to separate excellent saplings with superior crowns from stressed individuals with poor crowns.

Volume of live trees. The cubic-foot volume of sound wood in live trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Volume of saw-log portion of sawtimber trees. The cubic-foot volume of sound wood in the saw-log portion of sawtimber trees. Volume is the net result after deductions for rot, sweep, and other defects that affect use for lumber.

Table 1—Forest land area as a percentage of total land area by survey unit, Virginia, 2001

Survey unit	Total land area	Total forest area	Forest land area
	- - - thousand acres - - -		*percent*
Coastal Plain	6,293.0	3,817.7	61
Southern Piedmont	5,597.4	3,784.1	68
Northern Piedmont	4,392.0	2,405.1	55
Northen Mountains	4,290.2	2,744.3	64
Southern Mountains	4,767.6	3,092.9	65
All units	25,340.1	15,844.0	63

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

Table 2—Change in area of timberland by survey unit, Virginia, 1992 to 2001

Survey unit	Year 1992	Year 2001	Change	Change
	- - - - - - - thousand acres	*- - - - - - -*		*percent*
Coastal Plain	3,702.3	3,715.3	13.0	0.4
Southern Piedmont	3,778.3	3,784.1	5.8	0.2
Northern Piedmont	2,426.6	2,270.3	-156.3	-6.4
Northern Mountains	2,536.8	2,625.7	88.9	3.5
Southern Mountains	3,003.6	3,071.6	68.0	2.3
All units	15,447.6	15,467.0	19.4	0.1

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

Table 3—Area of forest land and timberland by ownership class, Virginia, 2001

Ownership class	Forest land		Timberland	
	thousand acres	*percent*	*thousand acres*	*percent*
Public	2,717.9	17	2,346.7	15
Forest industry	1,024.2	6	1,024.2	7
Nonindustrial private	12,101.9	76	12,096.1	78
All classes	15,844.0	100	15,467.0	100

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

Table 4—Percentage of private forest land owners[a] by timber harvesting and management plan, NWOS, Virginia, 1994 and 2004

Timber harvest and management plan	Year 1994	Year 2004
	percent	
Timber harvest		
Yes	53	47
No	47	51
No answer	—	2
Written management plan		
Yes	17	4
No	83	92
No answer	—	3

NWOS = National Woodland Owner Survey.

— = no data available.

[a] Does not include private corporate owners.

Table 5—Area and number of private forest land owners[a] by recent (past 5 years) forestry activity, NWOS, Virginia, 2004

Activity[b]	Area		Ownerships	
	thousand acres	*percent*	*number*	*percent*
Timber harvest	3,680	36	86,000	23
Collection of NTFPs	1,009	10	35,000	9
Site preparation	1,670	17	15,000	4
Tree planting	2,859	28	57,000	15
Fire hazard reduction	1,088	11	44,000	12
Application of chemicals	1,543	15	32,000	9
Road/trail maintenance	3,289	33	46,000	12
Wildlife habitat improvement	1,670	17	27,000	7
Posting land	4,823	48	99,000	27
Private recreation	4,634	46	107,000	29
Public recreation	1,135	11	15,000	4
Cost share	1,518	15	7,000	2
Conservation easement[c]	304	3	2,000	1
Green certification[c]	405	4	2,000	1

NWOS = National Woodland Owner Survey; NTFPs = nontimber forest products.

[a] Does not include private corporate owners.

[b] Categories are not exclusive.

[c] Not limited to past 5 years.

Table 6—Percentage of area and private forest land owners[a] by reason for owning forest land, NWOS, Virginia, 2004

Reason[b]	Area	Owner-ships
	percent	
Nontimber forest products	60	59
Aesthetics	59	57
Nature protection	53	57
Family legacy	52	52
Land investment	48	41
Part of farm, home, or cabin[c]	27	36
Privacy	41	32
Other recreation	39	24
No answer	28	23
Timber production	10	9
Firewood production	10	9
Hunting or fishing	35	8

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

NWOS = National Woodland Owner Survey.

[a] Does not include private corporate owners.

[b] Categories are not exclusive.

[c] Includes primary and secondary residences.

Table 7—Percentage of area and private forest land owners[a] by landowners' concerns, NWOS, Virginia, 2004

Concern[b]	Area	Owner-ships
	percent	
Land development	36	55
Family legacy	57	53
Air or water pollution	39	53
Property taxes	55	49
Insects/diseases	56	48
Dumping	48	46
Fire	54	45
Trespassing	52	43
Storms	41	31
Harvesting regulations	28	28
Wild animals	17	27
Noise pollution	22	27
Exotic plant species	25	24
Regeneration	21	24
Lawsuits	22	22
Endangered species	26	20
Timber theft	25	16
Domestic animals	9	9

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

NWOS = National Woodland Owner Survey.

[a] Does not include private corporate owners.

[b] Categories are not exclusive.

Table 8—Area of forest land by forest-type group and detailed forest type, Virginia, 2001

Forest-type group and detailed forest type	Forest land	Percentage of group acres	Percentage of total acres
	thousand acres		
Oak-hickory			
White oak-red oak-hickory	2,689.8	28	
Yellow-poplar-white oak-n. red oak	2,441.8	26	
Mixed upland hardwoods	1,849.9	19	
Chestnut oak	1,494.3	16	
Sweetgum-yellow-poplar	685.9	7	
Northern red oak	180.1	2	
White oak	127.5	1	
Post oak-blackjack oak	67.7	1	
Total	9,537.1	100	60
Loblolly-shortleaf pine			
Loblolly pine	2,279.6	72	
Virginia pine-southern red oak	597.5	19	
Eastern redcedar	93.7	3	
Shortleaf pine	76.1	2	
Pitch pine	61.6	2	
Table Mountain pine	40.2	1	
Pond pine	8.7	0	
Total	3,157.4	100	20
Oak-pine			
Loblolly pine-hardwood	725.1	37	
Virginia pine-southern red oak	465.6	24	
E. white pine-n.red oak-white ash	347.4	18	
Other pine-hardwood	310.1	16	
Shortleaf pine-oak	88.5	5	
Total	1,936.8	100	12
Bottomland hardwood			
Sweetbay-swamp tupelo-red maple	201.8	28	
River birch-sycamore	191.6	27	
Sweetgum-nuttall-willow oak	139.0	20	
Sugarberry or hackberry-elm-green ash	68.7	10	
Cypress-water tupelo	42.0	6	
Sycamore-pecan-american elm	27.0	4	
Swamp chestnut oak-cherrybark oak	18.5	3	
Willow	17.9	3	
Cottonwood	4.4	1	
Total	711.0	100	4

continued

Table 8—Area of forest land by forest-type group and detailed forest type, Virginia, 2001 (continued)

Forest-type group and detailed forest type	Forest land	Percentage of group acres	Percentage of total acres
	thousand acres		
White-red-jack pine			
Eastern white pine	207.4	65	
White pine-hemlock	60.5	19	
Eastern hemlock	50.5	16	
Total	318.4	100	2
Maple-beech-birch			
Sugar maple-beech-yellow birch	154.5	100	
Total	154.5	100	1
Nonstocked			
Nonstocked	22.3	100	
Total	22.3	100	0
Spruce-fir			
Red spruce-balsam fir	6.5	100	
Total	6.5	100	0
All groups	15,844.0		100

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

0 = a value > 0 but < 0.5 for the cell.

Table 9—Change in area of timberland by forest-type group, Virginia, 1992 to 2001

Forest-type group	Year 1992	Year 2001	Change	Change
	thousand acres	*thousand acres*	*thousand acres*	*percent*
Loblolly-shortleaf	3,103.8	3,122.4	18.6	0.6
Oak-pine	1,931.9	1,912.3	-19.6	-1.0
Oak-hickory	9,331.9	9,274.9	-57.0	-0.6
Bottomland hardwood	621.9	659.2	37.2	6.0
Other [a]	458.0	498.3	40.3	8.8
Total	15,447.5	15,467.1	19.5	0.1

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

[a] Other includes spruce-fir, maple-beech-birch, and white-red-jack pine forest-type groups as well as nonstocked.

Table 10—Change in area of loblolly-shortleaf pine stands by stand origin, Virginia, 1992 to 2001

Stand origin	Year 1992	Year 2001	Change	Change
	- - - - - - thousand acres		*- - - - - -*	*percent*
Planted	1,416.2	1,782.2	366.0	26
Natural	1,687.6	1,340.2	-347.4	-21

Table 11—Merchantable volume of live trees ≥5.0 inches d.b.h. on forest land by survey unit, Virginia, 2001

Survey unit	All species	Hardwoods	Softwoods	Forest land	Volume
	- - - - - - - - -	*million cubic feet*	*- - - - - - - - -*	*million acres*	*cubic feet per acre*
Coastal Plain	7,927.4	4,931.2	2,996.2	3.8	2,076.5
Southern Piedmont	6,652.3	4,697.0	1,955.2	3.8	1,758.0
Northern Piedmont	5,298.3	4,525.3	772.9	2.4	2,203.0
Northen Mountains	5,167.2	4,469.8	697.4	2.7	1,882.9
Southern Mountains	6,502.0	5,820.2	681.8	3.1	2,102.2
All units	31,547.1	24,443.6	7,103.5	15.8	1,991.1

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

Table 12—Number of live trees on forest land by species group, survey unit, and diameter class, Virginia, 2001

Species group and survey unit	All classes	1.0 – 2.9	3.0 – 4.9	5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0+
					Diameter class (*inches at breast height*)							
					million trees							
Hardwoods												
Coastal Plain	2,542.3	1,772.3	406.0	141.7	79.5	49.2	33.9	23.1	13.6	9.4	5.7	8.0
Southern Piedmont	2,411.8	1,652.6	379.0	148.1	84.9	52.5	36.3	23.9	16.1	9.0	4.5	4.9
Northern Piedmont	1,221.9	753.6	192.1	88.0	58.4	40.5	30.4	21.1	14.5	10.1	5.0	8.3
Northern Mountains	1,338.7	731.6	248.5	121.8	82.0	55.6	34.8	26.1	15.6	10.3	5.5	6.7
Southern Mountains	1,627.6	929.8	276.5	143.1	96.9	64.2	40.7	29.6	18.7	11.8	7.0	9.2
Total hardwoods	9,142.3	5,840.0	1,502.2	642.8	401.8	262.0	176.1	123.8	78.4	50.7	27.7	37.1
Percentage of stems in each size class		63.9	16.4	7.0	4.4	2.9	1.9	1.4	0.9	0.6	0.3	0.4
Softwoods												
Coastal Plain	767.3	298.2	172.0	123.9	81.4	45.3	21.9	10.5	6.6	3.6	2.0	1.9
Southern Piedmont	663.8	289.0	141.5	95.8	73.3	36.9	16.8	6.9	2.3	0.7	0.3	0.3
Northern Piedmont	242.6	101.3	54.2	36.1	25.1	15.4	5.7	3.1	0.9	0.3	0.2	0.5
Northern Mountains	188.7	77.8	41.8	22.9	18.2	12.9	6.8	4.4	2.1	1.1	0.3	0.4
Southern Mountains	154.3	60.7	32.4	20.8	15.7	9.5	7.4	3.6	1.8	1.4	0.3	0.7
Total softwoods	2,016.6	826.9	441.9	299.5	213.6	119.9	58.6	28.5	13.6	7.1	3.2	3.7
Percentage of stems in each size class		41.0	21.9	14.9	10.6	5.9	2.9	1.4	0.7	0.4	0.2	0.2
Total	11,158.9	6,666.9	1,944.1	942.3	615.4	381.9	234.6	152.2	92.0	57.7	30.9	40.8
Percentage of stems in each size class		59.8	17.4	8.4	5.5	3.4	2.1	1.4	0.8	0.5	0.3	0.4

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

Table 13—Change in live merchantable volume on timberland by species group and survey unit, Virginia, 1992 to 2001

Species group and survey unit	Year 1992	Year 2001	Change	Change
	- - - - - - - *million cubic feet*		- - - - - -	*percent*
Hardwoods				
Coastal Plain	4,059.5	4,664.1	604.6	15
Southern Piedmont	4,421.2	4,697.0	275.8	6
Northern Piedmont	3,999.5	4,235.8	236.3	6
Northern Mountains	4,030.3	4,249.1	218.8	5
Southern Mountains	5,378.5	5,775.9	397.4	7
Total	21,889.0	23,621.9	1,732.9	8
Softwoods				
Coastal Plain	2,491.9	2,922.3	430.4	17
Southern Piedmont	1,924.5	1,955.2	30.7	2
Northern Piedmont	945.2	756.2	-189.0	-20
Northern Mountains	726.7	686.7	-40.0	-6
Southern Mountains	635.2	677.2	42.0	7
Total	6,723.5	6,997.7	274.2	4
All species				
Coastal Plain	6,551.4	7,586.4	1,035.0	16
Southern Piedmont	6,345.8	6,652.3	306.5	5
Northern Piedmont	4,944.7	4,992.0	47.3	1
Northern Mountains	4,757.0	4,935.8	178.8	4
Southern Mountains	6,013.7	6,453.1	439.4	7
Total	28,612.6	30,619.6	2,007.0	7

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

Table 14—Area of timberland by survey unit and stand-size class, Virginia, 2001

Survey unit	All	Stand-size class: Sawtimber		Poletimber		Sapling-seedling		Nonstocked	
	thousand acres	*thousand acres*	*%*	*thousand acres*	*%*	*thousand acres*	*%*	*thousand acres*	*%*
Coastal Plain	3,715.3	1,454.3	39	1,322.0	36	939.0	25	0.0	0
Southern Piedmont	3,784.1	1,311.9	35	1,397.9	37	1,064.0	28	10.3	0
Northern Piedmont	2,270.3	1,164.7	51	798.9	35	296.2	13	10.5	0
Northern Mountains	2,625.7	1,281.8	49	1,175.3	45	167.1	6	1.5	0
Southern Mountains	3,071.6	1,725.8	56	927.2	30	418.7	14	0.0	0
All units	15,467.0	6,938.5	45	5,621.2	36	2,885.0	19	22.3	0

Numbers in rows and columns may not sum to totals due to rounding.
0.0 = a value of > 0.0 but < 0.05 for the cell; 0 = a value > 0 but < 0.5 for the cell.

Table 15—Area of timberland[a] by ownership class and stand-size class, Virginia, 1992 and 2001

Ownership class and stand-size class	Year: 1992		2001	
	thousand acres	*%*	*thousand acres*	*%*
Forest industry				
Sapling-seedling	564.6	37	358.8	35
Poletimber	506.0	33	408.2	40
Sawtimber	442.6	29	252.3	25
All	1,513.2	100	1,019.3	100
National forest				
Sapling-seedling	124.5	9	108.4	7
Poletimber	497.7	34	641.0	39
Sawtimber	841.1	57	899.3	55
All	1,463.3	100	1,648.7	100
Nonindustrial private				
Sapling-seedling	2,274.1	19	2,373.3	20
Poletimber	3,576.0	30	4,330.8	36
Sawtimber	6,005.9	51	5,376.1	44
All	11,856.0	100	12,080.2	100
Other public				
Sapling-seedling	70.9	14	44.5	6
Poletimber	130.3	25	241.1	35
Sawtimber	309.8	61	410.8	59
All	511.0	100	696.4	100

Numbers in columns may not sum to totals due to rounding.
[a] Does not include acres of nonstocked stands.

