West Virginia's Forests 2008

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Abstract

The first full annual inventory of West Virginia's forests reports 12.0 million acres of forest land or 78 percent of the State's land area. The area of forest land has changed little since 2000. Of this land, 7.2 million acres (60 percent) are held by family forest owners. The current growing-stock inventory is 25 billion cubic feet—12 percent more than in 2000—and averages 2,136 cubic feet per acre. Yellow-poplar continues to lead in volume followed by white and chestnut oaks. Since 2000, the saw log portion of growing-stock volume has increased by 23 percent to 88 billion board feet. In the latest inventory, net growth exceeded removals for all major species. Detailed information on forest inventory methods and data quality estimates is included in a DVD at the back of this report. Tables of population estimates and a glossary are also included.

Acknowledgments

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Letter From State Forester

On October 12, 2008, I received a letter from the Forest Management Review Commission, an interim committee of the West Virginia Legislature that cited 12 issues of concern. The committee's number one issue was forest inventory and analysis. No single document is more important to the sustainability of West Virginia's forests than this, our sixth forest inventory. This document was prepared by the Forest Inventory and Analysis program of the U.S. Department of Agriculture, Forest Service, Northern Research Station, with assistance from the West Virginia Division of Forestry, Department of Commerce. The sound scientific information contained within allows one to look at the evolution of our forest over the past 60 years, identify trends, and thus project the future condition of our forest. The ability to know the present condition of our forest and project the future is essential to ensure the sustainability of our forest.

A forest is many things to many different people. Today's society requires forest managers to recognize and balance the many ecological, social, and economic issues. This inventory and analysis report is more comprehensive and formatted totally different than those in the past for this reason. A forest provides clean water, clean air, carbon storage, scenic landscapes, recreational opportunities, wildlife habitat and, last but not least, jobs for those employed in the forest products industry.

Forests are dynamic and forever changing. This inventory indicates that we have not lost or gained forested acreage; the average tree size, quality, and total volume have all increased substantially since the last inventory in 2000. However, this trend cannot continue indefinitely and there are issues that need to be monitored closely. The most notable issue is that oaks make up 45 percent of the trees 20 inches and larger in diameter, but only 8 percent of the trees less than 10 inches in diameter. Oaks have historically been a high value species in the world lumber markets and therefore the decline of this species would most likely have a negative impact on the forest products industry. Of equal importance is the fact that numerous wildlife species would be negatively impacted if this important food source were reduced. This is just one example of the many challenges this report highlights.

This report will not be put on the shelf. It is a valuable tool that will enable the West Virginia Division of Forestry and other resource managers to recognize potential issues and develop strategies to address those issues, thus ensuring the sustainability of West Virginia's forest resource.

Sincerely,

Randy Dye

C. Randy Dye
Director/State Forester

Contents

Cathedral State Park. Photo courtesy of West Virginia Division of Forestry.

Highlights

On the Plus Side

West Virginia's forest land base has remained stable since 2000 at 12 million acres—78 percent of total land area—making it the third most forested state in the United States.

Timberland makes up 98 percent of West Virginia's forest land.

Public ownership of forest land has steadily increased, tripling since 1949. Publicly owned forests now total 1.5 million acres or 13 percent of the State's forest land.

Representing the largest ownership category, family forest owners hold 7.2 million acres—accounting for 60 percent of the State's forest land.

Sixty-seven percent of West Virginia's forest land is more than 300 feet from an agriculture use or developed edge, a general point where edge effect disappears and interior forest conditions begin.

Only 4 percent of forest land in West Virginia is located in a U.S. census block with population densities that exceed 150 people per square mile, the density at which the probability of commercial forestry drops to near zero.

Most of West Virginia's forest land is well stocked with trees of commercial importance.

Since 2000, the numbers of trees in the larger diameter classes have continued to increase while the numbers of trees in the 6-, 8-, and 10-inch classes have decreased.

The current growing-stock inventory is the highest recorded in West Virginia since FIA began. Growing-stock volume totals 25 billion cubic feet, which is 12 percent more than in 2000 and averages 2,136 cubic feet per acre.

Timber growth is concentrated on sawtimber-size trees (more than 11.0 inches in d.b.h.). Since 2000, the saw log portions of growing-stock volume increased by 23 percent to now total 88 billion board feet.

Yellow-poplar continues to lead in cubic-foot volume followed by white oak and chestnut oak.

The quality of saw logs in West Virginia has increased since the last inventory. The portion of sawtimber volume in high-quality tree grades 1 and 2 increased by 31 percent to 44 billion board feet.

During the last 60 years in West Virginia, the growth of trees has greatly outpaced mortality and removals. The growth-to-removals ratio averaged 1.9:1 for 2000-2008. Net growth exceeded removals for all major species except black locust.

West Virginia's forests are accumulating substantial amounts of biomass. These stores of carbon will receive more attention as we seek sources for renewable energy and ways to offset carbon dioxide emissions.

Issues to Watch

People at least 65 years old make up 19 percent of West Virginia's family forest owners and own 36 percent of family forest acreage. Because of the large change in ownership that is likely to occur in the next two decades, it will be important to watch how the new owners manage their lands.

The turnover of forest land to new owners will create a need for more education, advice, and other services to family forest owners.

A significant decrease in the area of small-diameter stands and a significant increase in the area of large-diameter stands have both occurred over the past three decades. There needs to be continued monitoring as the forest matures and less area contains stands of small-diameter trees.

The 2.0 million acres (17 percent) of timberland that are poorly stocked with commercially important species represent a loss of potential growth, although these forests still contribute to forest diversity.

Changes in species composition point toward potential reductions in tree quality for sawtimber into the future. Two of the species with a high proportion of low grade volume, American beech and red maple, are the same species that are showing large increases in saplings. Blackgum, another low valued species, is the fourth most numerous sapling-size tree.

In the current inventory, oaks represent more than 45 percent of the trees 20.0 inches and larger in diameter, but only 8 percent of trees less than 10.0 inches in diameter.

A lack of oaks in the small-diameter classes means that as large oaks are harvested or die, they likely will be replaced by species such as red and sugar maples that dominate the smaller diameter classes.

Future losses of oaks will affect wildlife populations and wood-using industries that now depend on oak.

Invasive insect pests that may impact important tree species in West Virginia in the future include the emerald ash borer, beech bark disease, and hemlock woolly adelgid.

Having markets for wood is essential to forest management. In 2007, there were 60 fewer operating mills than in 2000.

Background

Gauley River. Photo by Richard Widmann.

Introduction

Forests are one of West Virginia's most valuable assets due to their important contributions to the State's economy and the quality of life of its residents. Accurate and statistically defensible information is critical to understanding the current conditions, interpreting trends over time, and projecting future scenarios. In this report we highlight the current status and trends observed in West Virginia's forests.

This inventory was a cooperative effort of the Northern Research Station, the West Virginia Division of Forestry, Department of Commerce, and landowners of West Virginia. It is the culmination of the first complete inventory of West Virginia's forests using FIA's annualized forest inventory system. Previous inventories of West Virginia's forest resources were completed in 1949, 1961, 1975, 1989, and 2000 (Wray 1952, Ferguson 1964, Bones 1978, DiGiovanni 1990, and Griffith and Widmann 2003) and were collected under a different inventory system in which states were inventoried periodically with no measurements made between inventories. The annualized system was implemented to provide updated forest inventory information every year based on a 5- to 7-year cycle. The FIA program is the only source of data collected from a permanent network of ground plots from across the Nation that allows for comparisons among states and between regions.

More details on forest area estimation and other estimation procedures are included in the Data Sources and Techniques section at the back of this report and on the accompanying DVD.

A Beginners Guide to the Forest Inventory

What is a tree?

The FIA program of the U.S. Forest Service defines a tree as a perennial woody plant species that can attain a height of at least 15 feet at maturity.

What is a forest?

FIA defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having been stocked and not currently developed for nonforest use. The area with trees must be at least 1 acre in size and 120 feet wide.

What is the difference between timberland, reserved forest land, and other forest land?

West Virginia's forest land is broadly classified into three components that describe the potential of the land to grow timber products: reserved forest land, timberland, and other forest land. Two criteria are used to make these designations: site productivity (productive/unproductive) and reserved status (reserved/unreserved). Forest land where harvesting is restricted by statute or administrative designation is classified as reserved forest land regardless of its productivity class. Most land in this category is in state parks, national parks and recreation areas, and designated natural areas on the Monongahela National Forest. FIA does not use the harvesting intentions of private owners as a criterion for determining whether forests should be classified as reserved. Forest land without legal harvesting restrictions and capable of growing trees at a rate of at least 20 cubic feet per acre (equivalent to about 1/4 cord) per year is classified as timberland. The other forest land category is unreserved and low in productivity. It is incapable of growing trees at a rate of 20 cubic feet per acre per year. In West Virginia, this includes some surface-mined areas with extremely degraded soil. These categories help increase our understanding of the availability of forest resources and in forest management planning.

How is forest land area estimated?

FIA has established a set of permanent inventory plots across the U.S. that are periodically revisited. Each plot consists of four 24-foot radius subplots for a total area of approximately 1/6 of an acre.

Each plot is randomly located within a hexagon that is approximately 6,000 acres in size. Therefore, each plot represents about 6,000 acres of land and can be used to generate unbiased estimates, and associated sampling errors, for attributes such as total forest land area. For information on sampling errors, see the Statistics and Quality Assurance DVD at the back of this report. Full details of all estimation procedures are available in Bechtold and Patterson (2005)

How do we estimate the number of trees?

On the forested portions of each plot, all trees that have diameters of at least 5.0 inches at breast height (4.5 feet above the ground) are tallied. Because the total area sampled is known and the number of trees counted in this area, estimates of the number of trees can be made.

Saplings—trees between 1.0 and 4.9 inches—and seedlings are inventoried on 6.8-foot radius microplots that are nested within each subplot. The estimation procedure is analogous to that described above.

How do we estimate a tree's volume?

The volume for a specific tree species is usually determined by the use of volume equations developed specifically for a given species. Several volume equations have been developed at the Northern Research Station for each tree species found in the region. Models have been developed from regression analysis to predict volumes within a species group. We produce individual tree volumes based upon species, diameter, and merchantable height. Tree volumes are reported in cubic-foot and International ¼-inch rule board-foot scales.

What do stocking levels mean?

Stocking is the degree of occupancy of land by trees relative to the growth potential of the site being utilized. It is expressed as a percent of the "normal" value presented in yield tables and stocking guides. Two categories of stocking are used in this report: all live trees and growing-stock trees. The relationships between the classes and the percentage of the stocking standard are nonstocked (0 to 9); poorly stocked (10 to 34); moderately stocked (35 to 59); fully stocked (60 to 100); and overstocked (greater than 100). Current stocking levels should not be compared to previous periodic inventories because of changes in the stocking algorithm.

How much does a tree weigh?

Specific gravity values for each tree species or group of species were developed at the U.S. Forest Service's Forest Products Laboratory and applied to FIA tree volume estimates for developing merchantable tree biomass (weight of tree bole). To calculate total live-tree biomass, we have to add the biomass for stumps (Raile 1982), limbs and tops (Hahn 1984), and belowground stump and coarse roots (Jenkins et al. 2004). We do not currently report live biomass for foliage. FIA inventories report biomass weights as oven-dry short tons. Oven-dry weight of a tree is the green weight minus the moisture content. Generally, 1 ton of oven-dry biomass is equal to 1.9 tons of green biomass.

How do we compare data from different inventories?

Comparing new inventories with older datasets is commonly conducted to analyze trends or changes in forest growth, mortality, removals, and ownership acreage over time. A pitfall occurs when the comparison involves data collected under different schemes or processed using different algorithms. Recently, significant changes were made to the methods for estimating tree-level volume and biomass (dry weight) for northeastern states, and the calculation of change components (net growth, removals, and mortality) was modified for national consistency. These changes have focused on improving the ability to report consistent estimates across time and space—a primary objective for FIA. Regression models were developed for tree height and percent cull to reduce random variability across datasets.

Before the Component Ratio Method (CRM) was implemented, volume and biomass were estimated using separate sets of equations (Heath et al. 2009). With the CRM, determining the biomass of individual trees and forests has become simply an extension of our FIA volume estimates. This allows us to obtain biomass estimates for growth, mortality, and removals of trees from our forest lands, not only for live trees, but also for their belowground coarse roots, standing deadwood, and down woody debris.

Another new method, termed the "midpoint method," has introduced some differences in methodology for determining growth, mortality, and removals to a specified sample of trees (Westfall et al. 2009). The new approach involves calculating tree size attributes at the midpoint of the inventory cycle (2.5 years for a 5-year cycle) to obtain a better estimate for ingrowth, mortality, and removals. Although the overall net change component is equivalent under the previous and new evaluations, estimates for individual components will be different. For ingrowth, the midpoint method can produce a smaller estimate because the volumes are calculated at the 5.0-inch threshold instead of using the actual diameter at time of measurement. The actual diameter could be larger than the 5.0-inch threshold. The estimate for accretion is higher because growth on ingrowth, mortality, and removal trees are included. As such, the removals and mortality estimates will also be higher than before (Bechtold and Patterson 2005).

A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting especially because suitability and availability are subject to changing laws and ownership objectives. Simply because land is classified as timberland does not mean it is suitable or available for timber production. Forest inventory data alone are inadequate for determining the area of forest land available for timber harvesting because laws and regulations, voluntary guidelines, physical constraints, economics, proximity to people, and ownership objectives may prevent timberland from being available for production.

Forest Features

Seneca State Park. Photo courtesy of West Virginia Division of Forestry.

Dynamics of the Forest Land Base

Background

The amount of forest land in West Virginia and the percentage of land under forest cover are crucial measures in assessing forest resources and are vital for making informed decisions about forests. These measures are the foundation for estimating numbers of trees, wood volume, and biomass. Trends in forest land area are an indication of forest sustainability, ecosystem health, and land use practices. Gains and losses in forest area directly affect the amount of goods and services, including wood products, wildlife habitat, recreation, and watershed protection that forests can provide.

West Virginia spans five ecoregions (Bailey 1995) (Fig. 1). The Blue Ridge Mountains ecoregion covers only a small portion of Jefferson County in the State. It is not included in ecoregion analysis in this report because of high sampling errors. Grouping data into the remaining four regions aids analysis because estimates made for these have lower sampling errors than individual counties; thereby making estimates for them more precise. Areas within ecoregions are similar in topography, rainfall, and species composition. As such, management activities can broadly be tailored to conditions unique to each ecoregion. It could be expected that areas within an ecoregion would have similar fire regimes and responses to disturbance.

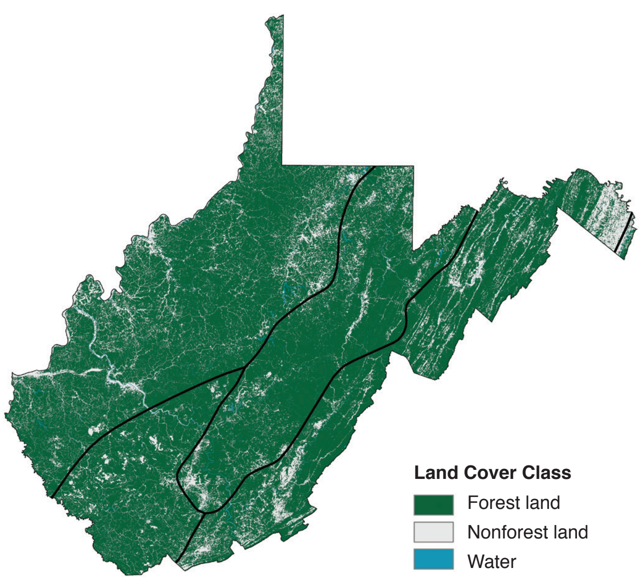


Figure 1.—Distribution of forest land in West Virginia based on the Multi-Resolution Land Characteristics project, NLCD-2006. The MRLC uses data from the Landsat satellite to map land across the Nation.

The Northern Ridge and Valley ecoregion runs along West Virginia's eastern border, east of the Allegheny Mountains. The northern portion of the ecoregion is closely associated with the Eastern Continental Divide that divides the Ohio/Mississippi River system from the Chesapeake Bay watershed. This region is in a rain shadow created by the Allegheny Mountains, and some areas average about half the rainfall of areas just to the west in the Allegheny Mountains ecoregion. The Allegheny Front, a major southeast-facing escarpment, forms a distinct western boundary for the region. On the east, it is bounded by the Blue Ridge Mountains ecoregion. In the Northern Ridge and Valley ecoregion, flatter and lower elevation land is typically underlain by limestone and dolomite bedrock that formed rich agricultural soils.

The Allegheny Mountains ecoregion includes most of the Monongahela National Forest and has some of the roughest terrain in the State. The Allegheny Mountains consist of nearly parallel northeast-southwest ridges and are among the oldest mountains on earth. Spruce Knob along the Allegheny Front Ridge is the highest point in the State at 4,863 feet elevation. Portions of the region receive average annual rainfall over 70 inches. The Allegheny Mountains and Northern Ridge and Valley ecoregions are drained through gorges that run parallel to the ridges. Examples include the North branch of the Potomac, Cheat, and Tygart Rivers in the north, and the Greenbrier River in the south.

Boundaries for the Northern Cumberland Mountains ecoregion are less distinct as the vegetation transitions from oak and hickory in the east to a more mixed mesophytic forest. Dissected uplands here are at a higher elevation than those of the adjacent Southern Unglaciated Allegheny Plateau to the northwest. This region has a history of more frequent and intense wildfires than other regions of the State. The major portion of the State's coal resource is located in the region. The mixed mesophytic forests of the Allegheny Mountains, Allegheny Plateau, and Cumberland Plateau have been characterized as the most complex and oldest associations of deciduous forests (Braun 1950).