Table 16—Area of timberland by stand-age class, Virginia, 2001

Stand-age class	Timberland	
years	*thousand acres*	*percent*
0–20	3,801.8	25
21–40	2,724.6	18
41–60	3,038.5	20
61–80	3,484.6	23
81+	2,417.5	16
Total	15,467.0	100

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

Table 17—Percentage of timberland by ownership class and stand-age class, Virginia, 1992 and 2001

Ownership class and stand-age class	1992	2001
	percent	
Forest industry		
0–20	49	51
21–40	23	23
41–60	11	9
61–80	11	11
81+	7	7
National forest		
0–20	7	6
21–40	6	8
41–60	13	8
61–80	36	34
81+	37	46
Nonindustrial private		
0–20	23	26
21–40	18	19
41–60	27	22
61–80	22	22
81+	11	12
Other public		
0–20	19	13
21–40	15	16
41–60	25	24
61–80	23	27
81+	19	20

Table 18—Top 50 tree species dominant for volume on forest land, Virginia, 2001

Species[a]	Volume[b]	Total[c]
	mcf	*percent*
Yellow-poplar	5,532.9	13.0
Loblolly pine	4,721.4	11.1
Chestnut oak	3,810.9	9.0
White oak	3,728.8	8.8
Red maple	3,413.3	8.0
Northern red oak	2,152.1	5.1
Virginia pine	1,983.9	4.7
Sweetgum	1,691.5	4.0
Scarlet oak	1,438.9	3.4
Black oak	1,256.0	3.0
Eastern white pine	905.7	2.1
Pignut hickory	878.4	2.1
Mockernut hickory	859.0	2.0
American beech	764.0	1.8
Southern red oak	708.2	1.7
Blackgum	672.0	1.6
White ash	485.8	1.1
Sugar maple	461.7	1.1
Shortleaf pine	442.1	1.0
Sourwood	405.5	1.0
Sweet birch	398.9	0.9
Black locust	394.6	0.9
Black cherry	390.8	0.9
Eastern redcedar	297.0	0.7
American sycamore	271.7	0.6
Pitch pine	269.0	0.6
American basswood	248.6	0.6
Eastern hemlock	249.7	0.6
Swamp tupelo	243.7	0.6
Willow oak	197.9	0.5
Green ash	186.4	0.4
Black walnut	172.6	0.4
American holly	166.6	0.4
Bitternut hickory	158.3	0.4
Flowering dogwood	158.0	0.4
Shagbark hickory	156.8	0.4
River birch	154.1	0.4
Sassafras	141.9	0.3
Post oak	127.4	0.3
Cucumbertree	126.6	0.3
American hornbeam	115.3	0.3

continued

Table 18—Top 50 tree species dominant for volume on forest land, Virginia, 2001 (continued)

Species[a]	Volume[b]	Total[c]
	mcf	*percent*
American elm	107.0	0.3
Swamp chestnut oak	103.2	0.2
Table Mountain pine	100.8	0.2
Yellow buckeye	87.9	0.2
Baldcypress	84.4	0.2
Ailanthus	83.8	0.2
Cherrybark oak	78.7	0.2
Water oak	65.9	0.2
Mountain magnolia	61.8	0.2

[a] Scientific names can be referenced in species list in appendix table C.1.

[b] Values are net cubic volume in million cubic feet for all live trees ≥1.0 inch d.b.h.

[c] Values are percentage of total volume.

Table 19—Top 15 tree species dominant for dead volume on forest land, Virginia, 2001

Species[a]	Volume[b]	Total[c]
	mcf	*percent*
Chestnut oak	271.6	12.5
Virginia pine	248.9	11.4
Black locust	226.6	10.4
Northern red oak	167.4	7.7
White oak	144.1	6.6
Scarlet oak	142.2	6.5
Loblolly pine	129.0	5.9
Black oak	100.9	4.6
Yellow-poplar	82.9	3.8
Pitch pine	65.6	3.0
Eastern white pine	64.6	3.0
Red maple	54.9	2.5
Table Mountain pine	41.7	1.9
Shortleaf pine	30.4	1.4
Sassafras	28.2	1.3

[a] Scientific names can be referenced in species list in appendix table C.1.

[b] Values are net cubic volume in million cubic feet for all live trees ≥5.0 inch d.b.h.

[c] Values are percentage of total volume.

Table 20—Top 10 tree species dominant for total live volume on forest land by survey unit, Virginia, 2001

Species[a]	Coastal Plain	Southern Piedmont	Northern Piedmont	Northern Mountains	Southern Mountains
			Volume (*million cubic feet*)		
Yellow-poplar	1,011.8	1,451.8	1,370.6	345.2	1,353.4
Loblolly pine	3,343.9	1,073.9	284.1	9.3	10.2
Chestnut oak	71.1	464.1	564.1	1,663.0	1,048.6
White oak	835.2	911.6	869.9	686.1	426.0
Red maple	1,032.8	723.9	448.0	442.8	765.9
Northern red oak	119.6	300.5	368.8	685.5	677.6
Virginia pine	274.1	938.4	485.2	174.7	111.4
Sweetgum	1,117.8	414.7	152.6	0.0	6.4
Scarlet oak	173.5	209.2	231.3	449.1	375.8
Black oak	171.8	186.7	209.6	334.1	353.9
			Percentage of total unit volume		
Yellow-poplar	9.4	15.7	19.7	5.0	15.7
Loblolly pine	31.0	11.6	4.1	0.1	0.1
Chestnut oak	0.7	5.0	8.1	24.0	12.2
White oak	7.8	9.9	12.5	9.9	5.0
Red maple	9.6	7.8	6.5	6.4	8.9
Northern red oak	1.1	3.3	5.3	9.9	7.9
Virginia pine	2.5	10.2	7.0	2.5	1.3
Sweetgum	10.4	4.5	2.2	0.0	0.1
Scarlet oak	1.6	2.3	3.3	6.5	4.4
Black oak	1.6	2.0	3.0	4.8	4.1
			Percentage of total species volume in unit		
Yellow-poplar	18.3	26.2	24.8	6.2	24.5
Loblolly pine	70.8	22.7	6.0	0.2	0.2
Chestnut oak	1.9	12.2	14.8	43.6	27.5
White oak	22.4	24.4	23.3	18.4	11.4
Red maple	30.3	21.2	13.1	13.0	22.4
Northern red oak	5.6	14.0	17.1	31.9	31.5
Virginia pine	13.8	47.3	24.5	8.8	5.6
Sweetgum	66.1	24.5	9.0	0.0	0.4
Scarlet oak	12.1	14.5	16.1	31.2	26.1
Black oak	13.7	14.9	16.7	26.6	28.2

0.0 = a value of >0.0 but <0.05 for the cell.

[a] Scientific names can be referenced in species list in appendix table C.1.

Table 21—Top 50 tree species dominant for number of stems on forest land, Virginia, 2001

Species[a]	Number[b]	Total[c]	Species[a]	Number[b]	Total[c]
	thousand trees	*percent*		*thousand trees*	*percent*
Red maple	1,474,721.4	13.2	White ash	133,154.6	1.2
Loblolly pine	958,800.4	8.6	Sweet birch	111,805.5	1.0
Yellow-poplar	782,059.1	7.0	Eastern redbud	111,273.6	1.0
Sweetgum	767,466.7	6.9	Striped maple	77,585.7	0.7
Blackgum	653,005.6	5.9	Serviceberry	74,853.6	0.7
Virginia pine	490,288.7	4.4	Eastern hemlock	67,675.3	0.6
Flowering dogwood	489,665.2	4.4	Green ash	55,252.5	0.5
White oak	467,180.6	4.2	Ailanthus	54,296.5	0.5
Chestnut oak	366,724.5	3.3	Water oak	48,765.0	0.4
American holly	330,451.1	3.0	Willow oak	46,112.3	0.4
Sourwood	325,014.4	2.9	Shortleaf pine	45,868.8	0.4
American hornbeam	251,137.4	2.3	American elm	44,337.6	0.4
Eastern redcedar	228,940.9	2.1	Winged elm	42,009.4	0.4
Mockernut hickory	221,720.0	2.0	Swamp tupelo	38,337.6	0.3
Black cherry	221,032.5	2.0	River birch	35,272.6	0.3
American beech	211,742.7	1.9	Post oak	34,441.5	0.3
Eastern white pine	176,312.7	1.6	American basswood	34,361.5	0.3
Scarlet oak	165,817.5	1.5	Sweetbay	32,616.7	0.3
Pignut hickory	164,910.0	1.5	hophornbeam	31,879.7	0.3
Northern red oak	164,833.3	1.5	Pitch pine	29,579.7	0.3
Southern red oak	151,408.8	1.4	Mountain magnolia	24,658.0	0.2
Sassafras	141,265.2	1.3	Hawthorn	24,452.9	0.2
Sugar maple	140,989.9	1.3	Common persimmon	23,810.2	0.2
Black oak	140,559.5	1.3	Bitternut hickory	22,777.5	0.2
Black locust	133,863.8	1.2	Cucumbertree	21,945.8	0.2

[a] Scientific names can be referenced in species list in appendix table C.1.

[b] Values are for all live trees ≥ 1.0 inch d.b.h.

[c] Values are percentage of total volume.

Table 22—Change in merchantable live volume and number of stems on timberland for the top 10 species, Virginia, 1992 to 2001

Species[a b]	Year 1992	Year 2001	Change	Change
	- - - **Volume** (*million cubic feet*) - - -			*percent*
Yellow-poplar	3,548.9	4,493.2	944.3	26.6
Loblolly pine	3,002.1	3,675.2	673.1	22.4
Chestnut oak	2,811.4	2,823.4	12.0	0.4
White oak	2,891.1	2,813.2	-78.0	-2.7
Red maple	1,773.6	2,031.8	258.2	14.6
Northern red oak	1,487.1	1,568.5	81.4	5.5
Virginia pine	1,852.7	1,496.9	-355.7	-19.2
Sweetgum	966.7	1,126.1	159.3	16.5
Scarlet oak	1,146.2	1,085.9	-60.2	-5.3
Black oak	904.9	963.3	58.4	6.4
	- - - **Stems** (*thousand trees*) - - -			*percent*
Yellow-poplar	191,656.0	217,407.5	25,751.4	13.4
Loblolly pine	384,977.1	424,120.3	39,143.2	10.2
Chestnut oak	215,609.0	210,342.4	-5,266.6	-2.4
White oak	193,450.0	166,888.7	-26,561.4	-13.7
Red maple	198,619.0	216,489.4	17,870.4	9.0
Northern red oak	70,695.0	69,046.7	-1,648.3	-2.3
Virginia pine	217,884.0	155,692.7	-62,191.3	-28.5
Sweetgum	99,628.0	105,077.3	5,449.3	5.5
Scarlet oak	92,736.0	77,354.9	-15,381.1	-16.6
Black oak	57,413.0	54,090.6	-3,322.4	-5.8

[a] Top 10 species based on volume, 2001.

[b] Scientific names can be referenced in species list in appendix table C.1.

Table 23—Average net annual growth, removals, and mortality on timberland by component, species group, and survey unit, Virginia, 1992–2000

Component and species group	All classes	Survey unit: Coastal Plain	Southern Piedmont	Northern Piedmont	Northern Mountains	Southern Mountains
	million cubic feet					
Growth						
Softwoods	327.2	176.1	105.9	32.8	-2.1	14.4
Hardwoods	662.9	149.8	165.4	117.3	79.8	150.6
Total	990.0	325.9	271.3	150.1	77.8	165.0
Removals						
Softwoods	298.7	135.3	91.7	44.4	7.8	19.5
Hardwoods	399.2	112.1	120.7	49.4	37.5	79.5
Total	697.9	247.4	212.3	93.8	45.4	99.0
Mortality						
Softwoods	119.4	29.1	31.2	19.7	25.6	13.8
Hardwoods	214.1	33.7	35.6	45.3	45.6	54.0
Total	333.6	62.8	66.8	65.0	71.2	67.8

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

Table 24—Average net annual growth, removals, and mortality on timberland by component, species group, and ownership class, Virginia, 1992–2000

Component and species group	All classes	Ownership class: Public	Ownership class: Forest industry	Ownership class: Nonindustrial private
	million cubic feet			
Growth				
Softwoods	327.2	7.9	60.4	258.9
Hardwoods	662.9	72.0	31.0	559.9
Total	990.0	79.8	91.4	818.8
Removals				
Softwoods	298.7	6.7	52.8	239.2
Hardwoods	399.2	22.0	34.8	342.3
Total	697.9	28.7	87.7	581.6
Mortality				
Softwoods	119.4	26.6	5.2	87.6
Hardwoods	214.1	52.1	6.9	155.2
Total	333.6	78.6	12.1	242.8

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

Table 25—Average net annual growth, removals, and mortality on timberland by forest-type group, Virginia, 1992–2000

Forest-type group	Growth	Removals	Mortality
	million cubic feet		
Oak-hickory	521.6	333.7	192.1
Loblolly-shortleaf pine	305.2	256.4	80.2
Oak-pine	97.9	67.2	37.3
Oak-gum-cypress	23.2	15.8	9.9
White-red-jack pine	20.2	16.8	4.5
Elm-ash-cottonwood	13.2	2.5	6.6
Other[a]	8.8	5.6	3.1
All groups	990.0	697.9	333.6

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

[a] Other includes maple-beech-birch, unknown, and nonstocked.

Table 26—Average net annual growth, removals, and mortality of growing stock per acre on timberland by ownership class, Virginia, 1986–1991 and 1992–2000

Ownership class	1986–1991 Net growth	1986–1991 Removals	1986–1991 Mortality	1992–2000 Net growth	1992–2000 Removals	1992–2000 Mortality
	cubic feet per acre per year					
Public	44.02	18.05	14.52	34.18	11.55	27.83
Forest industry	78.03	70.71	6.56	87.97	83.09	9.31
Nonindustrial private	53.75	38.11	11.49	64.29	45.87	16.38
All classes	54.92	38.78	11.39	61.28	43.13	17.65

Table 27—Area of timberland disturbed by cause or agent of damage, Virginia, 2001

Cause or agent	Timberland	
	thousand acres	*percent*
Weather	1,041.3	6.7
Insect	463.4	3.0
Disease	97.2	0.6
Fire	105.9	0.7
Grazing	262.1	1.7
Wild animals	199.8	1.3

Table 28—Area of gypsy moth defoliation, Virginia[a], 1997 to 2002

Year	Area
	thousand acres
1997 to 1999[b]	0.0
2000	71.2
2001	440.7
2002	51.8
Total	563.7

[a] Based on aerial sketch mapping and aerial photo interpretation.

[b] Defoliation too sparse to meet aerial mapping threshold.

Source: Virginia Department of Forestry (2005).