The Southern Unglaciated Allegheny Plateau is a severely eroded plateau. Relief is sharp although the elevations are not as high at those to the east and south. The plateau is dissected by many small creeks and streams forming sharp ridges and narrow valleys.

What we found

Seventy-eight percent of West Virginia's land area, 12.0 million acres, is forest land (Fig. 2).These forests are well distributed throughout the State (Fig. 1). From 1949 to 1989, forest land in the State increased by 2 million acres, mainly due to reversion of agricultural land (Fig. 3) Since 1989, the amount of forest land has changed very little as the amount of agricultural land in the State has stabilized (Fig. 4). The slight decrease in forest area since 2000 (0.3 percent) is not large enough to make the 2008 estimate statistically different from 2000. About a third of the forest land is above 2,000 feet in elevation (Fig. 5). The Allegheny Mountains ecoregion is the most heavily forested region at 81 percent and the Northern Ridge and Valley ecoregion is the least forested at 69 percent (Fig 6). There is great contrast between ecoregions in the distribution of forest land by elevation. The Allegheny Mountains ecoregion has almost no forest land below 1,000 feet whereas the Southern Unglaciated

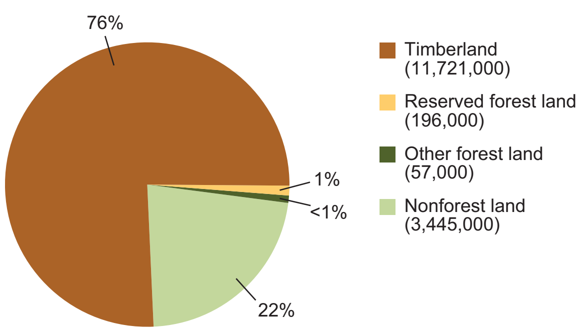


Figure 2.—Land area (in acres) by major use, West Virginia, 2008.

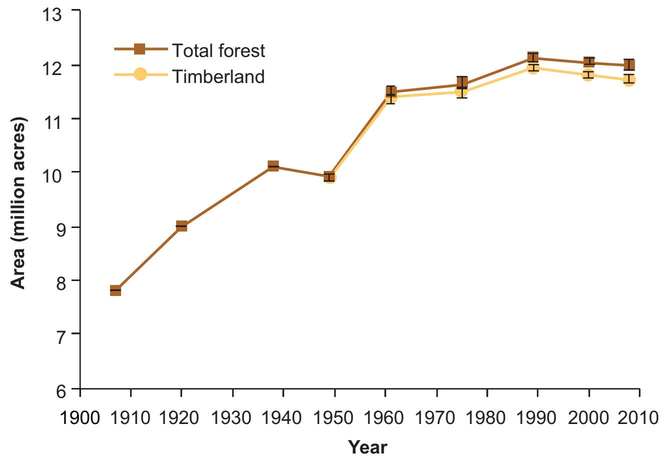


Figure 3.—Area of forest land and timberland in West Virginia by inventory year, 1949, 1961, 1975, 1989, 2000, and 2008 with approximations of forest land area given for 1907, 1920, and 1938 (Smith et al. 2009) (error bars represent 68-percent confidence intervals around the estimates).

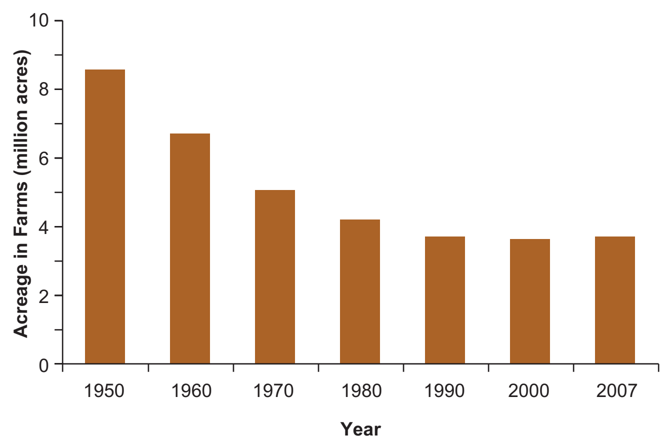


Figure 4.—Acreage in farms (includes farm woodlots), West Virginia, 1950-2007 (source: National Agriculture Statistics Service).

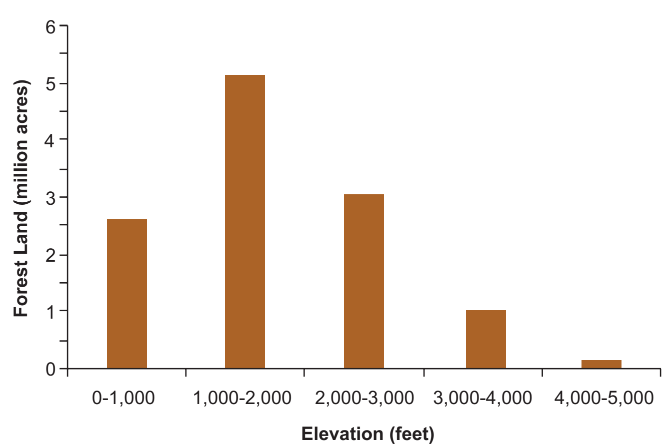


Figure 5.—Elevation of forest land, West Virginia, 2008.

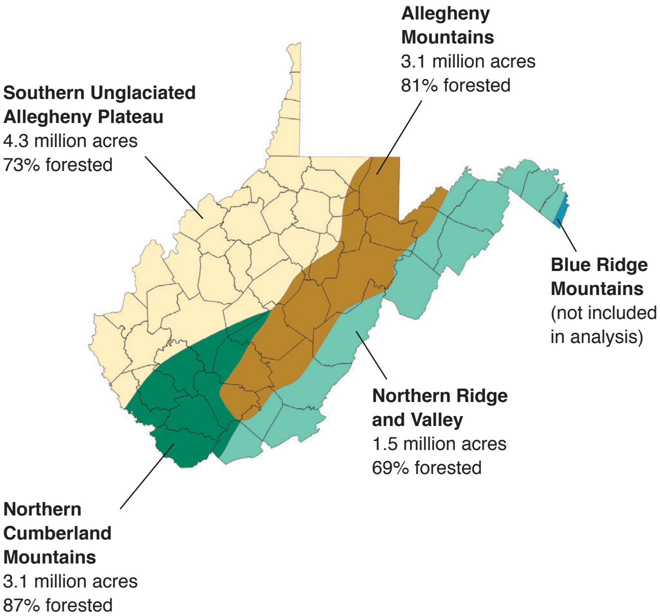


Figure 6.—Acreage of forest land and percentage of land in forest by FIA ecoregion, West Virginia, 2008.

Allegheny Plateau has about half its forest land below 1,000 feet and a negligible amount of forest land above 2,000 feet (Fig. 7). Although total forest land has shown little change statewide since 2000, gains in the Northern Cumberland Mountains ecoregion have mostly offset losses in the Northern Ridge and Valley ecoregion and other regions.

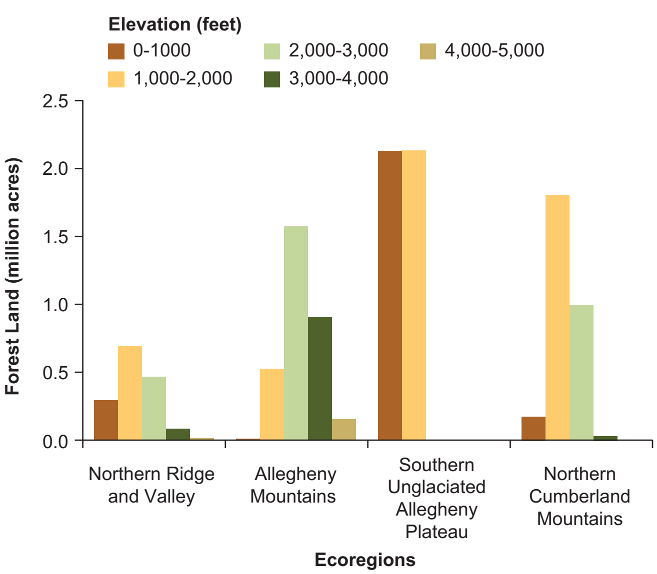


Figure 7.—Elevation of forest land area by ecoregion, West Virginia, 2008.

Ninety-eight percent of West Virginia's forest land, 11.7 million acres, is classified as timberland, an increase of 12,000 acres since 2000. However, this increase is not large enough to make the two estimates statistically different. The amount of forest land reserved from harvesting has increased with each successive inventory and now represents 1 percent of the total land area and 1.6 percent of forest land. Other forest land is relatively rare and amounts to less than half a percent of total forest land.

What this means

Trends in forest land area may indicate that the area of forest land in West Virginia is near a peak. With the amount of agricultural land stable, future changes in West Virginia's forest land will depend on the pace of land development.

With more than three-fourths of the State in productive forest, the timber resource contributes greatly to the State's economy and represents a significant share of the economic activity. Because most forest land is classified as timberland, major trends occurring on timberland also apply to forest land. Additions to reserved forest land usually come from the reclassification of timberland. But because losses in timberland to reserved forest land have been small, these changes have had little effect on the timber resource. Trees growing on timberland represent the resource base upon which the forest products industry relies and are considered potentially available for harvesting. The discussion on the woodland owner study later in this report provides more details on how much timberland is actually available and being actively managed for timber products.

The higher elevations of West Virginia are characterized by a cool-moist-temperate climate, associated with the higher elevations of the Eastern Continental Divide. These climate conditions produce large volumes of fresh water and enable high production of quality hardwood. West Virginia includes the headwaters of many major eastern rivers, with many downstream communities dependent on water flowing from the State. Forested watersheds provide water purification, mitigation of floods and droughts, soil retention, and maintenance of habitats.

Ownership of Forest Land

Background

How land is managed is primarily the owner's decision. Owners decide who they will allow on their land and what types of activities will take place. Therefore, to a large extent, the availability and quality of forest resources are determined by landowners, including recreational opportunities, timber, and wildlife habitat. Owners' decisions are influenced by their management objectives, size of land holdings, and form of ownership. Public and private owners often have different goals that reflect their priorities and management practices. Family forest owners are further influenced by their age, education, and life experiences. The National Woodland Owner Survey (NWOS) conducted by the Forest Service studies the attitudes, management objectives, and concerns of private forest landowners (Butler 2008). This survey has recently focused on understanding what is important to family forest owners.

What we found

Publicly owned forests represent a relatively small portion of West Virginia's forests. Public owners hold 1.5 million acres or 13 percent of the State's forest land. The largest public owner is the Federal Government, which holds 1.2 million acres or 10 percent of the forest land in the State (Fig. 8). Included in this are 1.0 million acres of forest land in national forests. State and local governments hold 337,000 acres (3 percent) in various parks and state forests. Public ownership of forest land has increased by nearly two-thirds since 1949.

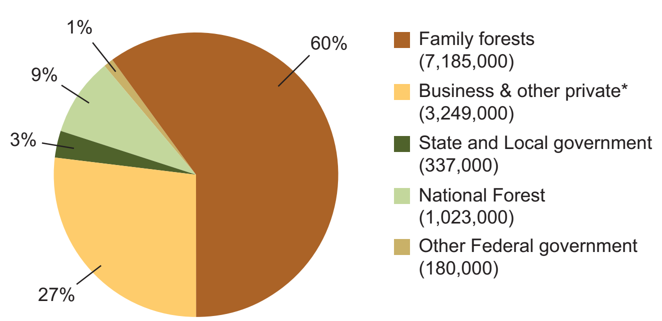


Figure 8.—Ownership of forest land (in acres) by major ownership category, West Virginia, 2008.

Generally, public ownership of forest land increases with increases in elevation; about half the forest land in the 3,000- to 4,000-foot class is in public ownership as well as nearly all the forest land above 4,000 feet (Fig. 9).

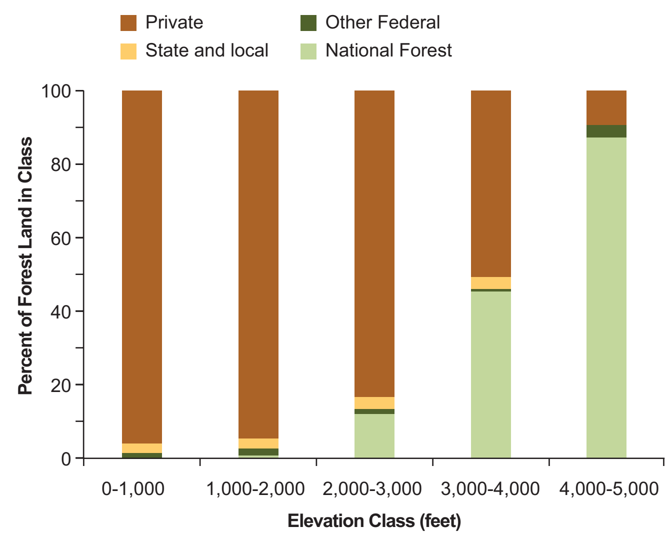


Figure 9.—Percentage of forest land by elevation class and major ownership category, West Virginia, 2008.

In West Virginia, 251,000 private individuals and enterprises own 87 percent of the State's forest land—10.4 million acres. Of this, businesses hold an estimated 3.2 million acres—27 percent of the forest land. This category includes corporations, nonfamily partnerships, nongovernmental organizations, clubs, and other private nonfamily groups. Representing the largest ownership category, family forest owners hold 7.2 million acres, accounting for 60 percent of the State's forest land.

The NWOS found that there are 243,000 family forest owners in West Virginia (Fig 10). This category is represented by individuals, farmers, small family corporations, and partnerships. Eighty-two percent of these owners hold fewer than 50 acres. These small holdings total 1.9 million acres and make up 27 percent of the family forest land in the State. Owners with more than 100 acres represent 8 percent of family forest owners but hold about half the family forest acres or 3.6 million acres. From a list of 12 reasons for owning forest

Figure 10.—Number of family forest owners and acres of forest land by size of forest land holdings, West Virginia, 2006.

land, "part of home or cabin" ranked first by number of ownerships and "privacy" ranked first by area owned (Fig. 11). Owning forest land for aesthetics, hunting or fishing, and family legacy also ranked high. Timber production ranked low in importance to West Virginia's family forest owners; it was ranked as important or very important by only 11 percent of owners who hold 23 percent of the acreage. However, 38 percent of owners

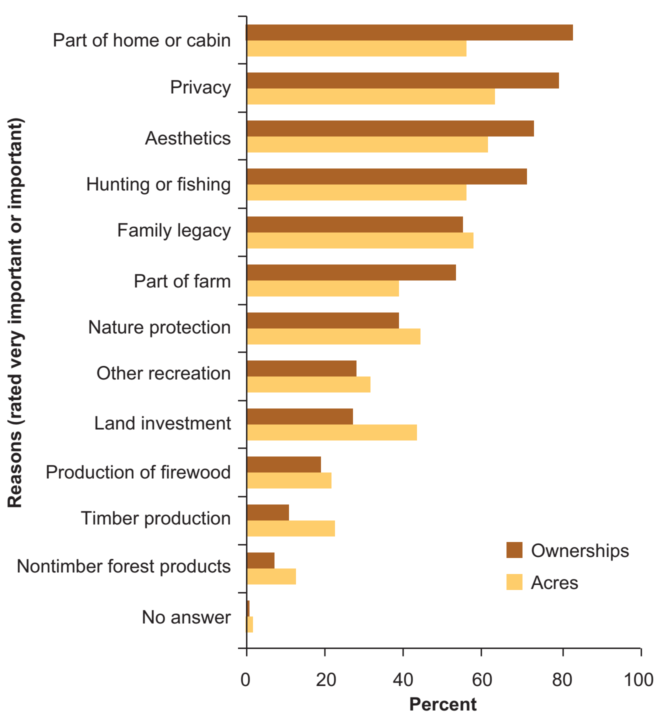


Figure 11.—Percentage of family forest owners and acres of forest land by reasons given for owning forest land ranked as very important or important, West Virginia, 2006. Categories are not exclusive.

holding 60 percent of the family forest land reported harvesting trees and 29 percent of owners had harvested saw logs (Fig. 12).

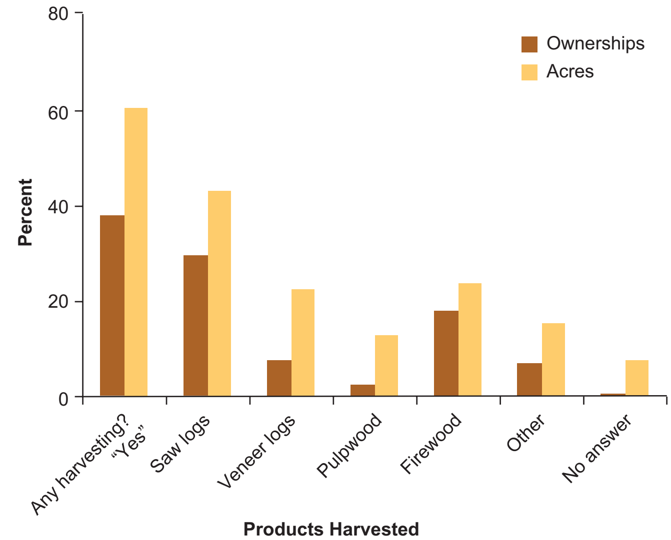


Figure 12.—Percentage of family forest owners and acres of forest land by harvesting experience and products harvested, West Virginia, 2006. Categories are not exclusive.

Written management plans exist for just 2 percent of the family owned forest land, and only 5 percent of the owners holding 19 percent of the family forest acreage have sought management advice (Fig. 13). The State Division of Forestry led as a source of management advice. Family forests are frequently associated with a residence or farm. Sixty-eight percent of owners with 58 percent of family forest acreage said that their forests are associated with their primary residence. Nineteen percent of West Virginia's family forest owners are at least 65 years old (Fig. 14). This group controls 36 percent of family forest acreage or 2.6 million acres. The tenure of family forest owners is fairly long: 39 percent of the acreage has been held for 25 years or longer. When owners were asked about activities taking place on their land in the past 5 years, private recreation, and posting land ranked high. And, when asked about future activity planned for their land in the next 5 years, 8 percent of owners holding 14 percent of the family forest land said they planned to transfer all or part of it to heirs, and 56 percent of owners with 69 percent of the area indicated "minimal activity" or "no activity" (Fig. 15). Harvesting either saw logs or pulpwood was planned on 19 percent of the family owned forest land.

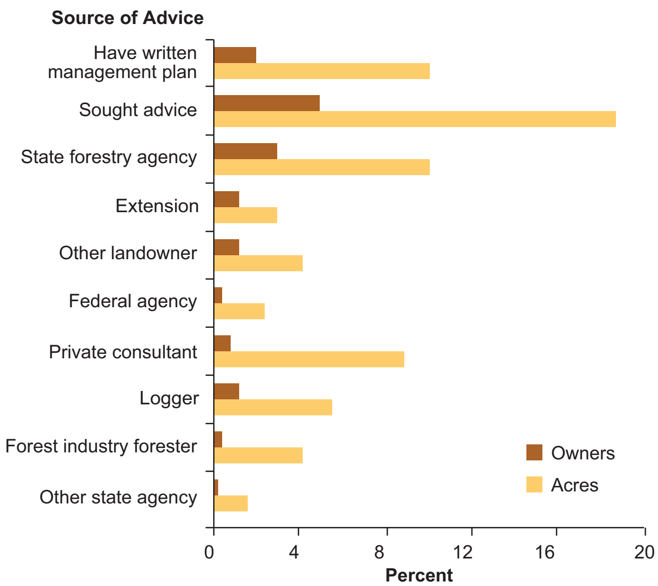


Figure 13.—Percentage of family forest owners and acres of forest land who have a written management plan, who have sought advice, and advice source, West Virginia, 2006. Categories are not exclusive.

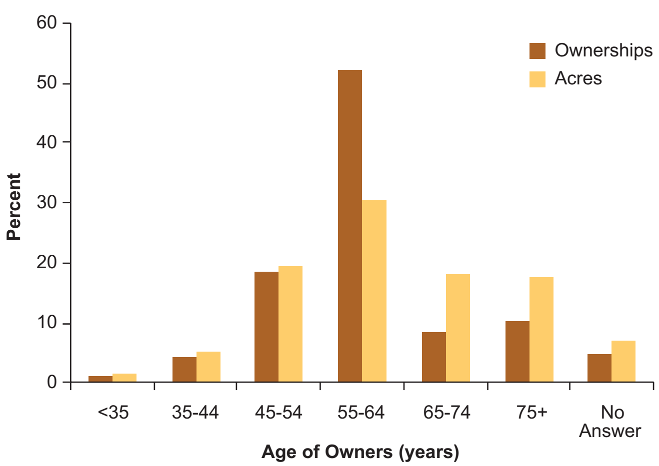


Figure 14.—Percentage of family forest owners and acres of forest land by age of owners, West Virginia, 2006.

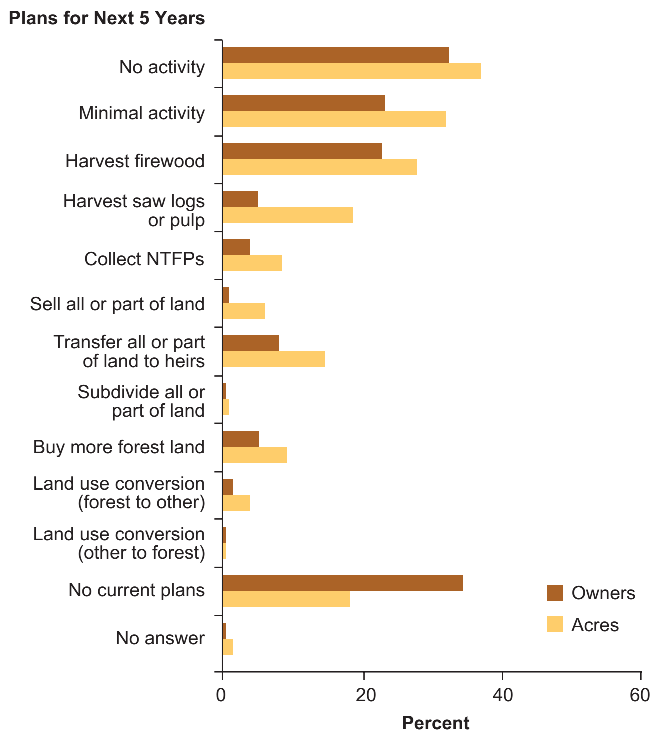


Figure 15.—Percentage of family forest owners and acres of forest land by plans for next 5 years, West Virginia, 2006. NTFPs are non-timber forest products.

What this means

The high percentage of publicly owned high-elevation forest land means that the headwaters of many watersheds are on public land. Because management of publicly owned forests is typically restricted by more rules and regulations than privately owned forest, public ownership brings a higher level of protection for these unique and often more vulnerable and less productive forests. However, on many acres of public land the mineral rights are privately owned, removing some of this protection.

Because most of West Virginia's forest land is held by thousands of private landowners, decisions by these owners will have a great influence on West Virginia's future forest. Family forest ownerships with 100 acres or more make up half of the family forest acreage but represent only 8 percent of the numbers of owners. Targeting government programs toward these owners would be more cost efficient than trying to reach all owners, but would miss the 3.6 million acres of forests in ownerships of fewer than 100 acres.

The low priority given by landowners to timber production does not mean that landowners will not harvest trees. The relatively high number of owners that actually harvest trees shows that when conditions are right most landowners will harvest trees, although the low priority given to timber production probably means that these harvests are not part of a long-term management plan.

Nearly a quarter of owners holding 43 percent of the family forest land are 65 or more years old, and 14 percent of family forest acreage is held by owners who are planning to transfer ownership in the next 5 years. This foretells a large turnover of forest land ownership in the near future. At the time ownership is transferred, forest land becomes vulnerable to unsustainable harvesting practices and division into smaller parcels. The turnover of forest land to new owners will increase the need for services to family forest owners such as advice on how to manage forest sustainability.

Urbanization and Fragmentation of Forest Land

Background

The expansion of urban lands that accompanies human population growth often results in the fragmentation of natural habitat (Wilcox and Murphy 1985). Forest fragmentation and habitat loss is recognized as a major threat to wildlife populations worldwide (Honnay et al. 2005, Rosenberg et al. 1999), particularly for species that require interior forest conditions for all or part of their life cycle (Donovan and Lamberson 2001) and species that are wide ranging, slow moving, and/or slow reproducing (Charry and McCollough 2007, Forman et al. 2003). Forest fragmentation can also affect forest ecosystem processes through changes in microclimate conditions, and it affects the ability of tree species to move in response to climate change (Iverson and Prasad 1998).

Honnay et al. (2005) and others have pointed out that the spatial/physical fragmentation of habitats is only one of the human-induced processes affecting natural habitats and their biodiversity. Urbanization, increasing the proximity of people, development, and other anthropogenic pressures to natural habitats, and changes in the ways in which humans use those natural habitats, can lead to overexploitation of species, environmental/habitat deterioration, changes in hydrology, and introduction of exotic species, to name a few. In addition to the negative effects on forested ecosystems, the fragmentation and urbanization of forest land may have direct economic and social effects as well. For example, smaller patches of forest or those in more populated areas are less likely to be managed for forest products (e.g., Kline et al. 2004, Wear et al. 1999) and are more likely to be "posted" (i.e., not open for public use) (Butler 2008), potentially affecting local forest industry, outdoor recreation opportunities, and local culture. Forested watersheds provide water purification, mitigation of floods and droughts, soil retention, and maintenance of habitats. Surface runoff is rare in forest environments because most rainfall moves to streams through subsurface flows where nutrient uptake, cycling, and contaminant absorption processes are rapid. Because of the dominance of subsurface flow on forest land, peak flows are moderated and base flows are prolonged. Fragmentation and urbanization of that forest land has been observed to affect both water quality and quantity (e.g., McMahon and Cuffney 2000, Riva-Murray et al. 2010).

The metrics presented here relate to some aspects of urbanization or fragmentation that are suspected of having, or have been documented to have, some effects on the forest, its management, or its ability to provide ecosystem services and products (Riemann et al. 2008). These measures are forest edge versus interior, proximity to roads, patch size, local human population density, and extent of houses intermixed with forest.

What we found

In West Virginia, 67 percent of the forest land is more than 300 feet from an agriculture use or developed edge, ranging from 62 percent in the Southern Unglaciated Allegheny Plateau ecoregion to 75 percent in the Northern Cumberland Mountains ecoregion (Table 1). Figure 16 shows to what extent forest land is affected by roads. As both Forman (2000) and Riitters and Wickham (2003) reported, this can be quite extensive, even in areas that appear to be continuous forest land from the air. In West Virginia, for example, 23 percent of the forest land is within 330 feet of a road of some sort and 57 percent is within 980 feet.

Forest land in West Virginia occurs primarily as a relatively contiguous forest matrix within which urban development, agriculture, roads, and other nonforest areas occur (Riiters et al. 2000). Forested areas containing higher proportions of small patches (patches <100 acres) occur only in the northeastern panhandle and other widely scattered areas. No ecoregion has more than 5 percent of its forest land in patches less than 100 acres in size, and the Northern Cumberland Mountains ecoregion has only 1 percent (Fig. 17).

Table 1.—Distribution of forest land with respect to urbanization and fragmentation factors, expressed as a percent of the total forest land area in each ecoregion

Ecoregion	% forest land in ecoegion[a]	Forest land with house density > 15.5 per sq. mile[b]	Forest land > 295 feet (90m) from an ag or developed edge[c]	Forest land > 980 feet from a road[d]	Forest land located in patches > 100 acres in size[e]	Forest land located in a block with population densities > 150/sq. mi. (57.9/sq. km.)[f]
Northern Ridge and Valley	77	20	68	47	97	3
Southern Unglaciated Allegheny Plateau	81	32	62	36	97	5
Allegheny Mountains	86	17	70	46	98	3
Northern Cumberland Mountains	86	31	75	51	99	2
West Virginia	82	26	67	43	97	4

[a] Percent forest estimate based on NLCD 2001. Values are generally higher than estimates from FIA plot data.
[b] Approximating the forest land potentially affected by underlying development.
[c] Approximating the forest land undisturbed by edge conditions.
[d] Approximating the forest land outside the effects of roads.
[e] approximating the forest land with potentially enough core area for sustainable interior species populations.
[f] Approximating the forest land not available for commercial forestry.

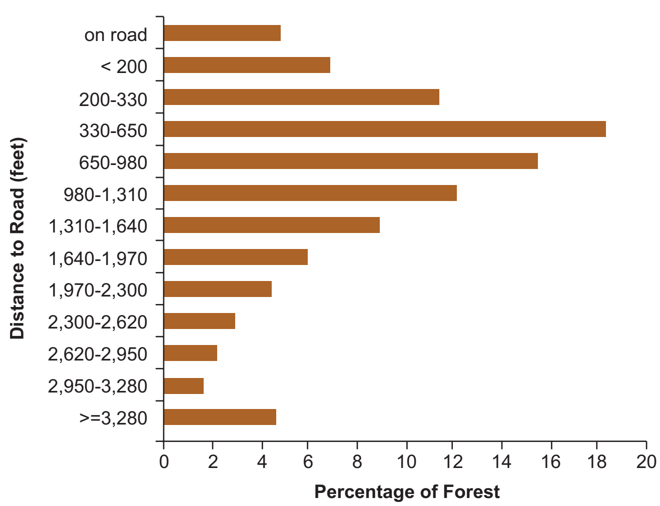


Figure 16.—Percentage of forest land by distance to nearest road, West Virginia, 2008.

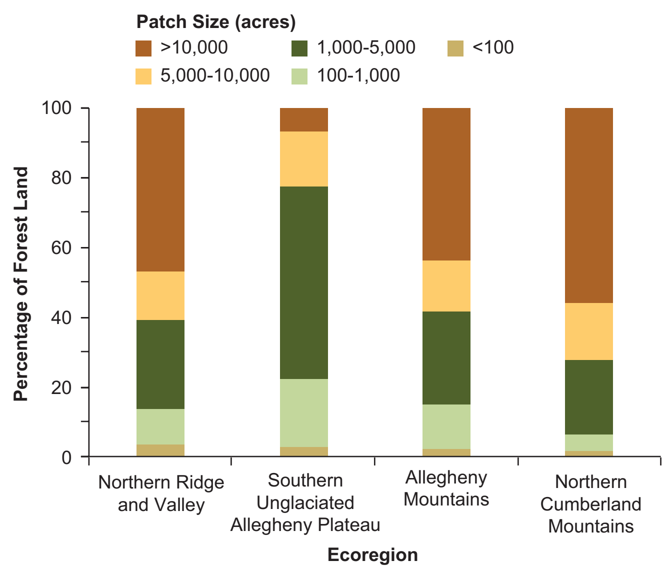


Figure 17.—Percentage of forest land by patch size and ecoregion, West Virginia, 2008.

The Wildland-Urban Interface (WUI) is commonly described as the transition zone where human development intermingles with undeveloped wildland vegetation. It is associated with a variety of human-environment conflicts and is defined in terms of density of houses (greater than 15.5 houses per square mile), percentage of vegetation coverage present, and proximity to developed areas (Radeloff et al. 2005). Figures 18 and 19 illustrate that 26 percent of the forest land in West Virginia is affected by underlying house densities greater than the threshold of 15.5 houses per square mile. Ecoregion percentages range from 17 percent (Allegheny Mountains) to 32 percent (Southern Unglaciated Allegheny Plateau) of the forest intermixed with house densities greater than 15.5 per square mile. A close proximity between humans and forest land has also been observed to affect the viability of commercial forestry and has been described most clearly to be related to local human population density near forested areas (Wear et al. 1999). In West Virginia, only 4 percent of the forest land is located in a U.S. census block with population densities above 150 people per square mile (Table 1).

The extent to which the current forest land base is being influenced by these factors is shown in Table 1.

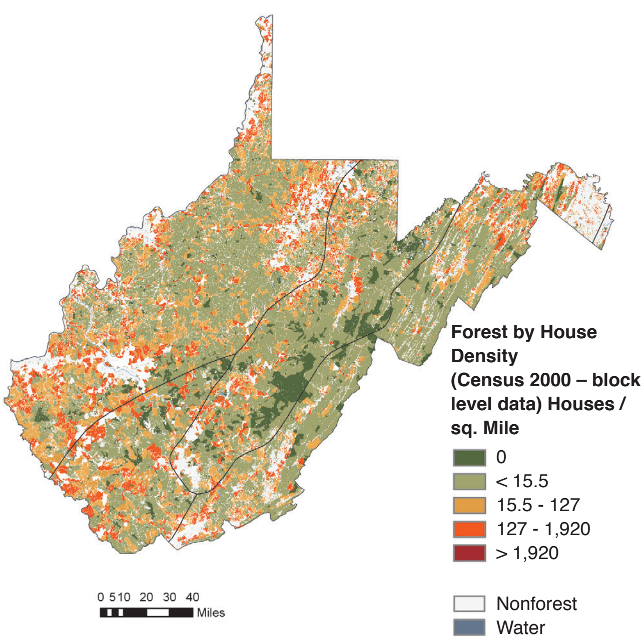


Figure 18.—Forest land by house density of the census block it is located in (U.S. Census Bureau 2000), West Virginia, 2008.

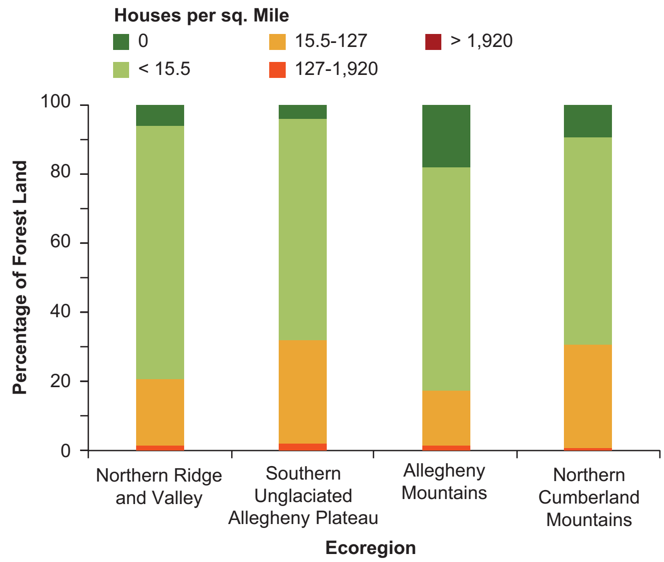


Figure 19.—Forest land by house density of the census block it is located in (U.S. Census Bureau 2000) and ecoregion, West Virginia, 2008.