Table 29—Number of plants evaluated for ozone-induced foliar injury by species, Virginia, 1997 to 2002

		Year						
Species[a]	Total	1997	1998	1999	2000	2001	2002	Average species index
	number							
Big leaf aster								0.0
Evaluated	10	—	—	—	—	—	10	
Injured	0	—	—	—	—	—	0	
Black cherry								0.0
Evaluated	767	—	61	74	120	174	338	
Injured	2	—	0	0	0	2	0	
Blackberry								17.9
Evaluated	2,307	193	339	408	192	708	467	
Injured	284	38	142	37	16	50	1	
Milkweed								0.0
Evaluated	468	—	30	33	40	103	262	
Injured	1	—	0	0	0	1	0	
Sassafras								2.5
Evaluated	787	80	80	131	100	203	193	
Injured	18	17	0	0	0	1	0	
Spreading dogbane								3.7
Evaluated	304	—	30	18	—	118	138	
Injured	3	—	0	0	—	3	0	
Sweetgum								16.8
Evaluated	1,133	43	162	216	314	248	150	
Injured	136	0	25	10	71	30	0	
White ash								0.0
Evaluated	177	—	46	—	81	—	50	
Injured	0	—	0	—	0	—	0	
Yellow-poplar								0.7
Evaluated	1,536	50	229	388	275	382	212	
Injured	19	0	7	2	10	0	0	
All								8.2
Evaluated	7,489	366	977	1,268	1,122	1,936	1,820	
Injured	463	55	174	49	97	87	1	

— = no sample for the cell.

[a] Scientific names can be referenced in species list in appendix table C.3.

Table 30—Summary of ozone biosite data for Virginia, 1997 to 2002

Year	Biosites	Sites with injury	Biosite index by category[a] 1	2	3	4	Average biosite index[b]
		- - - - - - - -	*number*	- - - - - - - -			
1997	9	3	6	1	—	2	11.0 (6.5)
1998	16	7	9	1	—	6	22.1 (8.7)
1999	26	6	22	4	—	—	1.8 (0.8)
2000	25	10	17	1	3	4	20.8 (11.4)
2001	30	11	23	5	2	—	3.1 (1.0)
2002	24	1	23	1	—	—	0.3 (0.3)

— = no value for the cell.

[a] For corresponding biosite index values see table 31.

[b] Values in parentheses represent one standard error of the mean.

Table 31—Classification scheme for the FIA ozone biosite index

Category	Biosite index	Bioindicator response
1	0–4.9	Little or no injury
2	5.0–14.9	Light-to-moderate injury
3	15.0–24.9	Moderate-to-severe injury
4	> 25	Severe foliar injury

Source: Smith and others (2003).

Table 32—Distribution of P3[a] plots by percentage of crown dieback, foliage transparency, and crown density by survey unit, Virginia, 1997 to 2001

Survey unit	Plots	Crown dieback (*percent*) 0 – 7.5	7.6 – 15.0	> 15.0	Foliage transparency (*percent*) 0 – 30.0	31.0 – 50.0	> 50.0	Crown density (*percent*) 0 – 20.0	21.0 – 50.0	> 50.0
	n	- - - - - - - -	- - - - - - - -	- - - - - - - -	*percentage of plots sampled*	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -
Coastal Plain	23	100	0	0	100	0	0	0	74	26
Southern Piedmont	30	97	3	0	100	0	0	0	63	37
Northern Piedmont	16	94	0	6	100	0	0	0	63	38
Northern Mountains	22	86	14	0	100	0	0	0	50	50
Southern Mountains	19	100	0	0	95	5	0	0	53	47
All units	110	95	4	1	99	1	0	0	61	39

[a] Only includes plots with more than five live trees ≥ 5.0 inches d.b.h.

Table 33—Distribution of tree species ≥ 5.0 inches d.b.h by percentage of crown dieback, foliage transparency, and crown density on P3 plots, Virginia, 1997 to 2001

			Crown dieback *(percent)*			Foliage transparency *(percent)*			Crown density *(percent)*		
Species	Trees (or stems)	Plots	0 – 7.5	7.6 – 15.0	> 15.0	0 – 30.0	31.0 – 50.0	> 50.0	0 – 20.0	21.0 – 50.0	> 50.0
	- - - *number* - - -		- - - *percentage of trees sampled* - - -								
Loblolly pine	560	27	100	0	0	98	2	0	1	86	13
Chestnut oak	306	36	80	15	5	96	3	1	2	64	34
Yellow-poplar	267	60	90	9	2	99	1	0	0	52	48
Virginia pine	242	26	96	3	1	79	20	1	3	87	10
Red maple	232	61	88	7	4	97	1	1	2	54	44
White oak	166	47	86	10	4	96	1	2	2	63	36
Sweetgum	124	31	85	10	5	98	1	2	2	62	36
Mockernut hickory	87	31	91	9	0	98	1	1	1	55	44
Northern red oak	78	31	74	21	5	94	4	3	1	68	31
Black oak	68	32	82	12	6	99	1	0	3	60	37
Scarlet oak	64	23	59	30	11	98	2	0	2	66	33
Eastern white pine	54	9	91	9	0	83	13	4	4	67	30
Blackgum	50	24	86	12	2	98	0	2	4	48	48
Southern red oak	49	18	84	14	2	100	0	0	0	76	24
Black cherry	43	21	84	14	2	98	2	0	0	72	28
Sourwood	41	13	68	15	17	93	5	2	5	46	49
Pignut hickory	38	21	100	0	0	97	3	0	0	50	50
Hickory	32	10	94	3	3	97	3	0	0	34	66
Sugar maple	31	7	84	10	6	97	0	3	3	29	68
American beech	30	11	97	3	0	100	0	0	0	33	67
Shortleaf pine	29	12	97	3	0	97	3	0	0	93	7
Black locust	23	11	83	9	9	87	9	4	0	70	30
Sweet birch	21	10	86	10	5	95	0	5	5	38	57
Eastern redcedar	18	14	100	0	0	94	6	0	0	67	33
Willow oak	18	7	89	11	0	100	0	0	0	78	22
Green ash	17	9	82	18	0	94	6	0	6	71	24
Other softwoods	35	10	89	9	3	80	20	0	6	80	14
Other hardwoods	151	53	83	13	4	96	1	3	1	62	37

Table 34—Crown vigor class ratings for saplings (1.0–4.9 inches d.b.h.) on P3 plots[a] by species, Virginia, 1997 to 2001

Species	All	Crown vigor class 1	2	3
	number of trees tallied			
Red maple	110	81	25	4
Loblolly pine	96	78	18	0
Sweetgum	66	59	7	0
Blackgum	53	33	16	4
Flowering dogwood	47	22	21	4
Mockernut hickory	44	37	6	1
Sourwood	23	16	6	1
Yellow-poplar	22	16	5	1
Eastern redcedar	20	16	4	0
Shortleaf pine	19	12	7	0
American beech	17	17	0	0
Pignut hickory	17	16	1	0
Black cherry	16	12	4	0
White oak	15	13	2	0

[a] Includes only species with at least 15 stems tallied.

Table 35—Average percent crown dieback, foliage transparency, and crown density on P3 plots[a] by year, Virginia, 1991 to 1995, and 2001

Year	Plots	Crown dieback	Foliage transparency	Crown density
	n	- - - - - - - - - - *percent*	- - - - - - - - - -	
1991	79	4.2	16.0	48.6
1992	79	5.9	10.0	47.6
1993	79	4.2	14.2	50.5
1994	79	2.5	9.1	47.4
1995	79	5.2	11.5	49.5
2001	79	2.8	20.0	47.4
All	79	4.1	13.5	48.5

[a] Includes only plots that were measured six times.

Table 36—Top eight damages recorded on live trees ≥ 5.0 inches d.b.h. on P3 plots, Virginia, 1997 to 2001

Damage	*n*[a]	*percent*
Conks/fruiting bodies/decay	226	52
Loss of apical dominance, dead terminal	54	12
Canker, gall	46	11
Vines in crown	43	10
Open wounds	16	4
Broken/dead branches	16	4
Cracks/seams	15	3
Damaged foliage/buds/shoots	7	2
Subtotal	423	97
All damages recorded	438	100

[a] *n* = number of times a particular damage was recorded. Up to three may be recorded per tree.

Table 37—Damage information for live trees ≥ 5.0 inches d.b.h. on P3 plots, Virginia, 1997 to 2001

Species	Damaged trees[a]	Live trees	Damaged trees/ live trees
	- - - - *number* - - - -		*percent*
Sourwood	15	41	37
Black locust	8	23	35
Northern red oak	21	78	27
Black oak	19	72	26
Sugar maple	6	31	19
White oak	32	167	19
Southern red oak	9	49	18
Mockernut hickory	16	89	18
American beech	5	30	17
Black cherry	7	43	16
Red maple	33	233	14
Sweetgum	17	124	14
Chestnut oak	41	306	13
Cucumbertree	2	15	13
Pignut hickory	5	38	13
Yellow-poplar	33	267	12
Green ash	2	17	12
Eastern white pine	6	54	11
Virginia pine	25	242	10
Blackgum	5	50	10
Scarlet oak	6	64	9
Willow oak	1	18	6
Sweet birch	1	21	5
Loblolly pine	22	563	4
Shortleaf pine	1	29	3

[a] Trees with damage only counted once, even if they had more than one damage listed.

Table 38—Volume of live, standing dead, and coarse woody debris by survey unit, Virginia, 2001[a]

Survey unit	Live[b]	Standing dead[c]	CWD[d]
		cubic feet per acre	
Coastal Plain	2,704.7	83.9	358.0
Southern Piedmont	2,326.4	75.3	317.7
Northern Piedmont	2,808.0	188.0	242.5
Northern Mountains	2,455.7	237.7	856.2
Southern Mountains	2,705.2	151.8	355.9
All	2,587.0	137.5	407.2

CWD = coarse woody debris.

[a] Data for live and standing dead from P2 plots and data for CWD from P3 plots

[b] ≥ 3.0 inches d.b.h.

[c] ≥ 5.0 inches d.b.h.

[d] Diameter ≥ 3.0 inches and length ≥ 3.0 feet.

Table 39—Biomass of coarse woody debris, fine woody debris, duff, litter, and slash on P3 plots by survey unit, Virginia, 2001 to 2003

Survey unit	Plots	CWD	Fine woody debris 1–hr	Fine woody debris 10–hr	Fine woody debris 100–hr	Duff	Litter	Slash	Total
	n				*tons per acre*				
Coastal Plain	24	2.1	0.2	0.7	1.9	11.3	5.4	0.3	21.9
Southern Piedmont	25	2.4	0.2	0.6	1.3	8.0	4.3	0.4	17.2
Northern Piedmont	16	2.1	0.1	0.4	1.6	10.1	3.2	7.4	24.8
Northern Mountains	16	3.2	0.1	0.5	1.4	11.0	1.9	1.4	19.5
Southern Mountains	22	2.9	0.2	0.5	1.7	11.9	2.4	1.0	20.5
All	103	2.5	0.2	0.6	1.6	10.4	3.6	1.8	20.6

CWD = coarse woody debris.

Table 40—Density of live, standing dead, and coarse woody debris by survey unit, Virginia, 2001[a]

Survey unit	Live[b]	Standing dead[c]	CWD[d]
		stems per acre	
Coastal Plain	324.6	7.8	136.3
Southern Piedmont	299.7	8.1	134.5
Northern Piedmont	253.5	13.9	145.3
Northern Mountains	261.6	17.1	122.2
Southern Mountains	255.9	14.8	151.1
All	283.5	11.8	138.2

CWD = coarse woody debris.

[a] Data for live and standing dead from P2 plots and data for CWD from P3 plots

[b] ≥ 3.0 inches d.b.h.

[c] ≥ 5.0 inches d.b.h.

[d] Diameter ≥ 3.0 inches and length ≥ 3.0 feet,

Table 41—Average lichen species richness by year on P3 plots, Virginia

Year	Plots	Species richness[a]
	n	
1994	13	10.5 (3.8)
1995	22	14.7 (5.3)
1998	27	10.2 (6.1)
1999	34	7.7 (3.8)

[a] Values in parenthesis represent the standard deviation.

Table 42—Average lichen climate gradient scores for Virginia and the southeastern gradient region, 1994, 1998, and 1999

Parameter	Virginia	Southeastern gradient region
Number of plots surveyed	53	268
Number of plots by climate index category [a]		
Most coastal, southern, warmest: index value < 25	1	57
Warm: index value 25–50	6	76
Cool: index value 50–75	19	90
Most mountainous, northern, coolest: index value > 75	27	45
Average score on climate index	72.73	48.14
Standard deviation of climate index scores	20.56	27.71
Range of climate index scores	-6.99–112.90	-10.99–114.12

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

Table 43—Average lichen air quality scores for Virginia and the southeastern gradient region, 1994, 1998, and 1999

Parameter	Virginia	Southeastern gradient region
Number of plots surveyed	53	268
Number of plots by air quality index category [a]		
Lowest (poorest): index value < 40	24	87
Intermediate: index value 40–80	27	137
Highest (best): index value > 80	2	44
Average score on air quality index	40.03	52.64
Standard deviation of air quality index scores	20.73	25.04
Range of air quality index scores	2.01–113.48	-0.70–115.41

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

Table 44—pH, soil moisture, organic carbon, and total nitrogen for soils from P3 plots, by layer and survey unit, Virginia, 2000 to 2002

Layer and survey unit	Plots	pH[a]	Soil moisture[b]	Organic carbon	Total nitrogen
	n		- - - - - - - - - *percent* - - - - - - - - -		
Forest floor					
Coastal Plain	23	NA	151	38.6	1.20
Southern Piedmont	25	NA	177	32.7	1.10
Northern Piedmont	15	NA	175	35.6	1.30
Northern Mountains	17	NA	157	36.8	1.40
Southern Mountains	19	NA	178	32.7	1.40
All	99	NA	168	35.2	1.30
M1					
Coastal Plain	19	4.4	27	2.0	0.09
Southern Piedmont	21	5.1	37	2.3	0.14
Northern Piedmont	14	4.8	46	3.0	0.16
Northern Mountains	7	4.6	63	5.1	0.28
Southern Mountains	15	4.8	50	3.4	0.22
All	76	4.8	41	2.8	0.16
M2					
Coastal Plain	19	4.7	27	1.0	0.06
Southern Piedmont	20	5.1	27	0.8	0.05
Northern Piedmont	14	4.8	31	0.8	0.05
Northern Mountains	7	4.5	39	1.5	0.10
Southern Mountains	14	4.8	42	1.8	0.12
All	74	4.9	32	1.1	0.07

NA = not applicable; M1 = mineral layer 1 (0–4 inches); M2 = mineral layer 2 (4–8 inches).

[a] Active acidity via H_2O method.

[b] Dry weight basis.