For example, in West Virginia as a whole, 26 percent of that forest land is potentially affected by house densities greater than 15.5 per square mile, while 67 percent of the forest land is far enough from an edge to be considered interior forest conditions. Nearly all of the forest land is in large patches (>100 acres), but only 43 percent is farther than 980 feet from a road. Many of these large patches are composed of many ownerships or parcels.

What this means

Edge effects vary somewhat with distance from the forest edge and depend on the type of effect and species of vegetation or wildlife present, (e.g., Chen et al. 1992, Flaspohler et al. 2001, Rosenberg et al. 1999). However, 100 to 300 feet is frequently used as a general range for the "vanishing distance" or the distance into a patch where the edge effect disappears and interior forest conditions begin.

The relationship between roads, urbanization, and forest fragmentation can also be assessed in the landscape (Figs. 20, 21). Road effects diminish when distances range from about 330 feet for secondary roads, 1,000 feet for primary roads in forest (assuming 10,000 vehicles per day), and 2,650 feet from roads in urban areas (50,000 vehicles per day) (Forman 2000). Roads have a variety of effects, including hydrologic, chemical (salt, lead, nutrients), sediment, noise, as vectors for the introduction of invasive species, habitat fragmentation, and increases in human access, impacting forest ecosystem processes, wildlife movement and mortality, and human use of the surrounding area. West Virginia is in the middle of a large section of the eastern United States with more than 60 percent of its land area within 1,250 feet of the nearest road (Riitters and Wickham 2003). With 69 percent of West Virginia's forest land within 1,310 feet of a road, cumulative ecological impacts from roads should be a very real consideration. Actual ecological impacts of roads will vary by the width of the road and its maintained right-of-way, number of cars, level of maintenance (salting, etc.), number of wildlife-friendly crossings, hydrologic changes made, perviousness of road surfaces, location with respect to important habitat, end other factors. These variables also suggest some of the changes that can be made to moderate the impact of roads on the forest (Charry and McCollough 2007, Forman 2000, Forman et al. 2003).

Habitat requirements for wildlife vary by species, but for reporting purposes, it is often helpful to summarize forest-patch data using general guidelines. Many wildlife species prefer contiguous forest patches of at least 100 acres. This patch area is often used as a minimum size, still containing enough interior forest to be a source rather than a sink for populations of some wildlife species. Without considering the impact of roads or houses that do not substantially break the tree canopy, 97 percent of West Virginia's forest land is in patches larger than 100 acres.

Human population density is generally recognized as having a negative effect on the viability and practice of commercial forestry (Barlow et al. 1998, Kline et al. 2004, Munn et al. 2002, Wear et al. 1999). Working in Virginia, Wear et al. (1999) identified a threshold of 150 people per square mile as the population density at which the probability of commercial forestry drops to practically zero. In West Virginia, 4 percent of forest land occurs within census blocks that exceed that threshold of 150 people per square mile.

Forest intermixed with houses represents areas of forest cover most likely to be in nonforest land use, or more likely to be experiencing pressures from recreation, invasive plant species, and other local human effects. This intermix area also represents a challenge to managing forest fires. A threshold of 15.5 houses per square mile represents the approximate density at which firefighting switches from "wildland" to "structure" firefighting techniques and costs (Radeloff et al. 2005). Although the other pressures from high housing densities can be more of an issue in some areas than forest fires, thresholds for those issues are less developed at this point. Therefore, Figure 18 should be interpreted as identifying where areas of increased pressure from intermixed residential development are likely to occur. Nationwide increases in lower density "exurban" development have been forecast by both Theobald (2005) and Hammer et al. (2004), particularly at the urban fringe and in amenity rich rural areas.

Forest health, sustainability, management opportunities, and the ability of forest land to provide products and ecosystem services are all affected to varying degrees and in different ways by changes in the fragmentation and urbanization of that forest land.

Forest Resource Attributes

Seneca Rocks. Photo by Richard Widmann.

Forest Structure—How Dense are the Woods?

Background

How well forests are populated with trees is determined by measures of trunk diameter (measured at breast height (d.b.h.)) and the number of trees. The number of trees is a basic measurement in forest inventories, whether the total number of trees in a forest or number of trees on a per acre basis. It is generally straightforward to estimate, reliable, objective, and comparable with past estimates. In spite of their simplicity, estimates of the number of trees by size are valuable in showing the structure of West Virginia forests and the changes that are occurring.

Numbers of trees per acre and their diameters are used to determine levels of stocking. Stocking levels indicate how well a site is being utilized to grow trees. Stocking levels are calculated in this report using two methods, one using all live trees and the other including only growing-stock trees. Growing-stock trees are economically important and do not include noncommercial species (i.e., hawthorn, striped maple, and sourwood) or trees with large amounts of cull (rough and rotten trees). In fully stocked stands, trees are using all of the space and resources (light, water, nutrients) of the site to grow. As stands become overstocked, trees become overcrowded, growth begins to slow, and mortality increases. In poorly stocked stands, trees are widely spaced, or if only growing-stock trees are included in the stocking calculations, the stands can contain many trees with little or no commercial value. Poorly stocked stands can develop on abandoned agricultural land and areas that have been surface-mined, or they can result from wildfires or poor harvesting practices. Poorly stocked stands are not expected to grow into a fully stocked condition in a reasonable amount of time whereas moderately stocked stands will. Comparing stocking levels of all live trees with that of growing-stock trees shows the effect cull and noncommercial species are having on stocking levels. These trees can occupy substantial amounts of growing space that otherwise could be used to grow trees of commercial value, even though they still contribute ecological value.

The seedling-sapling stage follows major disturbances such as clearcutting, surface-mine reclamation, and reversion of farm land to forest. In this stage many wildlife species use low-growing herbaceous and shrub vegetation. Typically found in such stands are early successional, pioneer tree species, such as aspen, black cherry, and white ash as well as a variety of herb and shrub plants that thrive in full sunlight. These stands provide unique nesting and feeding habitat for wildlife. As stands grow into the poletimber- and sawtmber-size classes, much of the low-growing vegetation is shaded out, and species that depend on early successional vegetation decline in number as species that use the boles of trees increase. Bole characteristics that develop as a stand matures include bark flaps and cavities.

What we found

Trees have increased in size, while the average number of trees per acre has remained nearly unchanged since 1989. Of trees 5.0 inches and larger in d.b.h., the average diameter has increased from 9.7 to 10.0 inches since 2000 (Fig. 20), and the number of trees per acre has remained statistically unchanged at 147 (Fig. 21). Since the 2000 inventory, the number of trees classified as rough, rotten, and noncommercial species has increased from 14 to 18 per acre.

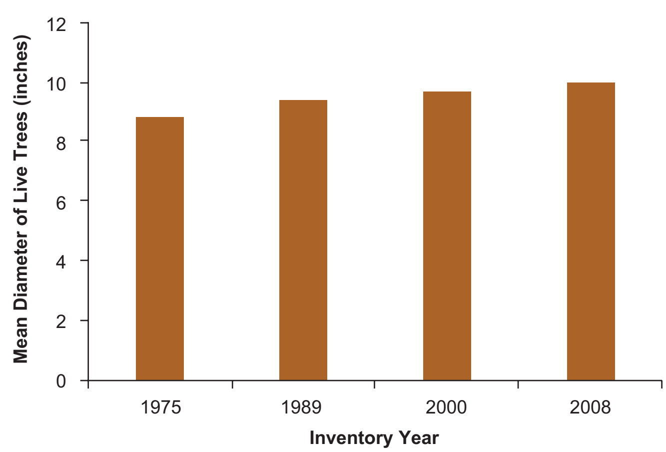


Figure 20.—Mean diameter of live trees (5.0 inches and larger in d.b.h.) by inventory year, West Virginia.

The Allegheny Mountains ecoregion has the highest number of trees per acre, and these trees have an average diameter larger than that for the State. The Northern

Figure 21.—Average number of trees per acre (5.0 inches and larger in d.b.h.) by inventory year, West Virginia.

Ridge and Valley ecoregion has the lowest average diameter with a high number of trees per acre. Trees in the Southern Unglaciated Allegheny Plateau and Northern Cumberland Mountain ecoregions, on average, have lower numbers of trees per acre with larger diameters than overall State averages (Fig. 22).

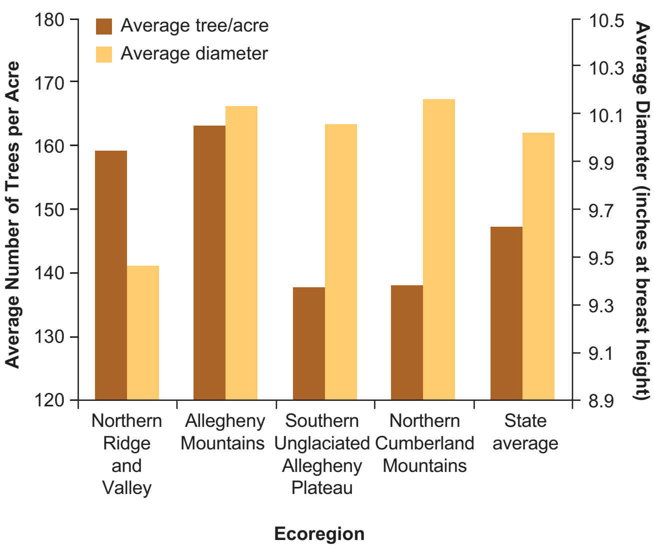


Figure. 22—Average number and diameter of trees 5.0 inches and larger on timberland, by ecoregion, West Virginia, 2008.

Changes in the number of trees have not been distributed evenly across diameter classes (Fig. 23). Between 1961 and 1989, the numbers of trees increased across all diameter classes with the largest increases taking place in the 6- and 8-inch diameter classes. Then, from 1989 to 2000, the numbers of trees in the 6- and 8-inch classes decreased

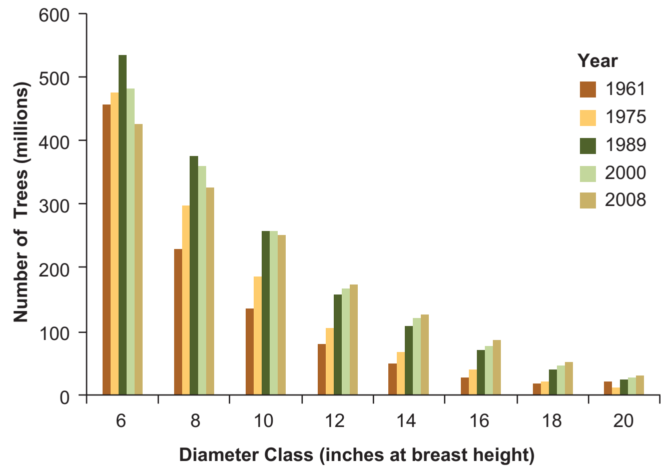


Figure 23.—Number of growing-stock trees by diameter class and inventory year, West Virginia.

while the numbers of trees in larger diameter classes continued to increase. This trend continued from 2000 to 2008, with tree numbers now decreasing in the 6-, 8-, and 10-inch diameter classes and trees in the even larger diameter classes continuing to increase. Generally, the larger the diameter class, the larger the percentage increase in number of trees (Fig. 24).

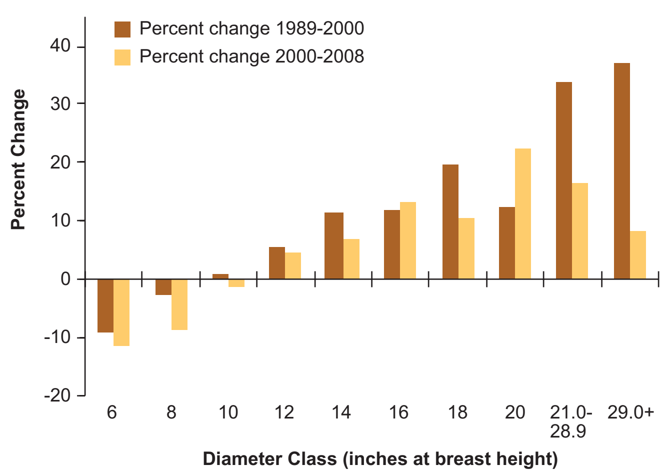


Figure 24.—Percent change in the numbers of trees by diameter class, West Virginia, 1989-2000 and 2000-2008.

In West Virginia, 5.9 million acres (50 percent) of timberland are fully stocked or overstocked with live trees, and 1.2 million acres (10 percent) are either poorly stocked or nonstocked (Fig. 25). Since 2000, stocking levels have decreased as acreage has shifted from fully stocked and overstocked levels to moderately and poorly stocked. Fully stocked and overstocked stands have decreased by 1.0 million acres since 2000, although half the timberland is still fully stocked with live trees.

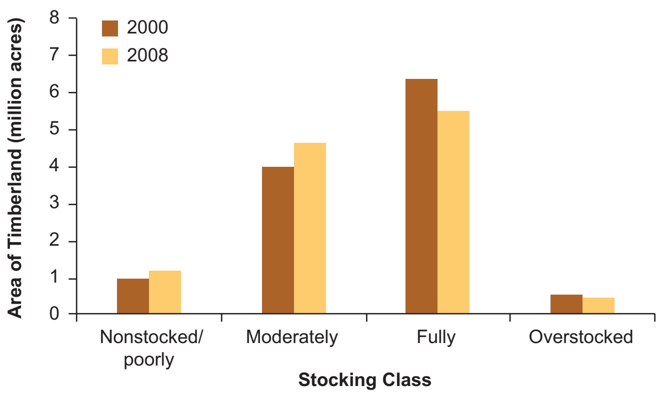


Figure 25.—Area of timberland by stocking class of live trees, West Virginia, 2000 and 2008.

If only the commercially important growing-stock trees are considered in calculating stocking, the area with poor stocking increases to 2 million acres—800,000 acres more than when all trees are included (Fig. 26). These poorly stocked stands are distributed across all stand-age classes and stand-size classes, although they make up a larger portion of older and larger stands. Seventy percent of these stands are more than 40 years old, and about half are dominated by large-diameter trees (Figs. 27, 28). The Allegheny Mountains ecoregion has the highest portion of its timberland in overstocked and fully stocked stands, whereas the Southern Unglaciated Allegheny Plateau ecoregion has the lowest portion of its timberland in overstocked and fully stocked stands, and the largest portion in poorly stocked and nonstocked stands (Fig. 29).

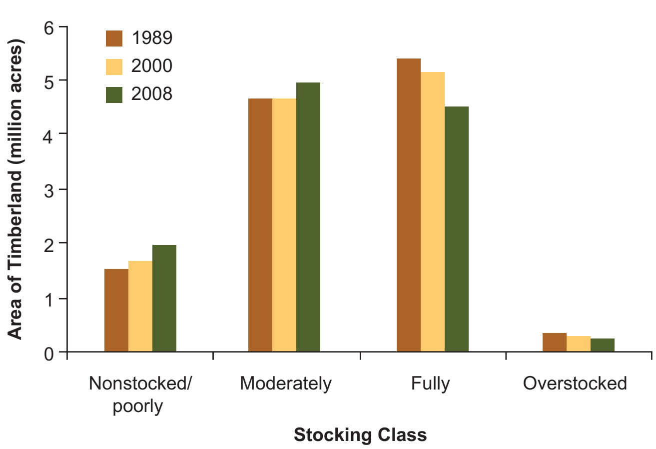


Figure 26.—Area of timberland by stocking class of growing-stock trees, West Virginia, 1989, 2000, and 2008.

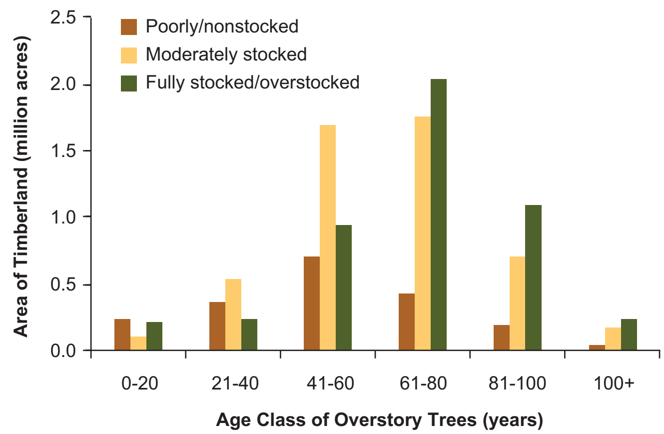


Figure 27.—Area of timberland by stocking of growing-stock trees and stand-age class, West Virginia, 2008.

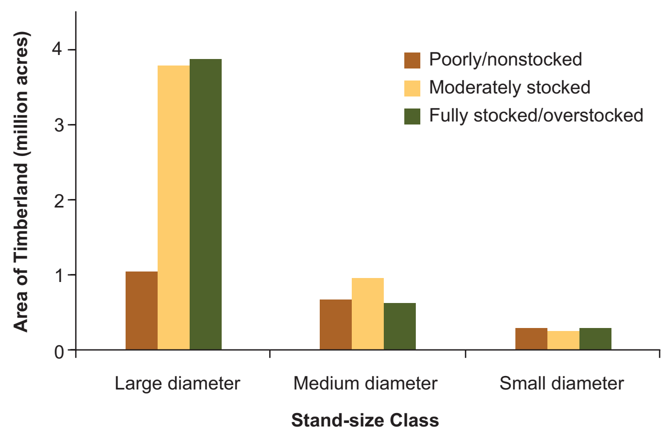


Figure 28.—Area of timberland by stocking of growing-stock trees and stand-size class, West Virginia, 2008.