Table 45—Exchangeable cations in mineral soil on P3 plots by layer and survey unit, Virginia, 2000 to 2002

Layer and survey unit	Plots	Exchangeable cations Na	K	Mg	Ca	Al	ECEC	Extractable S
	n	- - - - - - -	- - - -	*mg/kg*	- - - -	- - - - - - -	*cmol$_c$/kg*	*mg/kg*
M1								
Coastal Plain	18	7.7	44.8	46.1	157.5	166.8	3.2	12.9
Southern Piedmont	21	6.0	80.2	141.3	584.1	69.9	5.1	17.7
Northern Piedmont	14	6.4	125.6	89.0	532.6	145.8	5.4	19.3
Northern Mountains	7	9.3	112.6	80.3	614.4	179.6	6.1	20.3
Southern Mountains	15	10.3	117.2	102.8	465.6	223.5	6.0	21.1
All	75	7.7	90.0	94.6	447.4	148.5	4.9	17.7
M2								
Coastal Plain	19	7.0	47.8	36.8	85.0	154.4	2.6	11.1
Southern Piedmont	20	4.8	51.8	88.4	269.7	63.2	2.9	18.7
Northern Piedmont	14	5.3	60.6	30.1	103.5	154.5	2.7	20.3
Northern Mountains	7	4.3	54.0	41.0	122.6	212.1	3.5	12.7
Southern Mountains	14	6.2	78.6	61.4	208.4	203.9	4.0	20.9
All	74	5.7	57.7	54.5	165.3	144.6	3.1	16.9

Na = sodium; K = potassium; Mg = magnesium; Ca = calcium; Al = aluminum; ECEC = effective cation exchange capacity; S = sulfur; M1 = mineral layer 1 (0–4 inches); M2 = mineral layer 2 (4–8 inches).

Table 46—Mass of carbon in down woody material, forest floor, and mineral soil on P3 plots by survey unit, Virginia, 2000 to 2002

Survey unit	Down woody material CWD	FWD	Forest floor Litter and humus	Mineral soil M1	M2
			tons of carbon per acre		
Coastal Plain	1.1	1.4	4.9	8.4	4.5
Southern Piedmont	1.2	1.0	3.5	10.3	5.2
Northern Piedmont	1.0	1.0	3.6	13.0	5.1
Northern Mountains	1.6	1.0	10.6	15.2	8.0
Southern Mountains	1.5	1.2	5.1	13.5	8.0
All	1.3	1.2	5.3	11.4	5.8

CWD = coarse woody debris; FWD = fine woody debris; M1 = mineral layer 1 (0–4 inches); M2 = mineral layer 2 (4–8 inches).

The inventory design and methods used to collect and process the information needed to derive the current forest resource estimates for the 2001 survey of Virginia have undergone substantial change since the previous survey conducted in 1992. These changes necessitate the use of caution when making rigorous comparisons between forest resource assessments.

The current inventory is a 3-phase, fixed-plot design conducted on an annual basis. Phase 1 (P1) provides the area estimates for the inventory. Phase 2 (P2) involves on the ground measurements of sample plots by field personnel. Phase 3 (P3) is a subset of the P2 plot system where additional measurements are made by field personnel to assess forest health indicators.

Sample Design Overview: Annual versus Periodic

The current survey's sample design differs in several ways from the one employed previously. One change involved switching from a periodic survey to an annual survey. Another involved switching from a variable-radius sample to a fixed-plot sample. These changes, alone or in combination, weaken comparisons between surveys. The only way to quantify the true impact of such changes on trend analysis would be to conduct the survey using both plot designs simultaneously and compare the results of these two independent surveys. Neither the time nor money was available to do this.

Previous surveys of Virginia were periodic; all of the plots were measured in about 1 to 2 years, and the time between remeasurements averaged 7 to 10 years. The current, annual inventory design was implemented to provide more up-to-date information about forest resources. Under the annual inventory system, 20 percent (one panel) of the total number of plots in a State are measured every year over a 5-year period (one cycle). Each panel of plots is selected on a subgrid which is slightly offset from the previous panel, so that each panel covers essentially the same sample area (both spatially and in intensity) as the prior panel. In the sixth year the plots that were measured in the first panel are remeasured. This marks the beginning of the next cycle of data collection. After field measurements are completed, a cycle of data is available for the 5-year report. This dataset consists of data from < 1 year old to 5 years old.

One of the major impacts on data interpretation and analysis of switching to the annual inventory design is the length of time for data collection (5 years, versus 1 or 2 years). Data collected over a longer period of time have a higher probability of sampling a specific event, e.g., a hurricane or fire, but with only a small proportion of the sample. Data collected over a shorter time span (such as data collected in the periodic survey), however, may miss an event entirely until the next periodic measurement takes place, at which time all the sample plots reflect the event.

Sample Design Phases

Current P1—The three phases of the current sampling method are based on a hexagonal-grid design, with successive phases being sampled with less intensity. There are 16 P2 hexagons for every P3 hexagon. P2 and 3 hexagons represent about 6,000 acres and 96,000 acres, respectively.

For the 2001 inventory of Virginia the P1 forest area estimate was based on classifying points on a 25-point grid that was laid over each P2 sample plot location on an aerial photo. Each point represented about 222 acres. A photo interpreter classified each point as either forest or nonforest and a percentage for each class was derived for each county of the State. The forest area for each county was then determined by multiplying the percentage of forested dots by the Census Bureau's estimate of all land area for that county (U.S. Department of Commerce, Census Bureau 2000). Field personnel performed ground truthing at each P2 sample location and one additional location. Any incorrect classifications were used to adjust the forest percentage derived from the original P1 estimate. These correction factors adjust for possible misinterpretation of aerial photos and for real changes on the ground which may have occurred since the date of the aerial photography. Plot-level expansion factors were determined by dividing the number of forested plots into the total forest land area.

The designers of the new hex-grid layout intended that only one P2 plot would be located in each hex cell. This was to ensure that the sampling intensity would be the same in all FIA regions across the United States. In switching from the previous design system to the hex grid, as many existing plot locations as possible were retained. However, hexagons containing no prior survey plots had a new plot located within a certain distance from the hexagon center. If two or more plots from a prior survey existed within the same hexagon, then the additional plots were dropped from the inventory. Between the 1992 and 2001 survey, 2,955 plots (1,834 forested and 1,121 nonforested plots) were not retained (appendix table A.1).

Previous P1—The significant difference between the 1992 and 2001 P1 estimation procedures is that many more points were classified to estimate forest area in 1992. At that time, a grid of 25 clusters of 16 points each was laid over each photo. Therefore, 1,258,704 points were classified in 1992 and 125,000 points were classified in 2001. The number of classification points was higher in 1992 both because more points were counted for each P2 plot in 1992 and because more P2 plots were measured in 1992. The end result is the potential for the 2001 survey area estimates to have a higher sampling error.

Change in Assessing National Forest and Reserved Lands

Current—Under the annual inventory system, area estimation of all lands and ownerships was based on the probability of selection of P2 plot locations. There was no enumeration of any ownership (no use of known areas of ownership to determine area and plot expansion factors). As a result, the known forest land area (for specific ownerships) does not always agree with area estimates based on probability of selection. For example, the acreage of national forests, published by the National

Appendix table A.1—Number of plots remeasured, dropped, and added during the current and previous cycle, Virginia

Item	Remeasured 1992	Remeasured 2001	Dropped 1992	Dropped 2001	New 1992	New 2001	Plots 1992	Plots 2001
				number				
Nonforest	2,661	1,295	—	1,121	—	19	2,661	1,295
Forest [a]	4,627	3,062	26	1,834	24	28	4,651	3,090
Total	7,288	4,357	26	2,955	24	47	7,312	4,404

[a] Includes plots that were forested at T1 and T2, as well as plots that were forested only at T1 (diversions) and those that were forested only at T2 (reversions).

Forest System, will not agree exactly with the statistical estimate of national forest land derived by FIA. These numbers could differ substantially for very small areas.

Previous—Prior to the 2001 Virginia survey, all national forest and public agency forest lands (timberland and reserved) plus forest industry timberland in a county were enumerated. The enumerated or known acreages were taken from public agency reports and other public domain documents at the State and county level. The enumerated forest area in each county was divided by the number of sample locations for each enumerated owner class to derive expansion factors. The enumerated forest areas were subtracted from the total forest area derived for the county from P1 and the remaining forested plots were divided into this area to derive the expansion factors for the nonenumerated ownerships. In addition, supplemental plots were installed in counties that had over 1,000 acres in any enumerated ownership category that was not represented by a regular FIA plot.

Plot Design

Current P2—Bechtold and Patterson (2005) describe the current P2 and P3 ground plots and explain their use. These plots are clusters of four points arranged so that one point is central and the other three lie 120 feet from it at azimuths of 0, 120, and 240 degrees (appendix fig. A.1). Each point is the center of a circular subplot with a fixed 24-foot radius. Trees ≥ 5.0 inches d.b.h. are measured in these subplots. Each subplot in turn contains a circular microplot with a fixed 6.8-foot radius. Trees 1.0 to 4.9 inches d.b.h. and seedlings (< 1.0 inch d.b.h.) are measured in these microplots.

Sometimes a plot cluster straddles two or more land use or forest condition classes (Bechtold and Patterson 2005). There are seven condition-class variables that require mapping of a unique condition on a plot: (1) land use, (2) forest type, (3) stand size, (4) ownership, (5) stand density, (6) regeneration status, and (7) reserved status. A new condition is defined and mapped each time one of these variables changes during plot measurement.

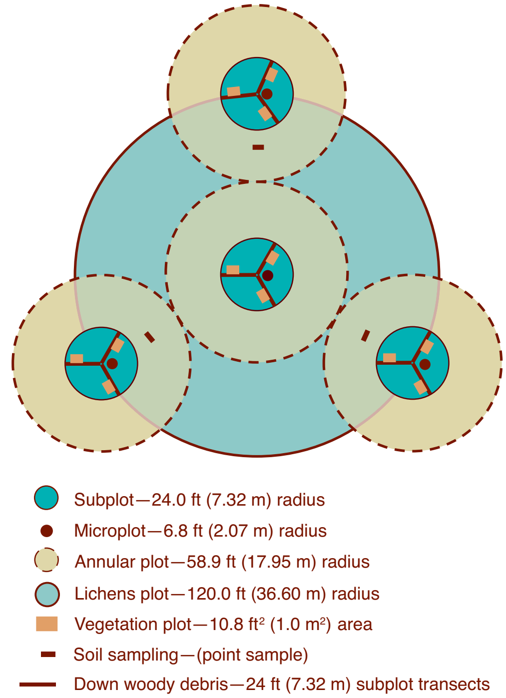

Figure A.1—Layout of fixed-radius plot.

Previous P2—In the previous inventory, FIA utilized a prism sampling technique. At each forested location, a sample plot cluster consisting of five satellite points was installed (in some instances involving irregularly shaped forest areas, as few as three satellite points were installed). The cluster covered about one-half acre (appendix fig. A.2). At each forested sample plot, trees ≥ 5.0 inches d.b.h. were selected with a 37.5 basal-area-factor prism at each of the five satellite points. Saplings (< 5.0 but > 1.0 inch d.b.h.) and seedlings (< 1.0 inch d.b.h.) were tallied on a 1/300-acre circular fixed plot centered on each satellite point.

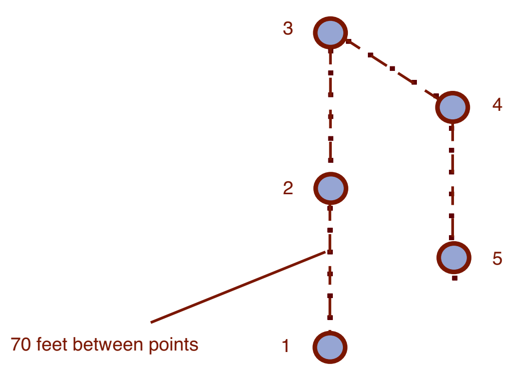

Figure A.2—Pattern of five-point prism plot used in Virginia.

Forest conditions were not mapped onto the prism 5-point cluster. Land use for the whole plot was based on land use at point 1: if point 1 fell in forest, the entire plot was classified as forest; if point 1 fell in a nonforest area, the entire plot was classed as nonforest. In situations where point 1 was forested but the plot cluster straddled a forest-nonforest area, points that fell in the nonforest area were rotated into the forest area. If all five points were located in forest but the forest condition of interest varied from point to point, then the points were systematically moved into areas that had a common forest condition, which was determined by point 1.

Current P3—Data on forest health variables (P3) are collected on about 1/16th of the P2 sample plots. P3 data are coarse descriptions, and are meant to be used as general indicators of overall forest health over large geographic areas. P3 data collection includes variables pertaining to tree crown health, down woody material (DWM), foliar ozone injury, lichen diversity, and soil composition. Tree crown health, DWM, and soil composition measurements are collected using the same plot design used during P2 data collection, while lichen data are collected within a 120-foot-radius circle around the center of each FIA P3 field plot (appendix fig. A.1).

Biomonitoring sites for ozone data collection are located independently of the FIA grid. Sites must be 1-acre fields or similar open areas adjacent to or surrounded by forest land, and must contain a minimum number of plants of at least two identified bioindicator species (U.S. Department of Agriculture 2004b). Plants are evaluated for ozone injury, and voucher specimens are submitted to a regional expert for verification of ozone-induced foliar injury.

Volume Estimation

Current—Tree volumes in Virginia were computed using the simple linear regression model:

$$Volume = Diameter^2 \times Height$$

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

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

Growth, Removals, and Mortality Estimation

Growth, removal, and mortality (GRM) estimates were determined from the remeasurement of 3,062 sample plots from the 1992 inventory. This was accomplished by remeasuring trees on the original prism plot points. However, a full remeasurement of the prism plot was not performed.

Trees ≥ 5.0 inches d.b.h. in 1992 were remeasured in 2001 on all prism points. Trees that were < 5.0 inches d.b.h. in 1992 and 2001 were remeasured on the microplot, but only on points 1, 2, and 3. Trees that were < 1.0 inch d.b.h. in 1992 and ≥ 5.0 inches d.b.h. (through-growth trees) in 2001 were measured on the microplots at points 1, 2, and 3.

The remeasurement information was then used in the calculation of seven components of change: (1) survivor growth, (2) ingrowth, (3) growth on ingrowth, (4) growth on mortality, (5) mortality, (6) growth on removals, and (7) removals. The Beers and Miller estimator technique (1964) was used to determine gross growth, net growth, removals, mortality, and net change of the inventory. This methodology required personnel to account only for previously tallied trees. Another change that may have affected estimates of GRM trends was the decrease in the number of plots. The number of plots used in the calculation of GRMs went from 4,627 in 1992 to 3,062 in 2001.

Changes in Variable Assessments—Data Reliability

The methods used to assess various attributes have changed in some cases and this may impact trend analysis. Three of the more important attributes assessed are forest type, stand size, and stand age. Forest type was assessed by field personnel in both the 1992 and 2001 surveys. Field personnel were instructed to use the plot tally, where possible, to define the forest type. The biggest difference between the 1992 and 2001 forest-type assessments would be in the sample design change.

In 1992, field personnel were instructed to describe the stand size of the sample plot without reference to any stand-level attributes. In 2001, field personnel were instructed to describe stand size based upon the predominant portion of the stand, e.g., the predominant stand layer. In 1992, field personnel recorded the stand age of the manageable portion of the stand, i.e., that portion of the stand that forest managers would carry through to harvest. In 2001, stand age was assigned on the basis of the predominant portion of the stand (as with stand size, above). Adding to the complexity of the comparisons over time is the complication of mapping by conditions across the plot. This changes the size and homogeneity of the assessment areas.