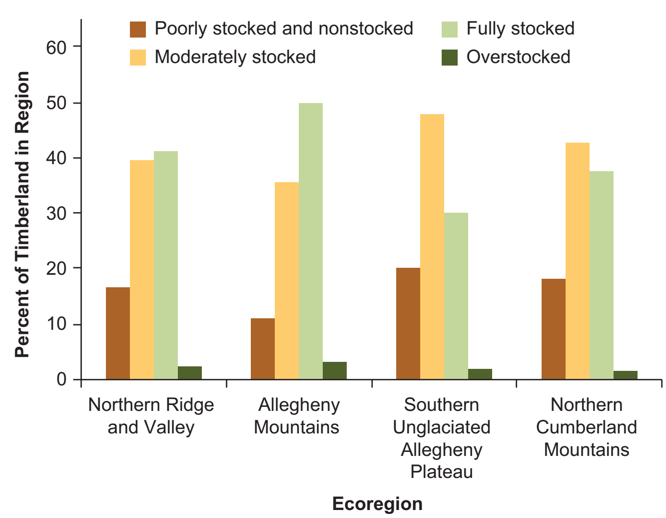


Figure 29.—Percentage of timberland by stocking class of growing-stock trees, by ecoregion, West Virginia, 2008.

Across the State, forests have continued to mature as large amounts of timberland have grown to sawtimber size. Sawtimber-size stands now occupy 75 percent of the timberland – 8.5 million acres. Since 1975, the area in sapling/seeding and nonstocked stands has remained nearly unchanged, now representing 7 percent of the timberland (Fig. 30). West Virginia has the lowest percentage of timberland in the sapling/seedling stand-size class when compared to the surrounding states: Maryland (10 percent), Kentucky (11), Pennsylvania (12), Ohio (13), and Virginia (16).

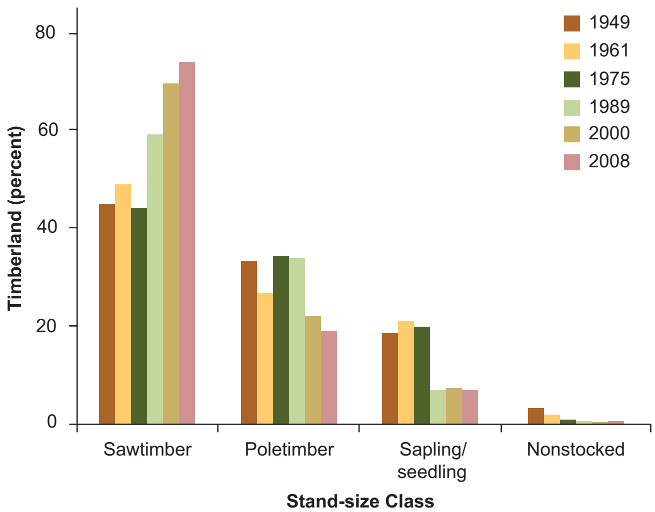


Figure 30.—Percentage of timberland by stand-size class, West Virginia, 1949, 1961, 1975, 1989, 2000, and 2008.

What this means

The average number of trees per acre has remained nearly unchanged although the average diameter has increased. This would typically be accompanied by increases in both stocking levels and area in sawtimber-size stands. Because it was found that sawtimber-size stands increased as stocking levels decreased, there is likely more than a single driver for change that is occurring. The increase in average diameter and acreage in sawtimber-size stands indicates that in general trees are getting larger and stands are maturing, but decreases in stocking indicate that disturbances such as harvesting, ice storms, and wildfire have reduced stocking levels on many acres.

The numbers of large-diameter trees have increased steadily since 1961. The recent decrease in 6-, 8-, and 10-inch trees indicates that as trees grow into larger size classes or succumb to competition, they are not being completely replaced by smaller trees growing into the lower classes. At the landscape level, West Virginia's forests have reached the point where the total number of trees will likely begin to decline because of crowding. Current trends indicate that the number of poletimber-size trees (5.0- to 10.9-inches d.b.h. for hardwood species) will continue to decline as the number of large sawtimber-size trees continues to increase.

Most stands are well stocked with trees of commercial importance. The large area of fully stocked and overstocked stands presents opportunities for forest management without diminishing forest growth. Managing these stands can keep them growing optimally by preventing them from becoming overstocked. Thinning stands to the moderately stocked level keeps them growing at their full potential but promotes the growth of shade-tolerant trees. The 2.0 million acres (17 percent) of timberland that are poorly stocked with commercially important species represents a loss of potential growth of valuable trees, although these forests still contribute to habitat diversity. Because of their age and stand size, it can be assumed that many poorly stocked stands have originated from poor harvesting practices. These represent a challenge to forest managers because they contain little value to pay for improvements. Stands that are poorly stocked with trees are probably more susceptible to invasion by nonnative species, such as multifora rose and honeysuckle, than fully stocked stands because of their more open growing conditions. These more open stands may also provide opportunities for some shade-intolerant species, such as yellow-poplar, to eventually get established. Higher stocking levels in the Allegheny Mountains ecoregion are likely due to the higher public ownership of timberland in this region.

West Virginia's forests have a variety of stand-size classes that provide diverse habitats for wildlife. The shift in stand size to more sawtimber-size trees is further evidence that West Virginia's forests are maturing. Declines in sapling- and seedling-dominated areas are likely to continue as more stands mature into larger size classes while decreasing amounts of farmland are allowed to revert to forest land. Continued losses of sapling/seedling stands could be problematic for species such as ruffed grouse that prefer dense patches of young trees for at least part of their life cycle. Besides offering diverse habitats and providing a steady flow of wood products, forests that contain all stand sizes might be more resistant to devastating outbreaks of insects and diseases.

Forest Composition

Background

The species composition of a forest is the result of the interaction between climate, soils, disturbance, competition among trees species, as well as other factors over time. Causes of forest disturbance in West Virginia include wildfires, ice storms, logging, droughts, insects and diseases (e.g., chestnut blight), and land clearing followed by abandonment. Also, as forests mature, changes in growing conditions favor the growth of shade-tolerant species. Forest attributes that describe forest composition include forest type, forest-type group, number of trees by species and size, and changes in the species makeup of total volume. Forest types describe groups of species that frequently grow in association with one another and dominate the stand. Similar forest types are combined into forest-type groups. While large trees represent today's forest, the composition of the smaller diameter classes represents the future forest. Comparisons of species composition by size can provide insights into future changes in overstory species.

What we found

The 2008 inventory of West Virginia identified 109 tree species, 46 forest types, and 13 forest-type groups. The oak/hickory forest-type group, which includes the yellow-poplar forest type, covers three-fourths (8.8 million acres) of West Virginia's forests, and the maple/beech/birch group covers 2.1 million acres (Fig. 31). The oak/hickory group consists of white oak, northern red oak, hickory species, white ash, walnut, yellow-poplar, and red maple.

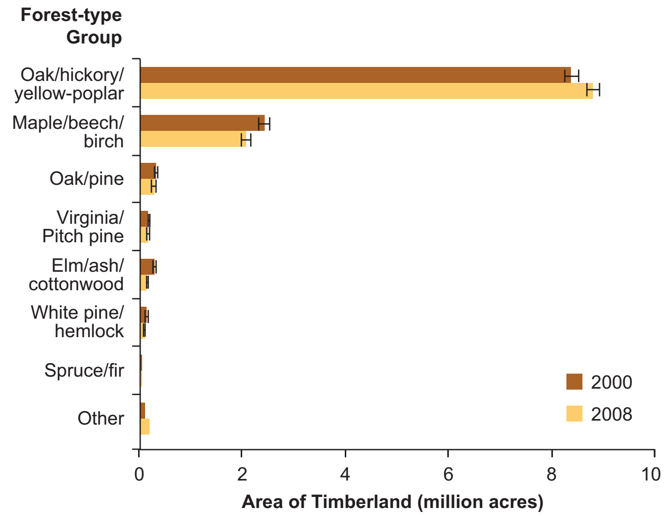


Figure 31.—Area of timberland by forest-type group, West Virginia, 2008 (error bars represent 68-percent confidence intervals around the estimates).

In West Virginia, 94 percent of oak volume, 88 percent of yellow-poplar, and 70 percent of red maple grow in the oak/hickory group, while 92 percent of yellow birch volume, 57 percent of sugar maple volume and 44 percent of American beech volume grow in the maple/beech/birch group. These broad species groups have changed little in area since 2000. Changes that do occur in forest-type-group are driven by the changes in numbers of large-diameter trees.

Charting the number of trees by diameter class yields the typical reverse "J" shaped curve expected for uneven-age forests, but if just oaks are examined the curve is fairly flat (Fig. 32). Comparing the ranking by number of trees 5.0 inches and larger (Fig. 33) to ranking by number of saplings (Table 2), we can see many differences. For example, chestnut oak ranks third in the number of trees 5.0 inches and larger, but only 26th in numbers of saplings, while blackgum ranks 18th in number of trees 5.0 inches and larger and fourth in numbers of saplings. Many of the major commercial species have had decreases in number of 5-inch and larger trees over the last 20 years, and also had decreases in numbers of saplings since 2000.

Red maple is the most numerous sapling (1.0- to 4.9- inches d.b.h.) followed by sugar maple (Fig. 34). Together the oaks are the most numerous trees in

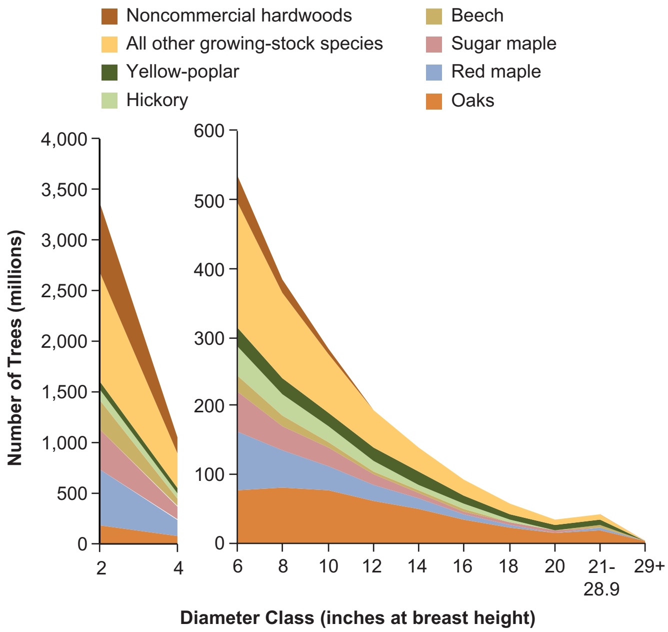


Figure 32.—Number of trees for selected species by diameter class, West Virginia, 2008.

diameter classes 8 inches and larger. In the current inventory, oaks represent about one-third of the trees in the 12-inch diameter class and more than 40 percent of trees 20.0 inches and larger, but only 6 and 7 percent of trees in the 2- and 4- inch diameter classes, respectively. Conversely, the maples have a disproportionate share of trees in the 2- and 4-inch diameter classes—28 and 29 percent, respectively—compared to their lower presence in the larger diameter classes—10 percent of trees 20.0 inches in d.b.h. and larger.

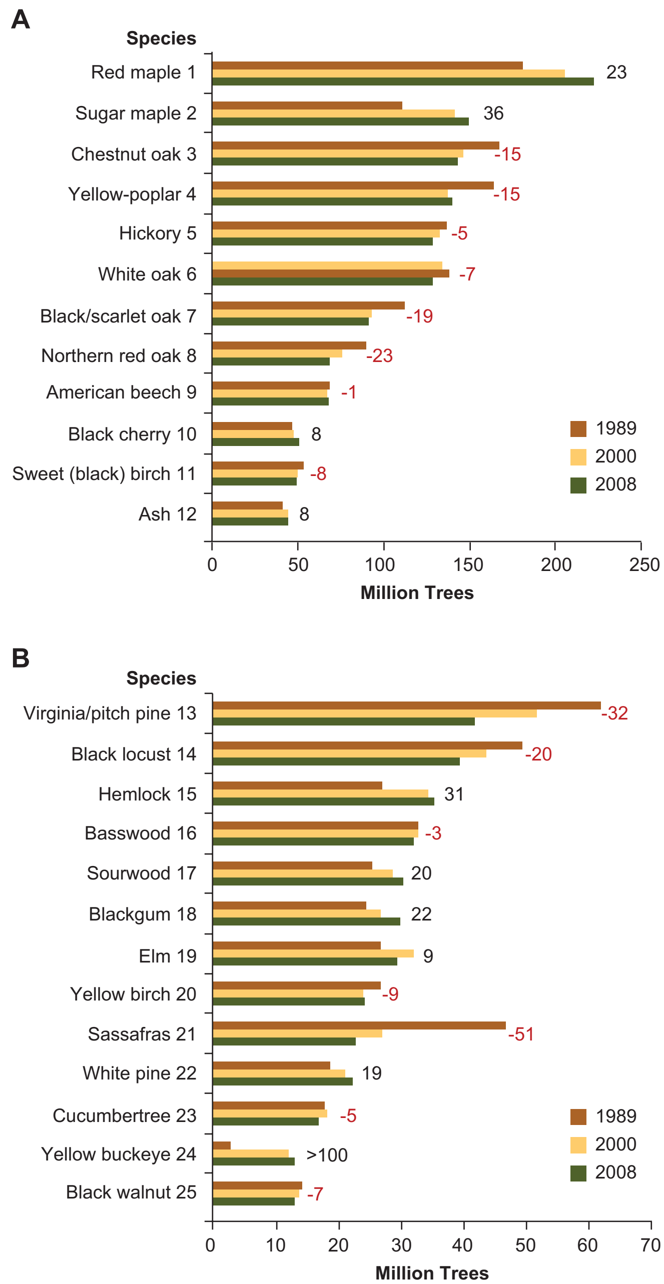


Figure 33—Top 25 species rank by the numbers of trees 5.0 inches in diameter and larger in 2008, with estimated number of trees, 1989, 2000, and 2008, and percent change from 1989 to 2008, West Virginia, A-species ranked 1-12, B-species ranked 13-25.

Table 2.—Species ranked by number of saplings (trees at least 1 inch and less than 5 inches d.b.h.), 2008 and 2000, total number of stems 2008, and percent change 2000-2008, West Virginia

Rank 2008	Rank 2000	Species	Millions of stems 2008	Percent change since 2000
1	1	Red maple	695	4
2	2	Sugar maple	530	-5
3	3	American beech	343	11
4	4	Blackgum	196	8
5	8	Sourwood	169	24
6	6	Hickory	141	-8
7	15	Sweet (black) birch	141	52
8	7	Yellow-poplar	140	-7
9	5	Flowering dogwood	130	-27
10	9	Sassafras	119	-1
11	11	White ash	99	-9
12	17	Striped maple	97	20
13	12	Eastern redbud	90	-11
14	16	American hornbeam	86	1
15	10	Black cherry	83	-27
16	20	Eastern hophornbeam	80	13
17	13	Black locust	80	-17
18	18	Eastern hemlock	79	1
19	23	Scarlet/black oak	76	16
20	14	American/slippery elm	69	-27
21	19	Serviceberry species	80	4
22	26	Eastern white pine	66	16
23	25	Red spruce	65	10
24	21	Hawthorn species	64	-10
25	24	Northern red oak	62	-2
26	22	Chestnut oak	62	-12
27	27	Pawpaw	58	15
28	28	White oak	50	0
29	33	Yellow birch	38	12
30	29	American basswood	37	-17
31	30	Virginia/pitch pine	36	-19
32	34	Ailanthus	35	50
33	31	Yellow buckeye	32	-6
34	34	American sycamore	22	29
35	36	Boxelder	20	26
36	37	Cucumbertree	19	22

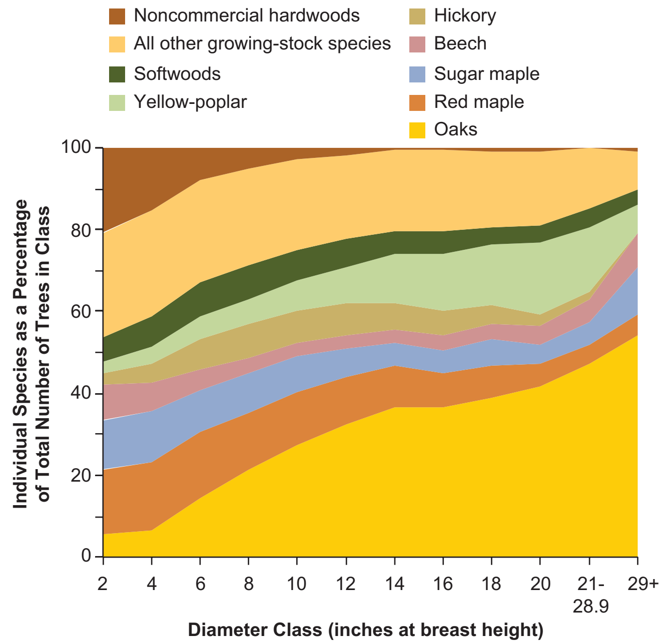


Figure 34.—Species composition by diameter class, West Virginia, 2008.

What this means

There are few areas in West Virginia where any one species represents more than half of the stocking of live trees. This diverse mix of species reduces the impact of insects and diseases that target a single tree species.

The small shift in area into the oak/hickory forest-type group from other groups does not fully depict the underlying shifts occurring in individual species. Because forest type is heavily influenced by large-diameter trees, changes in the composition of small-diameter trees that occupy the understory are not adequately reflected in changes by forest-type group.