Summary

Users wishing to make rigorous comparisons of data between surveys should be aware of the significant differences in plot designs and variable assessments. Assuming there is no bias in plot selection or maintenance of plot integrity, the most valuable and powerful trend information is obtained when the same plots are revisited from one survey to the next and measured in the same way. This is also the only method that yields reliable components of change estimation (GRM). This approach reduces the noise that is present in data for natural forest stands and increases the level of confidence in assessments of trends. However, if sample designs change, there can never be a high level of certainty that the trends in the data are real and not due to procedural changes. Even though both designs may be judged statistically valid, the naturally occurring noise in the data hinders confident and rigorous assessments of trend over time. Determining the strength of a trend, or determining the level of confidence associated with a trend, is difficult or impossible when sampling methods change over time.

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

Measurement Error

There are three elements of measurement error: (1) biased error, caused by instruments not properly calibrated; (2) compensating error, caused by instruments of moderate precision; and (3) accidental error, caused by human error in measuring and compiling. All of these are held to a minimum by a system, the FIA quality assurance (QA) program that incorporates training, check plots, and editing and checking for consistency. The goal of the QA program is to provide a framework to assure the production of complete, accurate, and unbiased forest assessments for given standards.

One of the objectives of the FIA program is to include data-quality documentation in all nationally available reports including State reports and national summary reports. The following is a summary of some of the P2 variables and measurement quality objective (MQO) analyses from FIA blind-check measurements. Quality assessments of the P3 data will be addressed in future reports.

It is not possible to determine measurement error statistically but it is held to a minimum level through a number of quality control (QC) procedures. These methods include use of nationally standardized field manuals, use of portable data recorders (PDR), thorough entry-level training, periodic review training, supervision, use of check plots, editing checks, and an emphasis on careful work. Additionally, data quality is assessed and documented using performance measurements and postsurvey assessments. These assessments are then used to identify areas of the data collection process that need improvement or refinement in order to meet quality objectives of the program.

Editing checks in the PDR and office screen out logical and data entry inconsistencies and errors for all plots. Use of PDRs also helps ensure that specified procedures are followed. The minimum national standards for annual training of field crews are (1) a minimum of 40 hours for new employees and (2) a minimum of 8 hours for returning employees. Field crew members are certified on a test plot. All crews are required to have at least one certified person present on the plot at all times.

Field audits consist of hot checks, cold checks, and blind checks. A hot check is an inspection normally done as part of the training process. The inspector is present with the crew to document crew performance as plots are measured. The recommended intensity for hot checks is 2 percent of the plots installed.

Cold checks are done at regular intervals throughout the field season. The crew that installed the plot is not present at the time of inspection and does not know when or which plots will be remeasured. The inspector visits the completed plot, evaluates the crew's data collection, and notes corrections where necessary. The recommended intensity for cold checks is 5 percent of the plots installed.

A blind check is a complete reinstallation measurement of a previously completed plot. However, the QA crew performs the remeasurement without the previously recorded data. This type of blind measurement provides a direct, unbiased observation of measurement precision from two independent crews. Plots selected for blind checks are chosen to be a representative subsample of all plots measured and are randomly selected. Blind checks are planned to take place within 2 weeks of the date of the field measurement.

The recommended intensity for blind checks is 3 percent of the plots installed.

Each variable collected by FIA is assigned an MQO and a measurement tolerance level. The MQOs are documented in the FIA national field manual (U.S. Department of Agriculture 2004a, 2004b). In some instances the MQOs are a "best guess" of what experienced field crews should be able to consistently achieve. Tolerances are somewhat arbitrary and are based on the ability of crews to make repeatable measurements or observations within the assigned MQO.

Evaluation of field crew performance is accomplished by calculating the differences between data collected by the field crew and that collected by the QA crew on blind-check plots. Results of these calculations are compared to the established MQOs. In the analysis of blind-check data, an observation is within tolerance when the difference between the field crew observation and the QA crew observation does not exceed the assigned tolerance for that variable. For many categorical variables, the tolerance is "no error" allowed, so only observations that are identical with the standard are within the tolerance level. Appendix tables B.1 and B.2 show the percentage of observations that were within the program tolerances. At this time, only the blind-check results for plot-level and tree-level variables are presented.

Sampling Error

Sampling error is associated with the natural and expected deviation of the sample from the true population mean. This deviation is susceptible to a mathematical evaluation of the probability of error. Sampling errors for State totals are based on one standard deviation. That is, there is a 68.27 percent probability that the confidence interval given for each sample estimate will cover the true population mean (appendix table B.3)

The size of the sampling error generally increases as the size of the area examined decreases. Also, as area or volume totals are stratified by forest type, species, diameter class, ownership, or other subunits, the sampling error may increase and be greatest for the smallest divisions. However, there may be instances where a smaller component does not have a proportionately larger sampling error. This can happen when the postdefined strata are more homogeneous than the larger strata, thereby having a smaller variance. The magnitude of the increase (where homogeneity is not improved over that of the normal State-level sample) is depicted in appendix table B.4. For specific postdefined strata the sampling error can be calculated using the following formula. Sampling errors obtained by this method are only approximations of reliability because this process assumes constant variance across all subdivisions of totals.

$$SE_s = SE_t \frac{\sqrt{X_t}}{\sqrt{X_s}},$$

where

SE_s = sampling error for subdivision of survey unit or State total

SE_t = sampling error for survey unit or State total

X_s = sum of values for the variable of interest (area or volume) for subdivision of survey unit or State

X_t = total area or volume for survey unit or State

For example, the estimate of sampling error for softwood live-tree volume on public timberland is computed as:

$$SE_s = 1.34\% \left[\frac{\sqrt{30{,}619.6}}{\sqrt{920.3}} \right] = 7.73\%$$

Thus, the sampling error is 7.73 percent, and the resulting 68.27-percent confidence interval for softwood live-tree volume on public timberland is 920.3 ± 71.1 million cubic feet.

Appendix table B.1—Results of plot-level blind checks for Virginia and the Southern Region[a]

Variable	MQO requirements	Tolerance	Results: VA	Southern region	Obs (VA)	Obs (region)
	percent		*- - - - percent - - - -*		*- - - - number - - - -*	
Distance to road	90	No tolerance	92	81	24	261
Water on plot	90	No tolerance	96	90	24	261
Latitude	99	± 2.3°	100	100	13	300
Longitude	99	± 2.3°	100	88	13	300
Elevation	99	No tolerance	23	24	13	268
Elevation with tolerance	99	± 5 ft	23	33	13	268
Public access restrictions	90	No tolerance	100	86	14	158
Recreation use 1	90	No tolerance	100	90	14	158
Recreation use 2	90	No tolerance	100	95	14	158
Recreation use 3	90	No tolerance	100	99	14	158
Road access	90	No tolerance	86	85	14	158
Trails or roads	90	No tolerance	71	73	14	158
Regional variables						
Human debris	80	No tolerance	88	85	24	261
Contiguous forest	90	No tolerance	79	84	24	261
Distance to agriculture	90	No tolerance	83	80	24	261
Distance to urban area	90	No tolerance	88	76	24	261

MQO = measurement quality objective; obs = observations.

[a] Data are for the period of 2001–2004 where available.

Appendix table B.2—Results of tree-level blind checks for Virginia and the Southern Region[a]

Variable	MQO requirements	Tolerance	Results: VA	Southern region	Obs (VA)	Obs (region)
	percent		*- - - - percent - - - -*		*- - - - number - - - -*	
D.b.h.	95	± 0.1 /20 in.	87	87	201	3,159
Azimuth	90	± 10°	98	97	201	3,131
Horizontal distance	90	± 0.2 /1.0 ft	97	97	201	3,131
Species	95	No tolerance	96	94	202	3,198
Tree genus	99	No tolerance	100	99	202	3,198
Tree status	95	No tolerance	100	100	202	3,198
Total length	90	± 10 %	82	78	177	2,980
Actual length	90	± 10 %	59	65	22	180
Compacted crown ratio	80	± 10 %	79	81	201	3,131
Crown class	85	No tolerance	74	78	201	3,131
Decay class	90	± 1 class	100	100	31	168
Cause of death	80	No tolerance	90	94	31	232
Standing dead	99	No tolerance	100	100	157	92
Mortality year	70	± 1 yr	94	97	31	232
Condition	99	No tolerance	95	99	145	1,588
Regional variables						
Azimuth		± 3°	88	86	201	3,131
Tree class	90	No tolerance	81	88	201	3,131
Tree grade	90	No tolerance	93	71	41	288
Utilization class	99	No tolerance	100	100	157	1,610
Board-foot cull	90	± 10	99	97	201	3,159
Cubic-foot cull	90	± 10	96	98	157	1,610
Fusiform rust/dieback incidence	80	No tolerance	99	98	201	3,131
Fusiform rust/dieback severity	80	No tolerance	98	99	157	1,610
Horiz dist–nonwoodland	90	± 0.2 /1.0 ft	99	97	144	1,549

MQO = measurement quality objective; obs = observations.

[a] Data are for the period of 2001–2004 where available.

Appendix table B.3—Statistical reliability for Virginia, 2001

Item	Sample estimate and 68.27 percent confidence interval			Sampling error
				percent
Forest land (acres)	15,844,000.0	±	49,882.9	0.31
All live on timberland [a]				
Inventory	30,619.6	±	410.3	1.34
Net annual growth	990.0	±	22.6	2.28
Annual removals	697.9	±	34.3	4.91
Annual mortality	333.6	±	12.2	3.65
Growing stock on timberland [a]				
Inventory	27,200.6	±	391.7	1.44
Net annual growth	947.8	±	21.6	2.28
Annual removals	667.1	±	33.2	4.97
Annual mortality	273.0	±	11.1	4.06
Sawtimber on timberland [b c]				
Inventory	89,551.7	±	1,862.7	2.08
Net annual growth	3,848.7	±	86.6	2.25
Annual removals	2,250.3	±	126.0	5.6
Annual mortality	716.1	±	39.2	5.48

[a] Million cubic feet.

[b] Million board feet.

[c] International 1/4-inch rule.

Appendix table B.4—Sampling error approximations to which estimates are reliable at the 68.27 percent confidence interval, Virginia, 2001

		Live				Sawtimber			
Sampling error [a]	Timberland	Volume	Net growth	Removals	Mortality	Volume	Net growth	Removals	Mortality
percent	*acres*	*million cubic feet*				*million board feet* [b]			
1	1,522.6								
2	380.6	14,166.1							
3	169.2	6,296.1	571.8			42,982.9	2,164.9		
4	95.2	3,541.5	321.7		277.8	24,177.6	1,217.8		
5	60.9	2,266.6	205.9	673.0	177.8	15,473.7	779.3		
10	15.2	566.6	51.5	168.3	44.4	3,868.4	194.8	705.7	215.0
15	6.8	251.8	22.9	74.8	19.8	1,719.3	86.6	313.6	95.6
20	3.8	141.7	12.9	42.1	11.1	967.1	48.7	176.4	5,308.0
25	1.6	90.7	8.2	26.9	7.1	619.0	31.2	112.9	34.4

[a] Components for given sampling error derived by ratio approximation.

[b] International 1/4-inch rule.

Trees

Appendix table C.1—Common and scientific names of tree species ≥ 1.0 inch in d.b.h. tallied in Virginia, 2001

Common name	Scientific name[a]
Softwoods	
Fraser fir	*Abies fraseri* (Pursh) Poir.
Atlantic white-cedar	*Chamaecyparis thyoides* (L.) B.S.P.
Eastern redcedar	*Juniperus virginiana* L.
Red spruce	*Picea rubens* Sarg.
Shortleaf pine	*Pinus echinata* Mill.
Table Mt. pine	*P. pungens* Lamb.
Pitch pine	*P. rigida* Mill.
Pond pine	*P. serotina* Michx.
Eastern white pine	*P. strobus* L.
Loblolly pine	*P. taeda* L.
Virginia pine	*P. virginiana* Mill.
Baldcypress	*Taxodium distichum* (L.) Rich.
Pondcypress	*T. distichum* var. *nutans* (Ait.) Sweet
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Carolina hemlock	*T. caroliniana* Engelm.
Hardwoods	
Florida maple	*Acer barbatum* Michx.
Boxelder	*A. negundo* L.
Striped maple	*A. pensylvanicum* L.
Red maple	*A. rubrum* L.
Sugar maple	*A. saccharum* Marsh.
Mountain maple	*A. spicatum* Lam.
Yellow buckeye	*Aesculus octandra* Marsh.
Ailanthus	*Ailanthus altissima* (Mill.) Swingle
Serviceberry	*Amelanchier* spp. Medic.
Yellow birch	*Betula alleghaniensis* Britton
Sweet birch	*B. lenta* L.
River birch	*B. nigra* L.
American hornbeam	*Carpinus caroliniana* Walt.
Bitternut hickory	*Carya cordiformis* (Wangenh.) K. Koch
Pignut hickory	*C. glabra* (Mill.) Sweet
Pecan	*C. illinoinensis* (Wangenh.) K. Koch
Shagbark hickory	*C. ovata* (Mill.) K. Koch
Mockernut hickory	*C. tomentosa* (Poir.) Nutt.
American chestnut	*Castanea dentata* (Marsh.) Borkh.
Allegheny chinkapin	*C. pumila* Mill.

continued

Appendix table C.1—Common and scientific names of tree species ≥ 1.0 inch in d.b.h. tallied in Virginia, 2001 (continued)

Common name	Scientific name[a]
Hardwoods *(continued)*	
Catalpa	*Catalpa* spp. Scop.
Sugarberry	*Celtis laevigata* Willd.
Hackberry	*C. occidentalis* L.
Eastern redbud	*Cercis canadensis* L.
Flowering dogwood	*Cornus florida* L.
Hawthorn	*Crataegus* spp. L.
Common persimmon	*Diospyros virginiana* L.
American beech	*Fagus grandifolia* Ehrh.
White ash	*Fraxinus americana* L.
Carolina ash	*F. caroliniana* Mill.
Green ash	*F. pennsylvanica* Marsh.
Pumpkin ash	*F. profunda* (Bush) Bush
Honeylocust	*Gleditsia triacanthos* L.
Silverbell	*Halesia* spp. Ellis ex L.
American holly	*Ilex opaca* Ait.
Butternut	*Juglans cinerea* L.
Black walnut	*J. nigra* L.
Sweetgum	*Liquidambar styraciflua* L.
Yellow-poplar	*Liriodendron tulipifera* L.
Osage-orange	*Maclura pomifera* (Raf.) Schneid.
Cucumbertree	*Magnolia acuminata* L.
Mountain magnolia	*M. fraseri* Walt.
Southern magnolia	*M. grandiflora* L.
Bigleaf magnolia	*M. macrophylla* Michx.
Sweetbay	*M. virginiana* L.
Apple	*Malus* spp. Mill.
Chinaberry	*Melia azedarach* L.
White mulberry	*Morus alba* L.
Red mulberry	*M. rubra* L.
Water tupelo	*Nyssa aquatica* L.
Blackgum	*N. sylvatica* Marsh.
Swamp tupelo	*N. sylvatica* var. *biflora* (Walt.) Sarg.
Eastern hophornbeam	*Ostrya virginiana* (Mill.) K. Koch
Sourwood	*Oxydendrum arboreum* (L.) DC.
Paulownia	*Paulownia tomentosa* (Thunb.) Seib. & Zucc.
Redbay	*Persea borbonia* (L.) Spreng.
American sycamore	*Platanus occidentalis* L.
Eastern cottonwood	*Populus deltoides* Bartr. ex Marsh.

continued

Appendix table C.1—Common and scientific names of tree species ≥ 1.0 inch in d.b.h. tallied in Virginia, 2001 (continued)

Common name	Scientific name[a]
Hardwoods (continued)	
Bigtooth aspen	*P. grandidentata* Michx.
Pin cherry	*Prunus pensylvanica* L. f.
Black cherry	*P. serotina* Ehrh.
Cherry and plum spp.	*P.* spp
White oak	*Quercus alba* L.
Swamp white oak	*Q. bicolor* Willd.
Scarlet oak	*Q. coccinea* Muenchh.
Southern red oak	*Q. falcata* var. *falcata* Michx.
Cherrybark oak	*Q. falcata* var. *pagodifolia* Ell.
Bear oak	*Q. ilicifolia* Wangenh.
Shingle oak	*Q. imbricaria* Michx.
Turkey oak	*Q. laevis* Walt.
Laurel oak	*Q. laurifolia* Michx.
Overcup oak	*Q. lyrata* Walt.
Blackjack oak	*Q. marilandica* Muenchh.
Swamp chestnut oak	*Q. michauxii* Nutt.
Chinkapin oak	*Q. muehlenbergii* Engelm.
Water oak	*Q. nigra* L.
Pin oak	*Q. palustris* Muenchh.
Willow oak	*Q. phellos* L.
Chestnut oak	*Q. prinus* L.
Northern red oak	*Q. rubra* L.
Shumard oak	*Q. shumardii* Buckl.
Post oak	*Q. stellata* Wangenh.
Dwarf post oak	*Q. stellata* var. *margaretta* (Ashe.) Sarg.
Black oak	*Q. velutina* Lam.
Black locust	*Robinia pseudoacacia* L.
Willow	*Salix* spp. L.
Sassafras	*Sassafras albidum* (Nutt.) Nees
American basswood	*Tilia americana* L.
Winged elm	*Ulmus alata* Michx.
American elm	*U. americana* L.
Cedar elm	*U. crassifolia* Nutt.
Slippery elm	*U. rubra* Muhl.
Elm spp.	*U.* spp. L.
Rock elm	*U. thomasii* Sarg.

[a] Little (1979).

Lichens

Appendix table C.2—Lichen species recorded on P3 plots, Virginia, 1994, 1995, 1998, and 1999

Species	Plots	Species	Plots	Species	Plots
	n		*n*		*n*
Anaptychia palmulata	5	*H. syncolla*	1	*P. ciliata*	2
Anzia colpodes	1	*Hypogymnia physodes*	4	*P. insignis*	1
Bulbothrix confoederata	1	*Hypotrachyna imbricatula*	1	*P. pusilloides*	17
Candelaria concolor	14	*H. livida*	17	*P. rubropulchra*	30
C. fibrosa	1	*H. osseoalba*	2	*Physcia aipolia*	14
Canoparmelia caroliniana	9	*H. revoluta*	1	*P. americana*	17
C. crozalsiana	3	*Imshaugia aleurites*	6	*P. millegrana*	30
Cetraria americana	3	*I. placorodia*	3	*P. neogaea*	8
C. ciliaris	10	*Leptogium cyanescens*	3	*P. stellaris*	14
C. fendleri	3	*Lobaria pulmonaria*	3	*Physciella chloantha*	2
C. oakesiana	9	*L. quercizans*	1	*Physconia detersa*	3
C. orbata	1	*Melanelia subaurifera*	1	*Platismatia tuckermanii*	4
Cetrelia cetrarioides	1	*Myelochroa aurulenta*	26	*Pseudevernia consocians*	8
C. chicitae	1	*M. galbina*	9	*Punctelia bolliana*	2
C. olivetorum	2	*Normandina pulchella*	2	*P. borreri*	1
Cladonia bacillaris	4	*Parmelia squarrosa*	9	*P. missouriensis*	6
C. chlorophaea	5	*P. sulcata*	8	*P. perreticulata*	1
C. coniocraea	7	*Parmeliella triptophylla*	1	*P. punctilla*	1
C. cristatella	3	*Parmelinopsis horrescens*	5	*P. reddenda*	2
C. cylindrica	2	*P. minarum*	19	*P. rudecta*	51
C. furcata	1	*Parmeliopsis ambigua*	1	*P. semansiana*	4
C. macilenta	1	*Parmotrema arnoldii*	2	*P. subrudecta*	14
C. ochrochlora	1	*P. austrosinense*	1	*Pyxine caesiopruinosa*	6
C. parasitica	3	*P. chinense*	9	*P. sorediata*	21
C. pyxidata	4	*P. crinitum*	5	*P. subcinerea*	3
C. ramulosa	4	*P. dilatatum*	3	*Ramalina americana*	10
C. rei	2	*P. eurysacum*	9	*Rimelia cetrata*	6
C. squamosa	2	*P. gardneri*	8	*R. diffractaica*	1
Everniastrum catawbiense	1	*P. hypoleucinum*	1	*R. reticulata*	24
Flavoparmelia baltimorensis	1	*P. hypotropum*	42	*R. subisidiosa*	2
F. caperata	52	*P. margaritatum*	11	*Usnea ceratina*	4
Flavopunctelia flaventior	1	*P. michauxianum*	10	*U. hirta*	2
F. soredica	1	*P. perforatum*	4	*U. miriabilis*	4
Heterodermia granulifera	4	*P. rigidum*	3	*U. mutabilis*	10
H. hypoleuca	2	*P. subtinctorium*	2	*U. rubicunda*	7
H. obscurata	25	*P. tinctorum*	2	*U. strigosa*	27
H. speciosa	7	*P. ultralucens*	1	*U. subfloridana*	1
H. squamulosa	1	*P. xanthinum*	3	*Xanthoria candelaria*	1
Hyperphyscia adglutinata	1	*Phaeophyscia adiastola*	5		

Ozone Bioindicator Plants

Appendix table C.3—Ozone bioindicator species, Virginia, 2001

Common name	Scientific name[a b]
Spreading dogbane	*Apocynum androsaemifolium* L.
Common and tall milkweed	*Asclepias* spp.
Big leaf aster	*Eurybia macrophylla* (L.) Cass.
White ash	*Fraxinus americana* L.
Sweetgum	*Liquidambar styraciflua* L.
Yellow-poplar	*Liriodendron tulipifera* L.
Pin cherry	*Prunus pensylvanica* L. f.
Black cherry	*P. serotina* Ehrh.
Allegheny blackberry	*Rubus allegheniensis* Porter
Sassafras	*Sassafras albidum* (Nutt.) Nees

[a] Little (1979).

[b] USDA Natural Resources Conservation Service (2006).

Appendix table D.1—Land area by survey unit and land class, Virginia, 2001

Survey unit	Total land area[a]	Forest land: Total forest	Forest land: Timberland	Forest land: Productive reserved	Forest land: Other	Other land[b]
	thousand acres					
Coastal Plain	6,292.9	3,817.7	3,715.3	102.4	—	2,475.3
Southern Piedmont	5,597.4	3,784.1	3,784.1	—	—	1,813.4
Northern Piedmont	4,392.0	2,405.1	2,270.3	134.8	—	1,986.9
Northern Mountains	4,290.2	2,744.3	2,625.7	118.5	—	1,545.9
Southern Mountains	4,767.6	3,092.9	3,071.6	15.5	5.8	1,674.7
All units	25,340.1	15,844.0	15,467.0	371.2	5.8	9,496.1

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

— = no sample for the cell.

[a] From the U.S. Bureau of the Census, 2000. Some city municipalities separated by the U.S. Bureau of the Census were merged back into counties by SRS FIA.

[b] Includes 132.91 thousand acres of water according to FIA standards of area classification, but defined by the Bureau of the Census as land.

Appendix table D.2—Area of timberland by survey unit and ownership class, Virginia, 2001

Survey unit	All classes	Ownership class: National forest	Ownership class: Other public	Ownership class: Forest industry	Ownership class: Nonindustrial private
	thousand acres				
Coastal Plain	3,715.3	—	190.6	418.0	3,106.6
Southern Piedmont	3,784.1	18.3	195.5	302.0	3,268.3
Northern Piedmont	2,270.3	85.7	132.4	110.5	1,941.7
Northern Mountains	2,625.7	1,070.6	94.5	71.9	1,388.7
Southern Mountains	3,071.6	475.7	83.4	121.8	2,390.8
All units	15,467.0	1,650.3	696.4	1,024.2	12,096.1

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

— = no sample for the cell.

Appendix table D.3—Area of timberland by survey unit and forest-type group, Virginia, 2001

Survey unit	All groups	White-red-jack pine	Spruce-fir	Loblolly-shortleaf	Pinyon-juniper [b]	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Maple-beech-birch	Non-stocked
	Forest-type group [a]										
	thousand acres										
Coastal Plain	3,715.3	0.0	—	1,421.1	—	623.0	1,259.8	313.3	98.0	—	—
Southern Piedmont	3,784.1	16.8	—	1,100.7	7.8	484.4	2,011.3	27.6	125.1	—	10.3
Northern Piedmont	2,270.3	24.2	—	326.6	31.9	248.7	1,550.8	16.7	61.0	—	10.5
Northern Mountains	2,625.7	82.5	—	127.9	20.7	330.2	1,997.6	—	9.4	55.9	1.5
Southern Mountains	3,071.6	191.4	6.5	52.3	33.2	226.0	2,455.4	—	8.2	98.6	—
All units	15,467.0	315.0	6.5	3,028.6	93.7	1,912.3	9,274.9	357.6	301.6	154.5	22.3

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

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

[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.

[b] Includes eastern redcedar forest type.

Appendix table D.4—Area of timberland by survey unit and stand-size class, Virginia, 2001

Survey unit	All classes	Sawtimber	Poletimber	Sapling-seedling	Non-stocked
		Stand-size class			
	thousand acres				
Coastal Plain	3,715.3	1,454.3	1,322.0	939.0	—
Southern Piedmont	3,784.1	1,311.9	1,397.9	1,064.0	10.3
Northern Piedmont	2,270.3	1,164.7	798.9	296.2	10.5
Northern Mountains	2,625.7	1,281.8	1,175.3	167.1	1.5
Southern Mountains	3,071.6	1,725.8	927.2	418.7	—
All units	15,467.0	6,938.5	5,621.2	2,885.0	22.3

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

— = no sample for the cell.

Appendix table D.5—Area of timberland by forest-type group, stand origin, and ownership class, Virginia, 2001

Forest-type group[a] and stand origin	All classes	Ownership class: National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
Softwood types					
White-red-jack pine					
Planted	123.3	—	—	12.6	110.7
Natural	191.7	52.7	—	—	139.0
Total	315.0	52.7	—	12.6	249.7
Spruce-fir	6.5	5.0	—	—	1.5
Loblolly-shortleaf					
Planted	1,778.0	—	57.3	447.1	1,273.7
Natural	1,250.6	84.2	122.9	55.6	987.9
Total	3,028.6	84.2	180.2	502.6	2,261.6
Pinyon-juniper[b]	93.7	1.5	0.8	—	91.4
Total softwoods	3,443.9	143.4	181.0	515.2	2,604.2
Hardwood types					
Oak-pine					
Planted	157.4	6.1	—	22.6	128.8
Natural	1,754.9	179.2	103.7	82.8	1,389.2
Total	1,912.3	185.3	103.7	105.3	1,517.9
Oak hickory	9,274.9	1,296.3	362.4	348.7	7,267.5
Oak-gum-cypress	357.6	—	21.8	36.5	299.3
Elm-ash-cottonwood	301.6	—	16.1	8.0	277.5
Maple-beech-birch	154.5	23.8	11.4	5.6	113.8
Total hardwoods	12,000.9	1,505.4	515.4	504.1	9,476.0
Nonstocked	22.3	1.5	—	4.8	16.0
All groups	15,467.0	1,650.3	696.4	1,024.2	12,096.1

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

— = no sample for the cell.

[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.

[b] Includes eastern redcedar forest type.

Appendix table D.6—Number of live trees on timberland by species group and diameter class, Virginia, 2001

Species group	All classes	1.0 – 2.9	3.0 – 4.9	5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
	Diameter class (*inches at breast height*)												
	thousand trees												
Softwood													
Yellow pine	1,709,566	647,008	373,869	273,483	198,275	112,476	54,190	26,615	12,118	5,897	2,759	2,804	71
Other softwoods	299,197	179,051	66,272	25,259	14,110	6,497	3,604	1,440	1,101	907	294	514	146
All softwoods	2,008,763	826,059	440,142	298,742	212,384	118,973	57,794	28,055	13,220	6,805	3,053	3,318	217
Hardwood													
Soft hardwoods	4,510,374	3,053,856	738,823	282,863	159,362	98,534	65,162	43,945	28,248	18,278	8,628	11,549	1,126
Hard hardwoods	4,471,034	2,709,061	734,164	342,443	230,475	155,180	105,066	75,820	47,517	30,404	18,102	20,663	2,140
All hardwoods	8,981,408	5,762,918	1,472,987	625,306	389,837	253,713	170,228	119,764	75,765	48,682	26,730	32,212	3,265
All species	10,990,171	6,588,977	1,913,129	924,047	602,222	372,687	228,022	147,820	88,984	55,487	29,783	35,531	3,483

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

Appendix table D.7—Number of growing-stock trees on timberland by species group and diameter class, Virginia, 2001

Species group	All classes	1.0 – 2.9	3.0 – 4.9	5.0 – 6.9	7.0 – 8.9	9.0 – 10.9	11.0 – 12.9	13.0 – 14.9	15.0 – 16.9	17.0 – 18.9	19.0 – 20.9	21.0 – 28.9	29.0 and larger
	Diameter class (*inches at breast height*)												
	thousand trees												
Softwood													
Yellow pine	1,542,757	533,772	346,362	260,967	192,261	107,816	52,718	26,031	11,661	5,779	2,729	2,589	71
Other softwoods	215,177	121,945	48,933	20,428	12,169	4,921	3,003	1,185	915	843	252	514	69
All softwoods	1,757,934	655,717	395,295	281,395	204,430	112,737	55,721	27,215	12,577	6,622	2,981	3,103	140
Hardwood													
Soft hardwoods	2,207,578	1,240,263	418,337	196,417	122,024	79,900	53,970	37,554	25,082	15,522	7,642	9,926	943
Hard hardwoods	1,961,417	806,937	356,419	231,759	181,304	131,164	89,435	65,146	40,769	25,681	15,045	16,270	1,488
All hardwoods	4,168,995	2,047,200	774,756	428,176	303,328	211,064	143,405	102,700	65,851	41,203	22,687	26,196	2,430
All species	5,926,929	2,702,917	1,170,051	709,571	507,758	323,801	199,126	129,915	78,428	47,825	25,667	29,300	2,570

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

Appendix table D.8—Volume of live trees on timberland species group and diameter class, Virginia, 2001