Sapling-size trees represent the future forest. As large trees are harvested or succumb to insects and diseases, they will eventually be replaced by saplings now growing in the understory. As this occurs, the dominance of maple species and blackgum in the understory will have an increasing influence on the composition of the future forest. Beech is ranked third in numbers of saplings, but because of beech bark disease, many of these trees may not reach large size. Beech saplings are now occupying growing space that could be used by more valuable species. The number of black birch saplings increased by 52 percent and it now ranks as the seventh most numerous sapling in the State. As these trees grow to be more than 5 inches in diameter, large increases in volume for this species can be expected. Decreases in the numbers of saplings for shade-intolerant species such as black cherry, black locust, and oak species that need full sunlight to thrive is consistent with a maturing forest.

Sourwood and striped maple are shade tolerant and usually remain in the understory throughout their life. They can interfere with the establishment of more desirable species after harvesting operations. Striped maple is most prevalent in the Allegheny Mountains ecoregion at elevations over 3,000 feet where it averages 56 trees (1.0 inch in diameter and larger) per acre. Sourwood is most prevalent in the Northern Cumberland Mountains ecoregion where it grows at elevations below 3,000 feet and averages 37 trees (1.0-inch diameter and larger) per acre. When making management decisions, land managers in these regions should be aware of the possibility of large numbers of these species in the understory.

Tree Condition—Crown Position and Live Crown Ratio

Background

The crown position of a tree indicates how well it is competing with neighboring trees for light. A tree in an intermediate or overtopped crown position is below the general level of the canopy and is shaded by its dominant and codominant neighbors. Intermediate and overtopped trees generally can be expected to have slower growth and higher mortality rates than trees in more dominant positions. The live crown ratio or the percentage of a tree's height in live crown is an indication of its vigor. Live crown ratios of less than 20 percent are typically assumed to be a sign of poor vigor. In the understory, trees with low live crown ratios have fallen behind in their struggle with surrounding trees for light and space and are unlikely to ever recover or grow into an overstory position, unless their crowns are released from their neighbors by forest thinning or another disturbance.

What we found

In West Virginia, most trees in the 2-, 4-, 6-, and 8-inch diameter classes are in an overtopped or intermediate crown position. Ninety-three percent of 2-inch trees and 52 percent of 8-inch trees are in these two crown classes (Fig. 35). Conversely, 92 percent of trees with diameters 12.0 inches or larger are either dominant or codominant. More than a fifth of trees in the 10-inch diameter class and smaller have live crown ratios of less than 20 percent (Fig. 36).

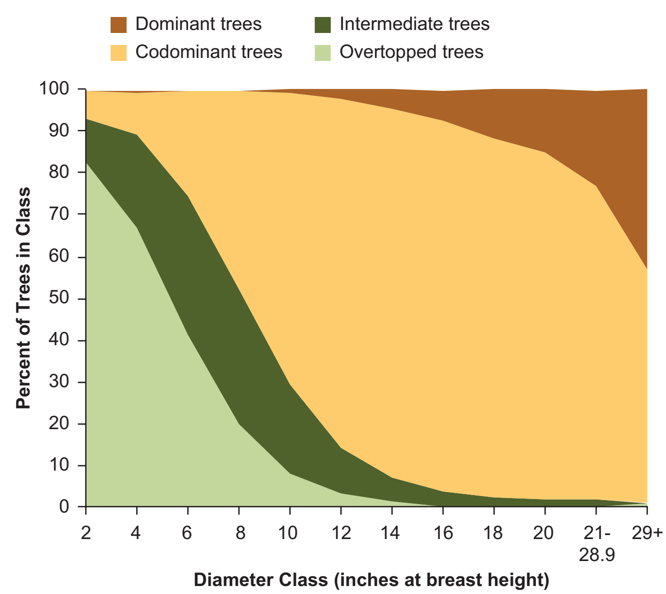


Figure 35.—Percentage of growing-stock trees by crown position and diameter, West Virginia, 2008.

Figure 36.—Percentage of growing-stock trees with a live crown ratio of 20 percent or less by diameter, West Virginia, 2008.

What this means

Shaded conditions created by overstory trees are stressing a large portion of trees below 10.0 inches in diameter. This finding is consistent with the maturing of West Virginia's forests and the likely cause for decreases in the number of trees in the 6-, 8-, and 10-inch diameter classes. Shaded conditions favor the growth of shade-tolerant species such as sugar maple over that of less shade-tolerant species such as black cherry, yellow-poplar, and the oaks.

Volume of Growing Stock

Background

Measurement of growing-stock volume on timberland is important in assessing the volume of wood available for commercial products. Volume in this category includes only trees of commercially important species and is the net volume after deductions are made for defects. Growing-stock volume is the resource base upon which the forest products industry depends. Measures of growing-stock volume are useful in making comparisons to older inventories where only estimates of growing stock are available. Growing-stock trees are within tolerances for rot and rough cull, and they are considered crop trees in silvicultural treatments where the goal is to maximize economic returns.

What we found

Eighty-four percent of the sound wood volume is categorized as growing-stock volume, amounting to 25 billion cubic feet (Fig. 37). Also contained within these growing-stock trees is an additional 3 billion cubic feet categorized as sound cull volume. Trees not meeting growing-stock standards either because they have large amounts of defect or are noncommercial species are classified as rough and rotten trees. Rough and rotten trees account for 1.8 billion cubic feet or for 5 and 1 percent of total sound volume on timberland, respectively.

Growing-stock volume on West Virginia's timberland has steadily increased since 1949. The 2008 estimate of 25 billion cubic feet is 12 percent more than the 2000 estimate and averages 2,136 cubic feet per acre (Figs. 38, 39).

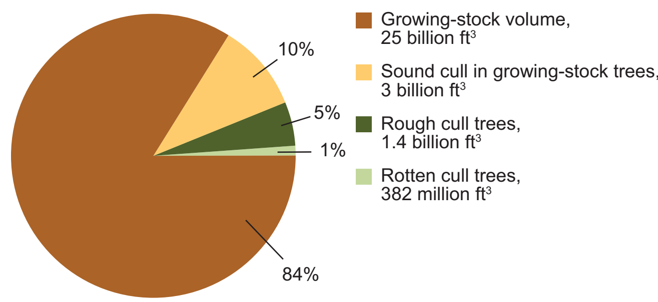


Figure 37.—Components of total volume, West Virginia, 2008.

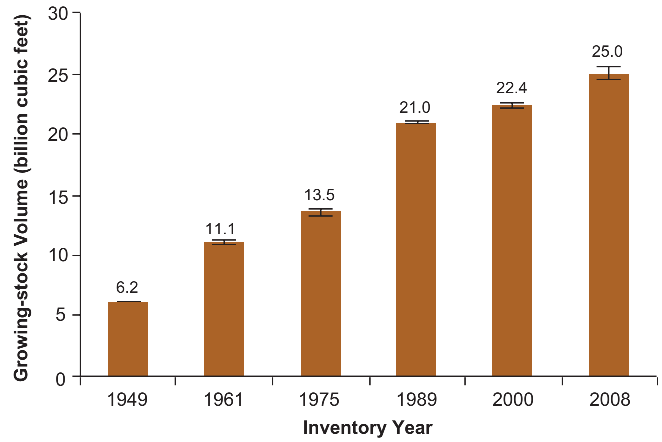


Figure 38.—Growing-stock volume by inventory year, West Virginia, 1949, 1961, 1975, 1989, 2000 and 2008 (error bars represent 68-percent confidence intervals around the estimates).

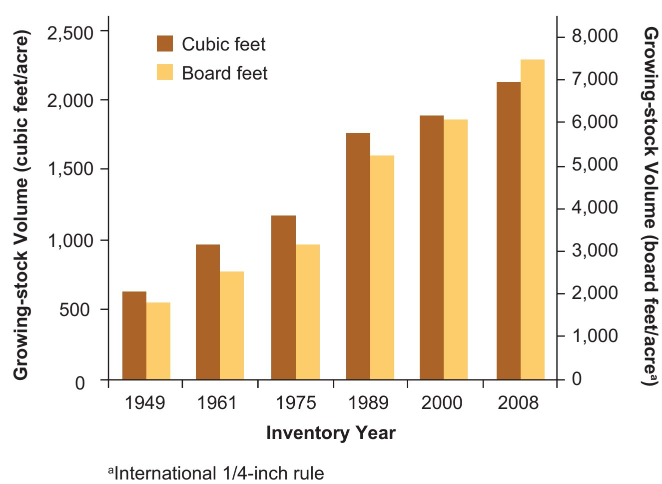


Figure 39.—Average growing-stock volume (board feet and cubic feet) per acre of timberland, West Virginia, 1949, 1961, 1975, 1989, 2000, and 2008.

Forest inventories show a steady shift in timber volume toward larger trees (Fig. 40). During the most recent inventory period, volume increased in all diameter classes 12 inches and larger, while volume decreased in the 6-, 8-, and 10-inch classes (Fig. 41). All of the gains in volume were in trees large enough to produce saw logs (11.0 inches in d.b.h. and greater for hardwood species), which reflects the changes in the numbers of trees discussed previously. The portion of volume large enough to produce saw logs increased by 23 percent to 88 billion board feet. Recent gains are a continuation of increases that have been occurring over the last 40 years.

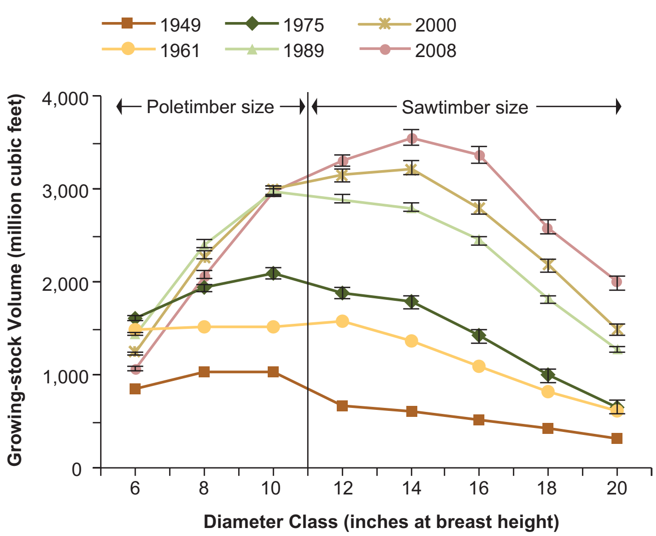


Figure 40.—Growing-stock volume by diameter class and inventory year, West Virginia, 1949, 1961, 1975, 1989, 2000, and 2008 (error bars represent 68-percent confidence intervals around the estimates).

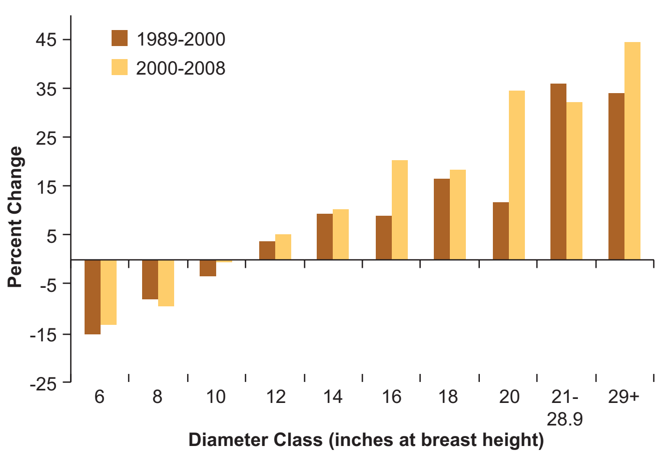


Figure 41.—Percent change in volume by diameter class on timberland, West Virginia, 1989-2000 and 2000-2008.

Yellow-poplar continues to lead in growing-stock volume followed by white oak, chestnut oak, red maple, and northern red oak (Fig. 42). Together these five species represent half the total growing-stock volume in both the 2008 and 2000 inventory. All oak species showed increases in volume, but the increases for white oak and northern red oak were below the State average for all species—12 percent. Many of the estimates of change are within the range of sampling error and are not statistically different.

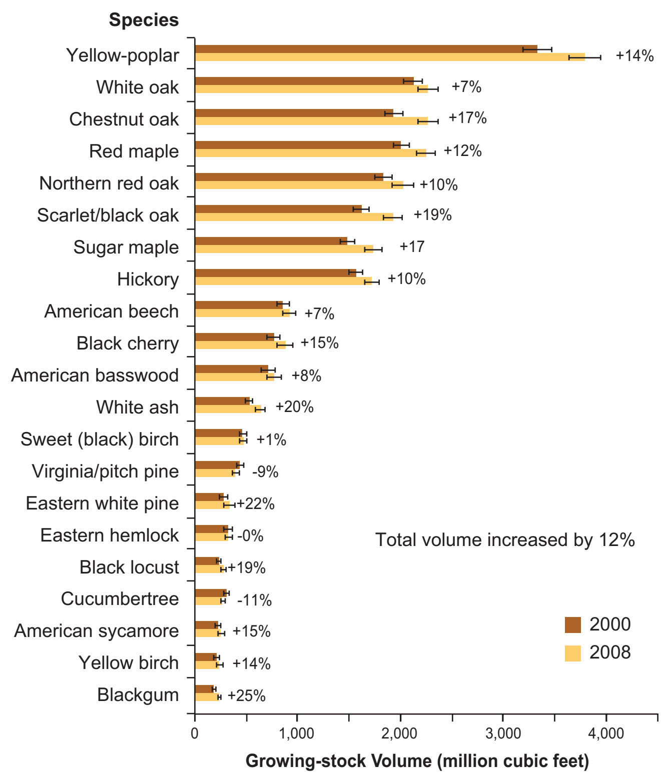


Figure 42.—Growing-stock volume on timberland by species and percent change, West Virginia, 2000 and 2008 (error bars represent 68-percent confidence intervals around the estimates).

The top-ranked species by board-foot volume differ little from those ranked by growing-stock volume (Fig. 43). Yellow-poplar remains the leading species, accounting for 18 percent of total board-foot volume followed by the four oak species groups. Together the oaks represent 37 percent of total board-foot volume and maples 12 percent. Ninety-five percent of West Virginia's sawtimber volume is in hardwood species.

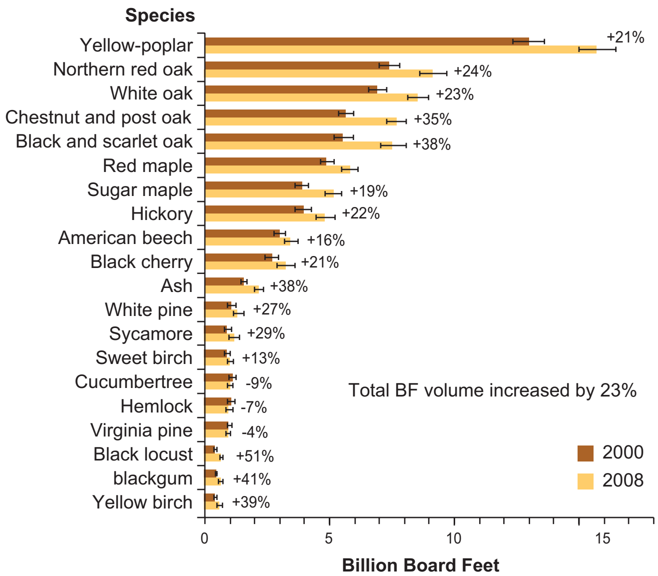


Figure 43.—Board-foot volume on timberland by species and percent change, West Virginia, 1991 and 2008 (error bars represent 68-percent confidence intervals around the estimates).

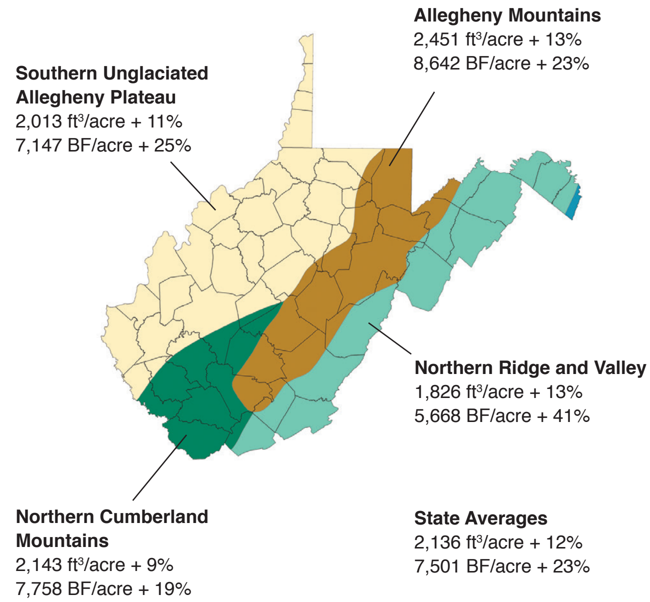


Figure 44.—Average cubic-foot and board-foot growing-stock volume per acre on timberland by ecoregion, 2008, and percent change 2000-2008, West Virginia.

Average volumes per acre are highest in West Virginia's Allegheny Mountains ecoregion in both terms of cubic-foot and board-foot volumes (Fig. 44). The largest volume by species in this region was red maple, which made up 13 percent of the growing-stock volume. Yellow-poplar is the top ranked species in both the Southern Unglaciated Allegheny Plateau and Northern Cumberland Mountains ecoregions. Lowest volumes per acre are in the Northern Ridge and Valley ecoregion. Oak species make up half of the total volume in this region (Fig. 45).