Species group	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*)										
	million cubic feet										
Softwood											
Yellow pine	6,549.2	716.1	1,283.5	1,371.6	1,084.6	772.9	490.2	320.7	201.1	296.5	12.1
Other softwoods	448.5	53.9	71.0	56.8	53.8	32.1	34.7	44.1	17.4	46.9	37.7
All softwoods	6,997.7	770.0	1,354.5	1,428.4	1,138.4	805.0	525.0	364.9	218.5	343.3	49.8
Hardwood											
Soft hardwoods	9,438.5	783.0	1,032.3	1,167.7	1,262.6	1,247.2	1,106.6	940.8	565.7	1,108.8	223.9
Hard hardwoods	14,183.4	892.5	1,386.5	1,723.1	1,873.7	1,958.8	1,702.7	1,414.8	1,077.0	1,777.6	376.8
All hardwoods	23,621.9	1,675.5	2,418.8	2,890.8	3,136.4	3,205.9	2,809.3	2,355.6	1,642.6	2,886.3	600.6
All species	30,619.6	2,445.5	3,773.4	4,319.2	4,274.7	4,010.9	3,334.2	2,720.5	1,861.2	3,229.6	650.4

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

Appendix table D.9—Volume of growing stock trees on timberland species group and diameter class, Virginia, 2001

Species group	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*)										
	million cubic feet										
Softwood											
Yellow pine	6,360.4	685.8	1,248.9	1,323.7	1,060.3	759.7	477.9	315.6	199.4	277.1	12.1
Other softwoods	379.4	45.0	62.7	44.7	47.4	27.8	30.7	41.8	16.1	46.9	16.3
All softwoods	6,739.9	730.8	1,311.6	1,368.4	1,107.7	787.5	508.6	357.5	215.5	324.0	28.4
Hardwood											
Soft hardwoods	8,222.5	580.5	834.1	992.6	1,097.8	1,113.6	1,024.7	847.3	530.2	1,000.6	201.1
Hard hardwoods	12,238.2	656.5	1,151.6	1,509.6	1,657.4	1,749.2	1,523.2	1,250.3	944.0	1,497.2	299.1
All hardwoods	20,460.7	1,237.0	1,985.8	2,502.2	2,755.1	2,862.9	2,548.0	2,097.6	1,474.2	2,497.8	500.2
All species	27,200.6	1,967.8	3,297.3	3,870.6	3,862.8	3,650.4	3,056.6	2,455.0	1,689.7	2,821.8	528.6

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

Appendix table D.10—Volume of sawtimber on timberland by species group and diameter class, Virginia, 2001

	Diameter class (*inches at breast height*)								
Species group	All classes	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 [a]								
Softwood									
Yellow pine	20,951.3	4,773.1	4,696.9	3,830.5	2,636.4	1,864.0	1,248.6	1,820.8	81.0
Other softwoods	1,368.4	164.8	207.3	136.3	157.3	226.2	90.9	279.5	106.0
All softwoods	22,319.7	4,938.0	4,904.2	3,966.8	2,793.7	2,090.1	1,339.5	2,100.3	187.0
Hardwood									
Soft hardwoods	27,943.6	—	3,836.5	4,656.3	4,824.6	4,372.3	2,912.2	5,991.3	1,350.5
Hard hardwoods	39,288.5	—	5,650.3	6,892.8	6,629.0	5,823.8	4,643.4	7,887.6	1,761.6
All hardwoods	67,232.0	—	9,486.7	11,549.2	11,453.5	10,196.1	7,555.6	13,878.9	3,112.1
All species	89,551.7	4,938.0	14,391.0	15,515.9	14,247.2	12,286.2	8,895.1	15,979.2	3,299.1

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

— = no sample for the cell.

[a] International 1/4-inch rule.

Appendix table D.11—Volume of live trees on timberland by survey unit and species group, Virginia, 2001

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million cubic feet			
Coastal Plain	7,586.4	2,922.3	2,837.7	84.6	4,664.1	2,493.6	2,170.5
Southern Piedmont	6,652.3	1,955.2	1,907.8	47.4	4,697.0	2,187.7	2,509.3
Northern Piedmont	4,992.0	756.2	700.9	55.3	4,235.8	1,737.4	2,498.4
Northern Mountains	4,935.8	686.7	589.3	97.4	4,249.1	801.8	3,447.2
Southern Mountains	6,453.1	677.2	513.4	163.9	5,775.9	2,218.0	3,557.9
All units	30,619.6	6,997.7	6,549.2	448.5	23,621.9	9,438.5	14,183.4

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

Appendix table D.12—Volume of growing stock on timberland by survey unit and species group, Virginia, 2001

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million cubic feet			
Coastal Plain	6,912.6	2,867.5	2,809.2	58.2	4,045.2	2,162.6	1,882.6
Southern Piedmont	6,010.8	1,893.0	1,856.2	36.7	4,117.9	1,899.4	2,218.5
Northern Piedmont	4,385.0	704.4	661.4	43.0	3,680.6	1,526.0	2,154.6
Northern Mountains	4,329.9	652.6	564.0	88.6	3,677.3	673.3	3,004.1
Southern Mountains	5,562.3	622.5	469.7	152.9	4,939.8	1,961.3	2,978.4
All units	27,200.6	6,739.9	6,360.4	379.4	20,460.7	8,222.5	12,238.2

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

Appendix table D.13—Volume of sawtimber on timberland by survey unit and species group, Virginia, 2001

Survey unit	All species	Softwoods: All softwood	Yellow pine	Other softwood	Hardwoods: All hardwood	Soft hardwood	Hard hardwood
	million board feet[a]						
Coastal Plain	23,734.3	10,313.3	10,029.3	284.0	13,420.9	6,914.9	6,506.0
Southern Piedmont	18,301.6	5,172.1	5,093.8	78.3	13,129.4	6,221.8	6,907.6
Northern Piedmont	15,543.4	2,087.5	1,992.3	95.3	13,455.9	5,999.1	7,456.8
Northern Mountains	13,658.6	2,333.0	2,018.7	314.3	11,325.6	2,131.6	9,193.9
Southern Mountains	18,314.0	2,413.7	1,817.2	596.5	15,900.2	6,676.2	9,224.1
All units	89,551.7	22,319.7	20,951.3	1,368.4	67,232.0	27,943.6	39,288.5

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

[a] International 1/4-inch rule.

Appendix table D.14—Volume of live trees and growing stock on timberland by ownership class and species group, Virginia, 2001

Ownership class	All species	Softwoods: All softwood	Yellow pine	Other softwood	Hardwoods: All hardwood	Soft hardwood	Hard hardwood
	Live trees (*million cubic feet*)						
National forest	3,308.9	417.5	350.2	67.3	2,891.4	627.0	2,264.4
Other public	1,743.1	502.8	472.8	30.0	1,240.4	557.1	683.3
Forest industry	1,434.8	626.2	596.3	29.9	808.6	355.4	453.3
Nonindustrial private	24,132.7	5,451.2	5,130.0	321.3	18,681.5	7,899.1	10,782.4
All classes	30,619.6	6,997.7	6,549.2	448.5	23,621.9	9,438.5	14,183.4
	Growing-stock trees (*million cubic feet*)						
National forest	2,905.8	402.2	336.1	66.1	2,503.6	564.1	1,939.5
Other public	1,552.9	480.4	452.1	28.4	1,072.5	490.4	582.1
Forest industry	1,302.6	596.8	589.0	7.8	705.9	313.7	392.2
Nonindustrial private	21,439.2	5,260.4	4,983.3	277.1	16,178.8	6,854.4	9,324.4
All classes	27,200.6	6,739.9	6,360.4	379.4	20,460.7	8,222.5	12,238.2

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

Appendix table D.15—Volume of sawtimber on timberland by ownership class and species group, Virginia, 2001

Ownership class	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
				All size classes (*million board feet* [a])			
National forest	8,999.9	1,528.8	1,269.9	259.0	7,471.1	1,800.9	5,670.2
Other public	5,680.2	1,900.5	1,766.2	134.3	3,779.7	1,826.0	1,953.6
Forest industry	3,521.3	1,361.1	1,336.0	25.1	2,160.1	940.1	1,220.1
Nonindustrial private	71,350.4	17,529.2	16,579.2	950.0	53,821.2	23,376.6	30,444.6
All classes	89,551.7	22,319.7	20,951.3	1,368.4	67,232.0	27,943.6	39,288.5
				Trees ≥ 15.0 inches d.b.h. (*million board feet* [a])			
National forest	5,665.2	610.9	479.5	131.4	5,054.4	1,324.0	3,730.4
Other public	3,899.2	995.0	875.2	119.8	2,904.2	1,452.7	1,451.4
Forest industry	1,795.0	338.1	319.5	18.6	1,456.9	606.9	850.0
Nonindustrial private	43,347.4	6,566.7	5,976.6	590.2	36,780.7	16,067.2	20,713.5
All classes	54,706.9	8,510.8	7,650.8	860.0	46,196.1	19,450.8	26,745.3

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

[a] International 1/4-inch rule.

Appendix table D.16—Volume of growing stock on timberland by forest-type group, stand origin, and species group, Virginia, 2001

Forest-type group[a] and stand origin	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	206.1	182.7	182.3	0.4	23.4	9.9	13.5
Natural	414.9	202.3	131.0	71.3	212.6	84.2	128.4
Total	621.0	385.0	313.3	71.7	236.0	94.1	141.9
Spruce-fir	31.3	29.1	—	29.1	2.2	—	2.2
Loblolly-shortleaf							
Planted	2,302.8	2,040.9	2,039.5	1.4	261.9	158.0	103.9
Natural	2,349.8	1,822.2	1,807.0	15.2	527.6	301.3	226.3
Total	4,652.6	3,863.1	3,846.5	16.6	789.5	459.3	330.2
Pinyon-juniper[b]	51.0	31.5	6.6	24.9	19.4	8.1	11.3
Total softwoods	5,356.7	4,309.4	4,166.3	143.1	1,047.3	561.6	485.7
Hardwood types							
Oak-pine							
Planted	164.7	77.3	77.0	0.3	87.5	42.3	45.2
Natural	3,009.9	1,248.5	1,197.3	51.1	1,761.5	694.9	1,066.6
Total	3,174.7	1,325.8	1,274.4	51.4	1,848.9	737.2	1,111.7
Oak-hickory	17,125.9	954.2	835.5	118.7	16,171.6	6,086.2	10,085.5
Oak-gum-cypress	798.4	120.4	69.2	51.2	678.1	468.8	209.3
Elm-ash-cottonwood	417.9	16.1	15.1	1.0	401.8	275.7	126.1
Maple-beech-birch	327.0	14.0	—	14.0	313.0	93.1	219.9
Total hardwoods	21,843.8	2,430.4	2,194.1	236.3	19,413.4	7,661.0	11,752.4
Nonstocked	0.1	—	—	—	0.1	—	0.1
All groups	27,200.6	6,739.9	6,360.4	379.4	20,460.7	8,222.5	12,238.2

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

— = no sample for the cell.

[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.

[b] Includes eastern redcedar forest type.

Appendix table D.17—Average net annual growth of live trees on timberland by survey unit and species group, Virginia, 1992–2000

Survey unit	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Coastal Plain	325.9	176.1	173.5	2.5	149.8	81.5	68.3
Southern Piedmont	271.3	105.9	104.7	1.2	165.4	87.5	77.9
Northern Piedmont	150.1	32.8	31.4	1.4	117.3	66.2	51.0
Northern Mountains	77.7	-2.1	-4.0	1.9	79.8	25.6	54.2
Southern Mountains	165.0	14.4	10.8	3.6	150.6	76.3	74.3
All units	990.0	327.2	316.5	10.7	662.8	337.1	325.8

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

Appendix table D.18—Average net annual growth of growing stock on timberland by survey unit and species group, Virginia, 1992–2000

Survey unit	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Coastal Plain	313.1	174.3	172.2	2.1	138.8	75.7	63.1
Southern Piedmont	255.5	103.6	102.7	0.9	151.9	78.6	73.4
Northern Piedmont	144.8	31.8	30.8	0.9	113.0	60.9	52.1
Northern Mountains	75.9	-2.1	-4.1	2.0	78.0	23.5	54.5
Southern Mountains	158.5	13.6	10.3	3.3	144.9	73.1	71.8
All units	947.8	321.2	312.0	9.2	626.6	311.7	314.9

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

Appendix table D.19—Average net annual growth of sawtimber on timberland by survey unit and species group, Virginia, 1992–2000

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million board feet[a]			
Coastal Plain	1,165.7	620.1	609.8	10.3	545.6	288.3	257.3
Southern Piedmont	938.5	327.7	325.1	2.6	610.8	312.7	298.2
Northern Piedmont	657.9	114.3	112.0	2.3	543.6	284.7	258.8
Northern Mountains	363.7	20.5	12.4	8.1	343.2	92.1	251.1
Southern Mountains	722.8	89.7	80.3	9.4	633.1	315.3	317.8
All units	3,848.7	1,172.4	1,139.6	32.7	2,676.3	1,293.1	1,383.2

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

[a] International 1/4-inch rule.

Appendix table D.20—Average annual removals of live trees on timberland by survey unit and species group, Virginia, 1992–2000

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million cubic feet			
Coastal Plain	247.4	135.3	135.2	0.1	112.1	52.4	59.7
Southern Piedmont	212.3	91.7	91.2	0.4	120.7	54.4	66.3
Northern Piedmont	93.8	44.4	43.0	1.4	49.4	16.9	32.4
Northern Mountains	45.4	7.8	7.8	—	37.5	7.7	29.8
Southern Mountains	99.0	19.5	19.1	0.4	79.5	39.4	40.1
All units	697.9	298.7	296.3	2.4	399.2	170.8	228.4

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

— = no sample for the cell.

Appendix table D.21—Average annual removals of growing stock on timberland by survey unit and species group, Virginia, 1992–2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Coastal Plain	238.0	134.4	134.3	0.1	103.7	48.9	54.8
Southern Piedmont	205.1	91.3	91.0	0.3	113.8	51.4	62.4
Northern Piedmont	89.2	43.8	42.4	1.4	45.4	14.9	30.4
Northern Mountains	43.0	7.6	7.6	—	35.4	7.3	28.0
Southern Mountains	91.8	19.4	19.0	0.4	72.4	37.0	35.4
All units	667.1	296.6	294.3	2.3	370.6	159.5	211.1

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

Appendix table D.22—Average annual removals of sawtimber on timberland by survey unit and species group, Virginia, 1992–2000

Survey unit	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million board feet[a]						
Coastal Plain	800.0	469.1	468.7	0.4	330.9	160.3	170.6
Southern Piedmont	627.6	240.3	240.3	—	387.3	182.5	204.8
Northern Piedmont	272.6	111.4	104.9	6.5	161.2	58.4	102.8
Northern Mountains	174.8	35.0	35.0	—	139.8	34.0	105.8
Southern Mountains	375.4	84.0	82.1	1.9	291.4	155.4	136.1
All units	2,250.3	939.8	931.0	8.7	1,310.6	590.6	720.0

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.
[a] International 1/4-inch rule.

Appendix table D.23—Average net annual growth and average annual removals of live trees, growing stock, and sawtimber on timberland by species group, Virginia, 1992–2000

Species group	Live trees		Growing stock		Sawtimber	
	Net annual growth	Annual removals	Net annual growth	Annual removals	Net annual growth	Annual removals
	- - - - - - - - - - - - - - - - *million cubic feet* - - - - - - - - - - - - - - - -				- - *million board feet*[a] - -	
Softwood						
Yellow pine	316.5	296.3	312.0	294.3	1,139.6	931.0
Other softwood	10.7	2.4	9.2	2.3	32.7	8.7
All softwoods	327.2	298.7	321.2	296.6	1,172.4	939.8
Hardwood						
Soft hardwood	337.1	170.8	311.7	159.5	1,293.1	590.6
Hard hardwood	325.8	228.4	314.9	211.1	1,383.2	720.0
All hardwoods	662.8	399.2	626.6	370.6	2,676.3	1,310.6
All species	990.0	697.9	947.8	667.1	3,848.7	2,250.3

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

[a] International 1/4-inch rule.

Appendix table D.24—Average annual mortality of live trees, growing stock, and sawtimber on timberland by species group, Virginia, 1992–2000

Species group	Live trees	Growing stock	Sawtimber
	- - - - *million cubic feet* - - - -		*million board feet*[a]
Softwood			
Yellow pine	115.9	112.4	286.1
Other softwood	3.5	3.3	11.7
All softwoods	119.4	115.7	297.8
Hardwood			
Soft hardwood	60.4	40.9	96.0
Hard hardwood	153.8	116.4	322.3
All hardwoods	214.1	157.3	418.3
All species	333.6	273.0	716.1

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

[a] International 1/4-inch rule.

Appendix table D.25—Average net annual growth and average annual removals of live trees on timberland by ownership class and species group, Virginia, 1992–2000

		Softwoods			Hardwoods		
Ownership class	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million cubic feet*)						
National forest	46.8	-2.9	-4.2	1.3	49.7	24.6	25.1
Other public	33.1	10.8	10.3	0.5	22.3	11.4	10.9
Forest industry	91.4	60.4	59.5	0.9	31.0	16.4	14.6
Nonindustrial private	818.8	258.9	250.9	8.0	559.9	284.7	275.2
All classes	990.0	327.2	316.5	10.7	662.8	337.1	325.8
	Average annual removals (*million cubic feet*)						
National forest	18.7	2.5	2.3	0.1	16.2	0.6	15.7
Other public	10.0	4.2	4.2	—	5.8	1.8	4.0
Forest industry	87.7	52.8	52.7	0.1	34.8	15.9	18.9
Nonindustrial private	581.6	239.2	237.1	2.1	342.3	152.5	189.9
All classes	697.9	298.7	296.3	2.4	399.2	170.8	228.4

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

— = no sample for the cell.

Appendix table D.26—Average net annual growth and average annual removals of growing stock on timberland by ownership class and species group, Virginia, 1992–2000

Ownership class	All species	Softwoods			Hardwoods		
		All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million cubic feet*)						
National forest	47.9	-2.7	-4.1	1.3	50.6	24.2	26.3
Other public	32.3	10.6	10.2	0.4	21.6	10.9	10.7
Forest industry	90.1	59.6	59.0	0.6	30.5	15.9	14.6
Nonindustrial private	777.6	253.7	246.8	6.9	523.9	260.6	263.3
All classes	947.8	321.2	312.0	9.2	626.6	311.7	314.9
	Average annual removals (*million cubic feet*)						
National forest	17.4	2.2	2.1	0.1	15.2	0.6	14.6
Other public	9.7	4.2	4.2	—	5.5	1.8	3.7
Forest industry	85.1	52.4	52.3	0.1	32.7	14.8	17.9
Nonindustrial private	554.9	237.7	235.7	2.0	317.2	142.3	174.9
All classes	667.1	296.6	294.3	2.3	370.5	159.5	211.1

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

— = no sample for the cell.

Appendix table D.27—Average net annual growth and average annual removals of sawtimber on timberland by ownership class and species group, Virginia, 1992–2000

Ownership class	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
Average net annual growth (*million board feet*[a])							
National forest	206.1	6.5	2.5	4.0	199.6	77.1	122.5
Other public	143.1	47.4	46.9	0.4	95.7	45.0	50.6
Forest industry	261.8	150.0	146.7	3.3	111.8	59.9	52.0
Nonindustrial private	3,237.7	968.5	943.5	25.0	2,269.2	1,111.1	1,158.1
All classes	3,848.7	1,172.4	1,139.6	32.7	2,676.3	1,293.1	1,383.2
Average annual removals (*million board feet*[a])							
National forest	65.0	10.6	10.0	0.6	54.4	1.4	52.9
Other public	37.5	11.9	11.9	—	25.6	8.0	17.6
Forest industry	241.8	137.6	137.3	0.4	104.2	49.9	54.3
Nonindustrial private	1,906.1	779.6	771.8	7.8	1,126.4	531.2	595.2
All classes	2,250.3	939.8	931.0	8.7	1,310.6	590.6	720.0

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

— = no sample for the cell.

[a] International 1/4-inch rule.

Appendix table D.28—Average net annual growth of growing stock on timberland by forest-type group, stand origin, and species group, Virginia, 1992–2000

Forest-type group[a] and stand origin[b]	All species	Softwoods: All softwoods	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwoods	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	6.4	6.4	6.4	—	0.0	0.1	-0.1
Natural	8.5	6.5	5.8	0.7	2.0	1.2	0.9
Total	14.8	12.9	12.2	0.7	2.0	1.2	0.7
Loblolly-shortleaf pine							
Planted	201.0	189.3	189.2	0.1	11.8	8.2	3.5
Natural	92.0	63.2	62.0	1.1	28.8	18.8	10.0
Total	293.0	252.4	251.2	1.2	40.5	27.1	13.5
Pinyon-juniper[c]	2.3	1.8	0.3	1.5	0.5	0.1	0.4
Total softwoods	310.1	267.1	263.7	3.4	43.0	28.4	14.6
Hardwood types							
Oak-pine							
Planted	22.2	13.9	13.9	0.0	8.3	4.5	3.7
Natural	69.8	20.1	18.9	1.2	49.7	22.8	26.9
Total	91.9	34.0	32.8	1.2	57.9	27.3	30.6
Oak-hickory	506.0	17.1	14.1	3.0	488.9	233.1	255.9
Oak-gum-cypress	17.0	2.4	1.0	1.4	14.6	10.0	4.6
Elm-ash-cottonwood	14.5	0.3	0.3	0.0	14.2	10.9	3.4
Maple-beech-birch	8.0	0.1	0.0	0.1	7.9	2.1	5.8
Total hardwoods	637.4	53.8	48.2	5.6	583.6	283.3	300.3
Nonstocked	0.3	0.1	0.1	—	0.2	0.4	-0.2
All groups	947.7	321.0	312.0	9.0	626.7	312.0	314.7

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

— = no sample for the cell; 0.0 = a value of > 0.00 but < 0.05 for the cell.

[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.

[b] Classification at the beginning of the remeasurement period.

[c] Includes eastern redcedar forest type.

Appendix table D.29—Average net annual removals of growing stock on timberland by forest-type group, stand origin, and species group, Virginia, 1992–2000

Forest-type group[a] and stand origin[b]	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	7.9	7.7	7.7	—	0.2	—	0.2
Natural	8.5	7.2	7.1	0.1	1.3	1.1	0.2
Total	16.4	14.9	14.8	0.1	1.5	1.1	0.4
Loblolly-shortleaf pine							
Planted	108.9	103.3	103.3	—	5.6	2.6	3.0
Natural	145.0	127.6	127.6	0.1	17.4	11.0	6.4
Total	254.0	230.9	230.9	0.1	23.0	13.6	9.4
Pinyon-juniper[c]	1.1	0.8	0.5	0.3	0.3	0.2	0.1
Total softwoods	271.4	246.6	246.1	0.5	24.8	15.0	9.8
Hardwood types							
Oak-pine							
Planted	2.5	1.6	1.6	—	0.8	0.1	0.7
Natural	57.5	30.1	28.8	1.3	27.5	9.8	17.7
Total	60.0	31.7	30.4	1.3	28.3	9.9	18.4
Oak-hickory	315.9	17.2	16.7	0.5	298.7	124.5	174.2
Oak-gum-cypress	9.8	1.1	1.1	—	8.7	6.3	2.4
Elm-ash-cottonwood	5.4	—	—	—	5.4	2.2	3.2
Maple-beech-birch	4.5	—	—	—	4.5	1.5	3.0
Total hardwoods	395.7	50.0	48.2	1.8	345.7	144.5	201.2
Nonstocked	0.1	—	—	—	0.1	—	0.1
All groups	667.2	296.6	294.3	2.3	370.7	159.5	211.2

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

— = no sample for the cell.

[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.

[b] Classification at the beginning of the remeasurement period.

[c] Includes eastern redcedar forest type.

Appendix table D.30—Area of timberland treated or disturbed annually and retained in timberland by treatment or disturbance and ownership class, Virginia, 1992–2001

Treatment or disturbance[a]	Ownership class: All classes	Public	Forest industry	Private
	thousand acres			
Final harvest	146.9	5.8	25.3	115.8
Partial harvest[b]	110.6	3.9	2.0	104.7
Seed tree/shelterwood	2.9	0.8	—	2.1
Commercial thinning	28.6	0.7	1.9	26.0
Other stand improvement	19.2	1.5	4.9	12.8
Site preparation	57.1	0.5	14.8	41.8
Artificial regeneration[c]	62.1	0.5	19.7	41.8
Natural regeneration[c]	94.6	3.4	7.1	84.0
Other cutting	76.3	5.5	3.8	67.0
Natural disturbance				
Disease	11.9	4.7	—	7.2
Insects	58.7	19.5	0.7	38.5
Fire	13.5	4.7	1.3	7.5
Weather	132.5	28.6	3.4	100.4
Animals	24.1	3.3	1.8	19.0
Other disturbances				
Grazing	34.1	—	—	34.1
Other human-caused disturbance	—	—	—	—
Other naturally caused disturbance	49.6	3.2	1.6	44.8

Since some acres are affected by more than one treatment or disturbance, there are no column totals.

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

— = no sample for the cell.

[a] For previously established plots, only treatments and disturbances that occurred since the last inventory were noted. For new plots, only treatments that occurred within the last 5 years were noted.

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

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

Rose, Anita K. 2007. Virginia's forests, 2001. Resour. Bull. SRS–120. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 140 p.

Between 1997 and 2001, the Forest Service's Forest Inventory and Analysis (FIA) Program conducted the seventh inventory of the forests of Virginia. About 15,844,000 acres, or 62 percent, of Virginia was forested. The majority (12,102,000 acres) of Virginia's forest land was in nonindustrial private forest ownership. Public ownership and forest industry ranked second and third, with 2,718,000 and 1,024,000 acres, respectively. Red maple dominated in terms of number of live stems (≥ 1.0 inch d.b.h.) with 1.5 billion stems (13 percent of total). Loblolly pine was second, with 959 million live stems, 72 percent of which were in stands classified as planted. Yellow-poplar, sweetgum, and blackgum ranked third, fourth, and fifth, respectively, by number of stems. Yellow-poplar dominated the total live-tree volume with 5.5 billion cubic feet (13 percent of total). Loblolly pine was the second most dominant species, with 4.7 billion cubic feet (11 percent of total). Chestnut oak, white oak, and red maple ranked next in total live-tree volume. Across Virginia, 95 percent of forest health plots had an average crown dieback ≤ 7.5 percent. Scarlet oak and sourwood had the highest percentage of trees with ≥ 7.5 percent dieback. FIA is the only program that conducts forest assessments across all land in the United States. Increasing demands on the resource and anthropogenic-related impacts on forests have intensified the need to conduct ecosystem-based inventories such as these.

Keywords: FIA, forest health, forest inventory, forest ownership, forest type, species distribution.

October 2007

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Virginia State Facts

Commonwealth of Virginia:
Old Dominion State

Capital City: Richmond

Location: 37.53105 N, 077.47458 W

Origin of State's Name: Named for England's "Virgin Queen," Elizabeth I

Nicknames: Old Dominion, Mother of Presidents

Population: 7,058,515; 12th - 2000 census

Geology: Land Area; 39,594 sq. mi.; 36th

Highest Point: Mt. Rogers; 5,729 feet

Inland Water: 1,063 sq. mi.

Largest City: Virginia Beach

Lowest Point: Atlantic coast; sea level

Border States: Kentucky - Maryland - North Carolina - Tennessee - West Virginia

Coastline: 112 mi.

Constitution: 10th State

Statehood: June 25, 1788

Motto:

Sic Semper Tyrannis - Thus Always to Tyrants

Bird: In 1950, the General Assembly chose the northern cardinal *(Cardinalis cardinalis)* as the State bird because of its bright plumage and cheerful song. In eighteenth-century England, the cardinal was called "the Virginia nightingale." The cardinal is part of the finch family.

Agriculture: Cattle, poultry, dairy products, tobacco, hogs, soybeans, apples, potatoes, tomatoes, peanuts.

Industry: Transportation equipment, textiles, food processing, printing, electric equipment, chemicals.

Minerals: Virginia is one of the top ten coal producers in the U.S. Coal accounts for about 70 percent of Virginia's mineral value; crushed stone and gravel, lime, and kyanite are also mined.

Flag: In 1861, the Virginia State Convention passed an ordinance establishing a design virtually identical to that in current use. This flag has a deep blue field with a circular white center. The obverse of the great seal of the Commonwealth has been identically painted or embroidered on each side of the flag. A white silk fringe adorns the edge farthest from the flag staff.

Tree: In 1956, the State adopted the American dogwood *(Cornus florida)* as the official tree. The dogwood is well distributed throughout the Commonwealth, and its beauty is symbolic of the many attractive features of Virginia. The dogwood blooms in early spring and its blossom is a tiny cluster of flowers surrounded by four white leaves that look like petals.

Flower: In 1918, the State floral emblem commonly known as the American dogwood was adopted. It was selected to foster a feeling of pride in our State and to stimulate an interest in the history and traditions of the Commonwealth.

Presidential Birthplace:

George Washington, 1789-1797
Thomas Jefferson, 1801-1809
James Madison, 1809-1817
James Monroe, 1817-1825
William Henry Harrison, 1841
John Tyler, 1841-1845
Zachary Taylor, 1849-1850
Woodrow Wilson, 1913-1921

Seal: The great seal of the Commonwealth was adopted by the Virginia's Constitutional Convention on July 5, 1776. Its design was the work of a committee composed of George Mason, George Wythe, Richard Henry Lee, and Robert Carter Nicholas. George Wythe was probably the principal designer, taking its theme from ancient Roman mythology.

The original design was never properly cast and a number of variations came into use. Attempting to legislate uniformity, the General Assemblies of 1873 and 1903 passed acts describing the seal in detail. In 1930, a committee was named to prepare an "accurate and faithful description of the great seal of the Commonwealth, as it was intended to be by Mason and Wythe and their associates." The committee set forth the official design in use today, which is essentially the design adopted by the Virginia's Constitutional Convention of 1776.

Official colors were established by the Art Commission in 1949 and a water color, the only official model for flag makers and stationers, hangs in the office of the Secretary of the Commonwealth. The Secretary of the Commonwealth is designated by the Code of Virginia as the keeper of the great seal. The great seal of the Commonwealth is affixed to documents signed by the governor and intended for use before tribunals and for purposes outside the jurisdiction of Virginia.

State information courtesy of www.infoplease.com/states.html