What this means

Continuous increases in volume have brought West Virginia's timber resource to record levels in both total growing-stock volume and board-foot volumes per acre. And most of the volume is in trees that meet minimum requirements to qualify as growing-stock trees. Timber growth is concentrated on sawtimber-size trees, which explains why increases in board-foot volume (+23 percent) were more than cubic-foot volume (+12 percent). As trees grow into sawtimber size, their value for timber products increases abruptly because they can now be used for higher value products. Because more growth is being put on these higher value trees than previously, West Virginia's forests are now adding value at an increasing rate. This increase in value is good for landowners and the forest products industry. But, as the number of new trees growing into sawtimber size decreases, as shown by decreases in the numbers of 6-, 8-, and 10-inch trees, harvesting practices become an increasing concern. Any mismanagement of sawtimber stands will become more apparent in stands where most growth is occurring on residual sawtimber-size trees left after harvesting operations.

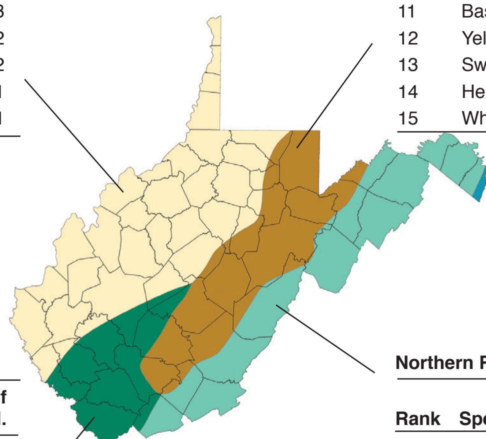
Changes in volume by species do not fully reflect changes occurring in West Virginias forests. For instance, increases in oak volume give no indication that these increases are not sustainable due to the lack of oak reproduction. Virginia pine and pitch pine have declined in volume in West Virginia as well as in the neighboring states of Pennsylvania and Ohio. This decline is probably because these two shade-intolerant species typically drop out of hardwood stands as they mature. Declines in pitch and Virginia pine were hastened by an ice storm in February 2003 that disproportionally affected these species (Widmann 2005).

Southern Unglaciated Allegheny Plateau

Rank	Species	Volume (million ft³)	Percent of total vol.
1	Yellow-poplar	1,426	16
2	White oak	1,140	13
3	Hickory	877	10
4	Black and scarlet oak	808	9
5	Red maple	684	8
6	Chestnut oak	668	7
7	Sugar maple	618	7
8	Northern red oak	532	6
9	Ash	333	4
10	Beech	305	3
11	Black cherry	258	3
12	Virginia and pitch pine	189	2
13	American sycamore	166	2
14	Basswood	126	1
15	Black walnut	122	1

Allegheny Mountains

Rank	Species	Volume (million ft³)	Percent of total vol.
1	Red maple	1,096	13
2	Northern red oak	847	10
3	Yellow-poplar	830	10
4	Sugar maple	722	9
5	Black cherry	659	8
6	Chestnut oak	515	6
7	White oaks	408	5
8	Beech	390	5
9	Black and scarlet oak	317	4
10	Hickory	307	4
11	Basswood	256	3
12	Yellow birch	255	3
13	Sweet (black) birch	250	3
14	Hemlock	213	3
15	White pine	205	3



Northern Cumberland Mountains

Rank	Species	Volume (million ft³)	Percent of total vol.
1	Yellow-poplar	1,523	22
2	Chestnut oak	652	10
3	Red maple	541	8
4	Black and scarlet oak	532	8
5	White oak	477	7
6	Northern red oak	462	7
7	Hickory	444	6
8	Sugar maple	413	6
9	Beech	361	5
10	Basswood	320	5
11	Sweet (black) birch	184	3
12	Cucumbertree	138	2
13	Hemlock	136	2
14	Ash	125	2
15	Blackgum	80	1

Northern Ridge and Valley

Rank	Species	Volume (million ft³)	Percent of total vol.
1	Chestnut oak	599	20
2	Black and scarlet oak	345	11
3	White oak	338	11
4	Northern red oak	295	10
5	Virginia and pitch pine	190	6
6	Hickory	153	5
7	Red maple	152	5
8	Sugar maple	146	5
9	Yellow-poplar	108	4
10	Basswood	101	3
11	White pine	101	3
12	Ash	61	2
13	Backgum	59	2
14	Sweet (black) birch	54	2
15	Black cherry	50	2

Figure 45.—Fifteen most common species by ecoregion, ranked by 2008 growing-stock volume and percent of total volume in ecoregion, West Virginia.

Although most of the major species in the State occur across all the ecoregions, their portion of total volume varies, reflecting different growing conditions and management in the ecoregions. Highest volumes per acre are found in the Allegheny Mountains ecoregion, which corresponds to the large amount of publicly owned land in this ecoregion, because nearly the entire Monongahela National Forest is located here. The lowest volumes per acre, in the Northern Ridge and Valley ecoregion, may be the result of agricultural land reverting to forest, gypsy moth caterpillars killing oaks, and selective harvesting of oaks. The high proportion of oak and pine in this ecoregion is consistent with the lower rainfall it receives compared to other ecoregions.

Hardwood Quality Varies by Species

Background

The use of the timber resource for sawn timber products is determined largely by tree quality and species. The best trees are used in the manufacture of furniture, cabinets, and other millwork that command high prices. Lower quality trees are used for pallets, pulpwood, and fuelwood. Quality varies by species due to differences in average diameter, growth characteristics, and past management practices. FIA assigns tree grades to sawtimber-size trees as a measure of quality. Tree grades are based on the amount of knot-free bole, amount of cull, and tree diameter. Trees need to be at least 13.0 inches d.b.h. to be considered for a grade 2, and 16.0 inches d.b.h. for a grade 1. Trees in the grade 1 category have the least amount of defects and yield the most high quality lumber. Trees assigned to the tie/local use grade are the lowest quality and yield low value products.

What we found

The distribution of hardwood sawtimber by tree grade changed very little between the 2000 and 2008 inventories. Fifty percent of hardwood sawtimber volume was contained in trees graded 1 and 2 in 2000, compared to 53 percent in 2008 (Fig. 46). In absolute terms the volume in grades 1 and 2 increased by 31 percent to 44 billion board feet, while volume in the lowest grade (tie/local use) increased by 10 percent to 16 billion board feet.

In West Virginia, many of the major species in volume have high percentages of their volume in tree grades 1 and 2 (Fig. 47). Yellow-poplar, northern red oak, white oak,

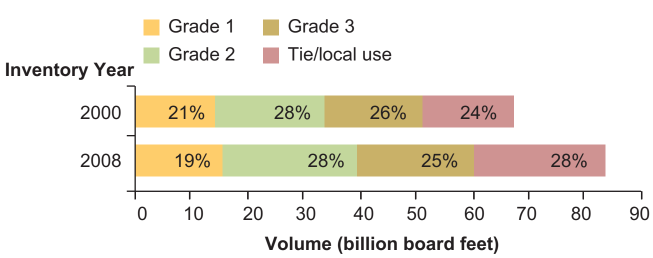


Figure 46.—Hardwood board-foot volume by tree grade, West Virginia, 2000 and 2008.

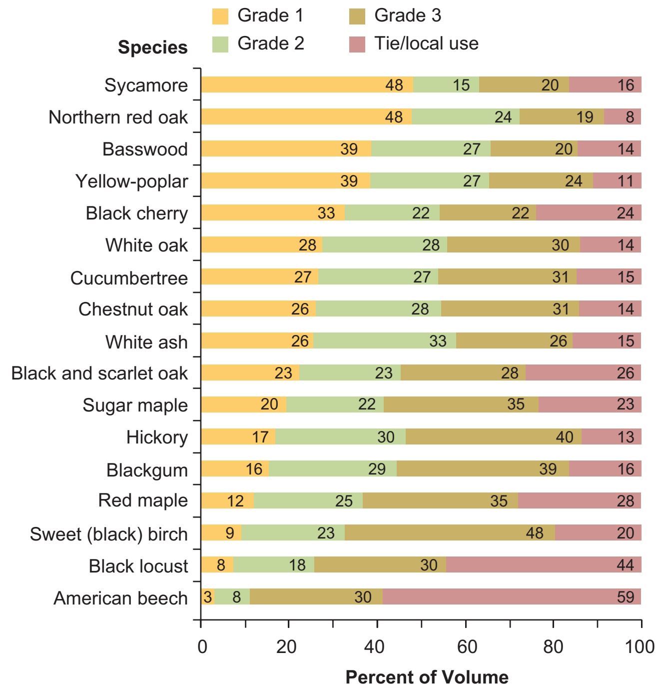


Figure 47.—Percentage of saw log volume by tree grade for major species, West Virginia, 2008.

and chestnut oak all have at least half of their sawtimber volume in tree grade 2 or better. Of the other major species in the State, beech had the lowest portion of volume in grades 1 and 2, followed by black locust, black birch, red maple, and blackgum.

Many beech trees in West Virginia are degraded because of large amounts of rotten wood. Red maple is graded lower than other species because it typically has more defects and smaller diameters. Beech, red maple, and sugar maple also do not self prune as well as other species such as yellow-poplar and white ash.

What this means

Because small sawtimber-size trees can be assigned a low grade on the basis of size alone, the increase in size of West Virginia's trees has brought about a corresponding increase in saw log quality. This along with increases in total saw log volume has brought about a tremendous increase in the value of the forest resource for timber products.

This increase in value is demonstrated in yellow-poplar and northern red oak, the top two species ranked by volume in the State. Each has 60 percent of its board-foot volume in grades 2 or better trees, and each has increased by more than 20 percent in board-foot volume since 2000. Most of the volume increase in these trees has been on high quality trees more than 18.0 inches in diameter.

Countering the increase in quality because of tree size are changes in species composition. Red maple, sugar maple, beech, and blackgum, species that typically grade poorer than other species, are the most numerous saplings (Table 1). Future tree quality may be affected by changes in species composition toward these lower valued species.

In West Virginia, about one-third of hardwood sawtimber volume is in trees less than 16.0 inches in d.b.h. These trees are too small to be rated grade 1. Forest land owners can receive high financial returns by practicing sustainable forestry and thinning around trees with the potential to grow into higher quality grade 1 and 2 trees. Landowners receive financial compensation from the harvest and the residual forest is healthier. The State's wood-using industries benefit through value added in manufacturing.

Biomass Volume of Live Trees

Background

Trees play an important role in the world's carbon cycle. They act as a sink for carbon, removing it from the atmosphere in the form of carbon dioxide (a greenhouse gas) and storing it as cellulose. In this role, forests help mitigate the effect of burning fossil fuels and the resulting global climate change associated with increased levels of carbon dioxide in the atmosphere. West Virginia's forests contribute greatly to the sequestration of carbon dioxide due to increases in tree volume.

Tree biomass, a measure of how much carbon is being stored in trees on forest land, is the total weight of both live and dead trees, including branches, roots, and stumps. Typically the carbon content of biomass is equal to half the biomass weight measured in dry tons. Estimates of biomass are important for knowing not only the amount of carbon stored but also the potential amount of biomass available for energy uses.

What we found

Biomass of all trees standing in West Virginia's forests equals 964 million dry tons—an average of 82 tons per acre. The greatest portion (55 percent) is found in the merchantable boles of commercially important trees—growing-stock volume (Fig. 48). It is this component that can be converted to high value wood products. Other portions of tree biomass are underutilized and can be considered as potential sources of fuel for commercial power generation. Biomass in live trees has increased by 13 percent since 2000.

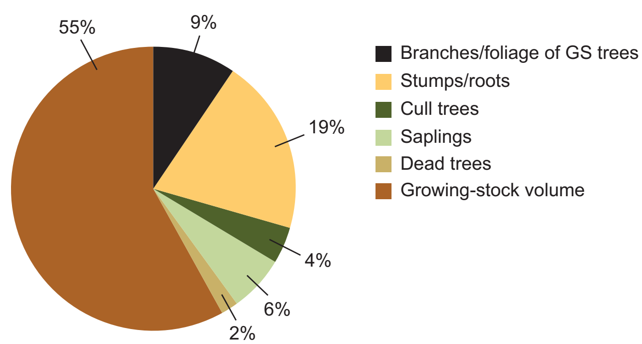


Figure 48.—Components of tree biomass on forest land in West Virginia, 2008.

What this means

West Virginia's forests are accumulating substantial amounts of biomass. These stores of carbon will receive increasing attention as the Nation seeks sources of renewable energy and ways to offset carbon dioxide emissions. Because biomass is a renewable source of energy, it can help reduce the Nation's dependence on fossil fuels. Utilizing biomass for fuel would provide markets for low grade and underutilized wood. As biomass markets develop, forest managers will need to integrate the harvesting of biomass into their management plans.

Forest land owners are not financially compensated for contributions their trees make in absorbing carbon dioxide and storing carbon. However, this may change if recent proposals to pay landowners for storing carbon in their forests become a widespread reality. Improvements in how biomass is measured and accounted for would likely help promote this new income source for landowners.

Components of Annual Volume Change

Background

Well-tended forests supply a continuous flow of products without impairing long-term productivity. Unlike coal and oil, forests are alive and renewable. One way to judge the sustainability of a forest is to examine the components of annual change in inventory volume: growth, removals, and mortality. Removals includes trees harvested on land that remains in timberland, trees on timberland that has been reclassified to reserved forest land, and trees lost because the forest was developed for a nonforest use. Analysis of these individual components can help us better understand what is influencing net change.

What we found

During the last 50 years in West Virginia, the growth of trees has greatly outpaced mortality and removals. The most recent inventory revealed that since 2000, on an annual basis, gross growth has totaled 780 million cubic feet (Fig. 49). Annual mortality averages 169 million cubic feet, resulting in a net growth of 611 million cubic feet. On land that was in timberland in both 2000 and 2008, 93 percent of growth was accretion on trees 5.0 inches d.b.h. and larger in 2000 and the remaining 7 percent was from trees growing into 5-inch or larger diameter classes. The removals of trees due to both harvesting and land use change averaged 323 million cubic feet, leaving an annual surplus or net increase of 288 million cubic feet on West Virginia's timberland.

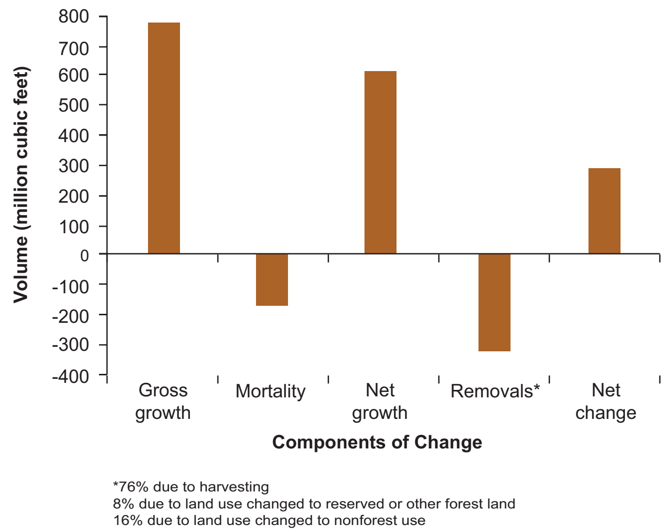


Figure 49.—Annual components of change in growing-stock volume, West Virginia, 2000-2008.

Seventy-six percent of the removals was due to the harvesting of trees and the remainder was due to changes in land use—mostly due to timberland being reclassified as nonforest land. As a percentage of the inventory, gross growth was 3.1 percent, mortality—0.7 percent, net growth—2.4 percent, and removals—1.3 percent, resulting in a net change of 1.1 percent annually.

The ratio of total growth-to-removals (G/R) averaged 1.9:1 from 2000 to 2008 but varied considerably between species (Fig. 50). Net growth exceeded removals for all major species, except black locust. Yellow-poplar had the largest amount of growth followed by red maple and sugar maple. Yellow-poplar also accounted for the largest share of removals, although growth still outpaced removals by a ratio of 2.0 to 1. G/R ratios for red maple and sugar maple were 3.0:1 and 3.9:1, respectively. Generally, the oaks had lower G/R ratios than other species, probably because oaks have slower growth rates and are highly favored for removal during harvests. G/R ratios were higher on publicly owned forest land than on privately owned, 2.3:1 versus 1.9:1.

The Northern Ridge and Valley ecoregion had the largest surplus of growth over removals with a G/R ratio of 2.3:1 and the Northern Cumberland Mountains ecoregion had the lowest at 1.5:1 (Fig. 51).

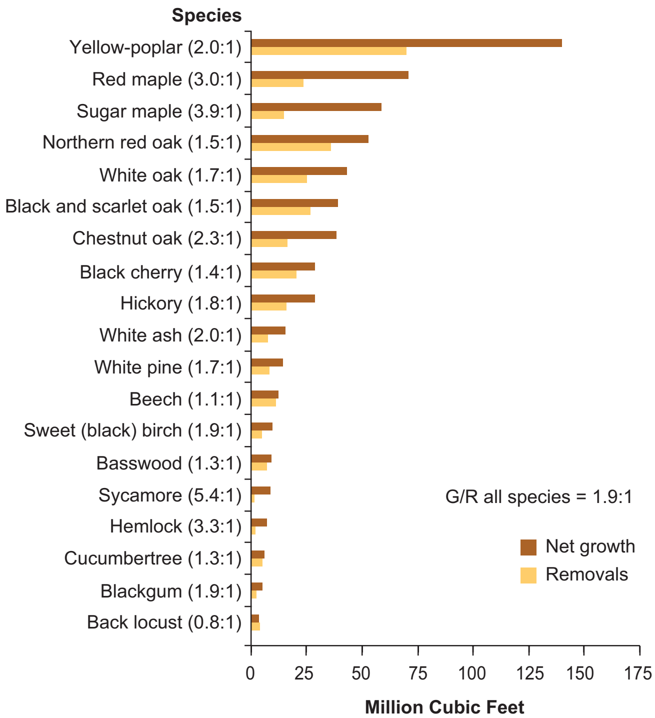


Figure 50.—Average annual net growth, removals, and growth-to-removals (G/R) ratio for major species, West Virginia, 2000-2008.

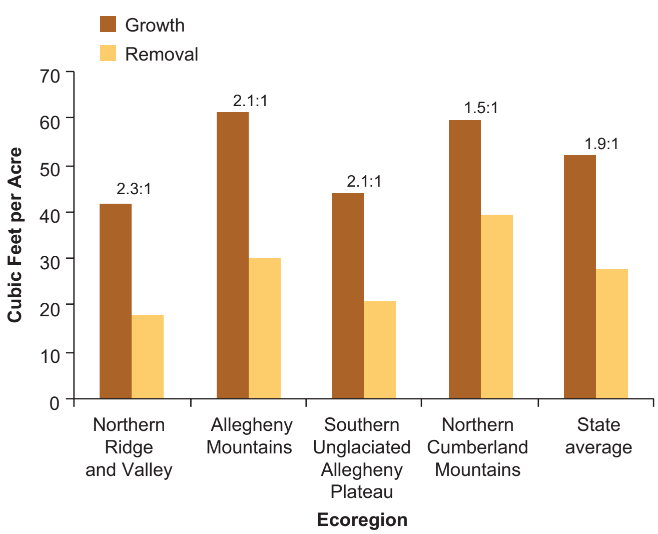


Figure 51.—Average annual growth and removals per acre on timberland and G/R ratio by ecoregion, West Virginia, 2000-2008.

What this means

Today's well-stocked forests are a product of growth consistently outpacing removals during the last half century and the surplus accumulating in the forest. Since 2000, net growth has been twice that of removals, with the net change amounting to an annual increase of 1.1 percent in inventory volume. This finding implies that the current level of removals is sustainable and that increases in timber volumes will continue at the State level as well as in each of the ecoregions.

The large amount of accretion growth is a characteristic of a maturing forest. Currently gaps in the forest created by mortality and harvesting seem more likely to be filled by growth on existing trees rather than by ingrowth of new trees into the 5-inch diameter class.

Comparing the growth-to-removals ratios of individual species to the average ratio for all species (1.9:1) reveals which species are increasing in importance and which are decreasing. The high growth-to-removals ratios for red maple and sugar maple indicate these species will increase in importance in West Virginia's forests.

Mortality

Background

The volume of trees that die from natural causes such as insects, diseases, fire, wind, and suppression from other trees is reported as mortality; harvested trees are not included. Tree mortality is a natural process that occurs in a functioning ecosystem although dramatic increases in mortality from catastrophic events can indicate problems in forest health.

What we found

In West Virginia, average annual mortality was 169 million cubic feet between 2000 and 2008, a rate of 0.7 percent of inventory volume that is unchanged from the previous inventory (1989-2000). The mortality rate in West Virginia is similar to that in the neighboring states of Pennsylvania (0.7) and Maryland (0.7) and lower than rates in Ohio (0.9), Kentucky (0.8), and Virginia (0.8). Mortality rates were higher for smaller diameter trees than for larger ones (Fig. 52). The mortality rate in the 6-inch class was 1.5 percent per year, which is more than twice

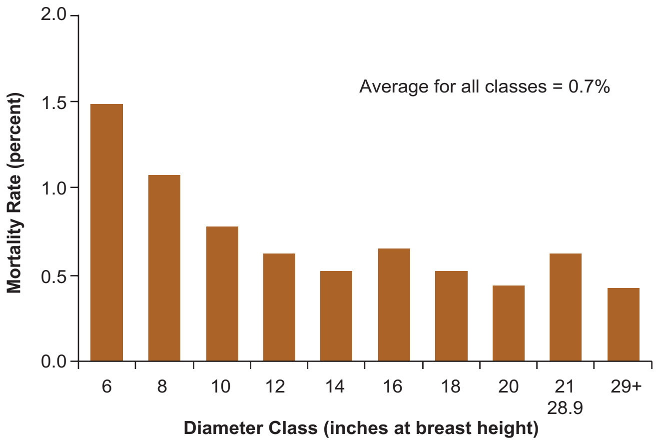


Figure 52.—Average annual mortality rate (in percent) of growing-stock volume on timberland by diameter class, West Virginia, 2000-2008.

the average rate across all diameter classes. The 20- and 29-inch and larger classes had the lowest mortality rate—0.4 percent. Trees less than 9.0 inches in diameter accounted for 23 percent of total mortality, even though they represent only 12 percent of volume. Species groups with high annual mortality rates were Virginia/pitch pine and black locust—3.2, and 2.1 percent, respectively (Fig. 53). The mortality rate for yellow-poplar (0.3 percent) was less than half that of the State average for all species.

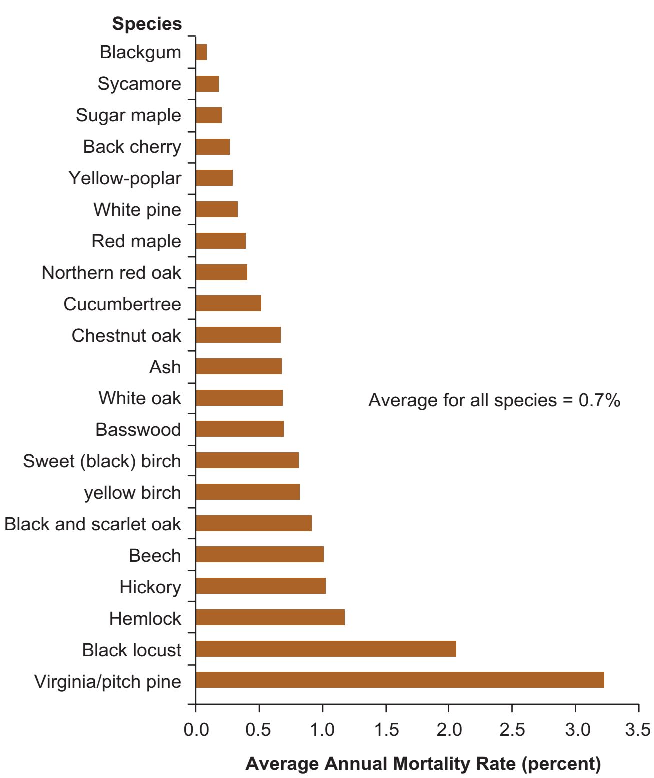


Figure 53.—Average annual mortality rate for major species, West Virginia, 2000-2008.

The average annual rate of mortality was highest in the Southern Unglaciated Allegheny Plateau ecoregion and lowest in the Allegheny Mountains and Northern Cumberland Mountains ecoregions, 1.0, 0.5, and 0.5, respectively (Fig 54).

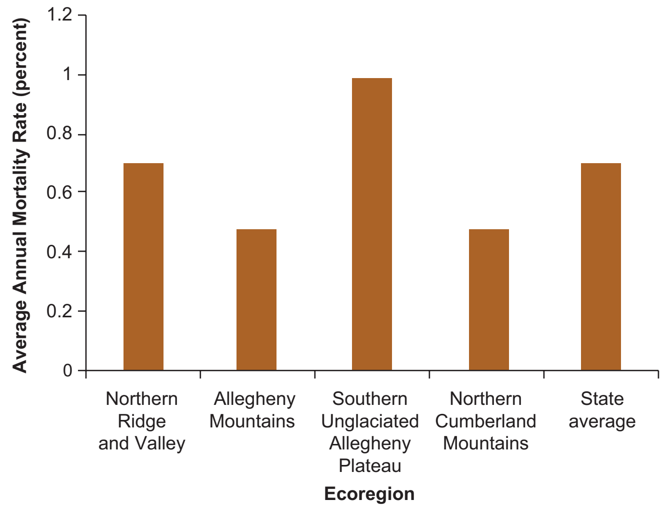


Figure 54—Average annual mortality rate by ecoregion, West Virginia, 2000-2008.

What this means

Tree mortality rates in West Virginia are lower than in many surrounding states and can be considered normal. Much of the mortality can be explained by stand dynamics, insects and diseases that target specific species, and disturbances such as the ice storm of 2003. The maturing of West Virginia's forests has resulted in crowded growing conditions. As trees compete for light and growing space, some fall behind their neighbors, lose vigor, and eventually succumb to insects and diseases. This is evident in the condition of trees in the small-diameter classes. As discussed earlier, most trees less than 8.0 inches in diameter grow in the understory (Fig. 35), and one-fourth of trees in the 6- and 8-inch diameter classes have live crowns less than 20 percent of their height—a sign of poor vigor in the smaller diameter classes (Fig. 36).

The higher mortality rate in the Southern Unglaciated Allegheny Plateau ecoregion was likely the result of an ice storm that hit this region February 16-17, 2003. Virginia pine in the region was disproportionally affected by this storm. Remeasurement of FIA plots immediately following this storm showed a 30-percent decline in softwood volume in the storm's footprint (Widmann 2005). This partially explains the higher mortality rate for Virginia/pitch pine. These two species likely became established when wildfires were much more prevalent than they are today. These conifers are slowly being replaced by hardwood species in West Virginia, as well as in many neighboring states, as natural succession progresses. Black locust is another shade-intolerant species with a high mortality rate. It is probably dropping out of stands as they mature. Beech and eastern hemlock in the State are being infected by beech bark disease and hemlock woolly adelgid, respectively. As these infestations continue to spread in the State, mortality for these species will likely remain high.

Despite having most of its volume in small trees, blackgum had the lowest mortality rate in the State. It is shade tolerant, and as shown in Table 2, it is well represented in the understory. Sugar maple is another shade-tolerant species with a low mortality rate and large numbers of saplings in the understory.

Status of Oaks

Background

Concern is growing about the sustainability of oaks across the oak/hickory forests of the Northern States. Oak species serve as keystone species in the forest ecosystem by creating a community structure and environment that maintains critical ecosystem processes (Fralish 2004). The oaks provide hard mast that is especially important because of the demise of American chestnut and the reduced numbers of large American beech in many areas because of beech bark disease. Estimates of annual oak acorn production can be made per tree by using individual tree size and species (Downs 1944). These can be used with FIA data to estimate total acorn production per acre. Oaks are also important to the forest products industry.

Analysis of inventory data typically looks at changes in growing-stock volume. In West Virginia, the cubic-foot volume of oaks increased by 13 percent and board-foot volume increased by 29 percent between the 2000 and 2008 inventories. Because volume estimates are heavily influenced by changes in large trees, further examination of the numbers of trees, especially oaks in the smaller diameter classes, can give us insight into future changes in the status of oaks.

What we found

West Virginia has had an overall decrease in the numbers of small trees. Decreases in small trees are more pronounced in oaks than in non-oak species (Figs. 55, 56). By 2-inch diameter class, numbers of oaks have decreased in the 2-, 4-, 6-, 8-, and 10-inch classes since 1989. These decreases have exceeded those of non-oak species by a wide margin. The oak portion of trees declined in most diameter classes between the 1989 and 2008 inventories, with large decreases in diameter classes 4 through 10 inches (Fig. 57). Only in some of the larger diameter classes did the portion of oaks increase. Oaks are well represented in the large diameter classes but are poorly represented in the smaller ones. Currently, oaks make up 45 percent of the trees in diameter classes 20.0 inches and larger compared to 8 percent of the trees less than 10.0 inches in diameter (Fig. 58). By contrast, maple species represent 28 percent of the trees less than 10.0 inches in diameter and their proportion decreases as diameter increases. Oaks produce significant amounts of mast throughout the State, with production most pronounced in the Northern Ridge and Valley ecoregion (Fig. 59).

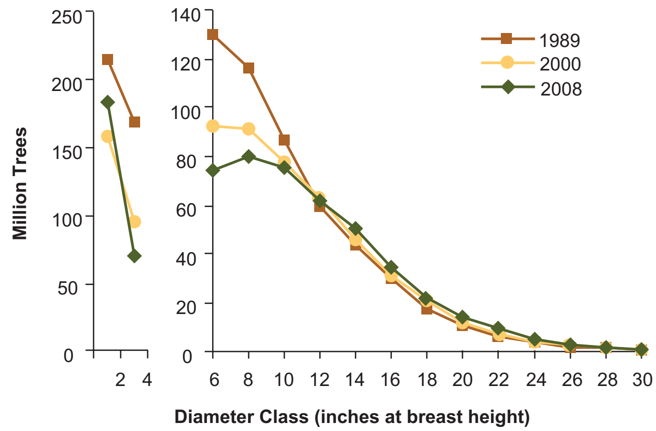


Figure 55.—Number of oak trees by diameter class, West Virginia, 2000 and 2008.

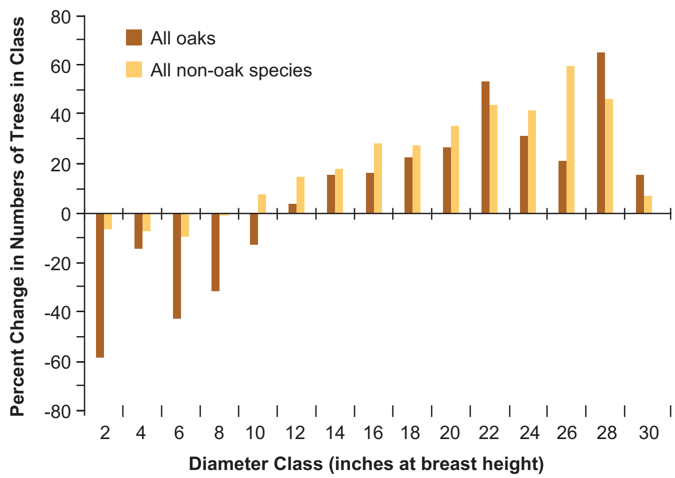


Figure 56.—Percent change in numbers of oaks and all other non-oak species by diameter class, West Virginia, 1989-2008.

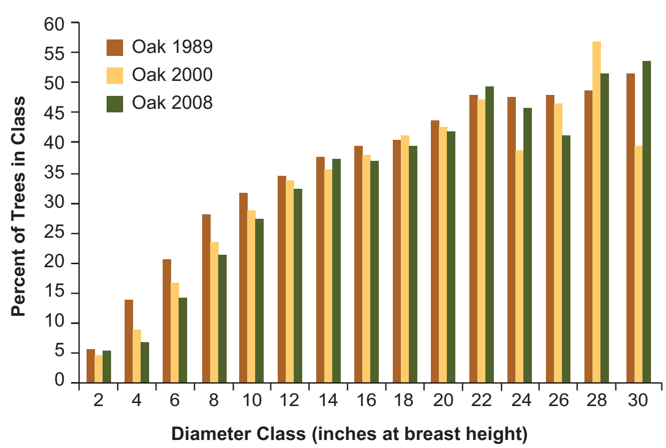


Figure 57.—Oaks as a percentage of total number of trees in class, West Virginia, 1989, 2000, and 2008.

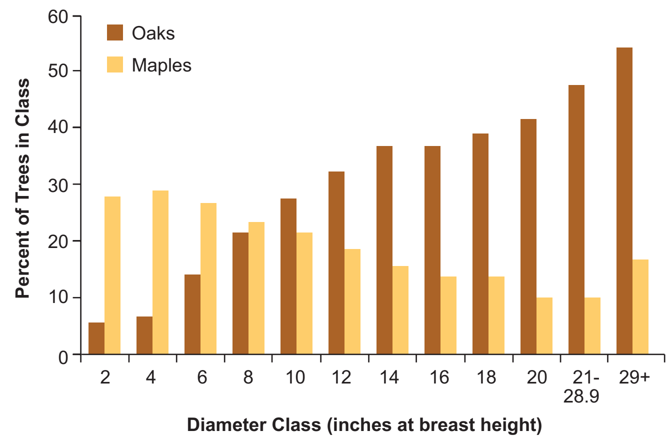


Figure 58.—Comparison of oaks and maples as a percentage of total number of trees in diameter class, West Virginia, 2008.

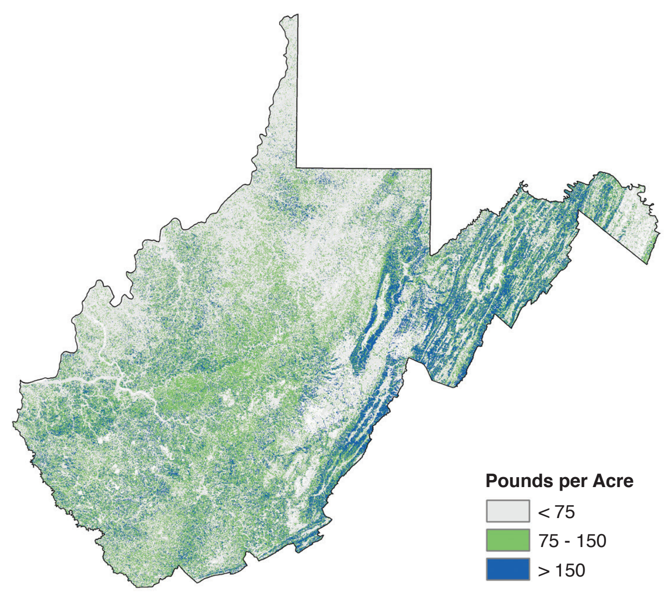


Figure 59.—Estimated average annual acorn production in West Virginia, 2008.

What this means

The current predominance of oak in the larger diameter classes is not sustainable unless oaks are recruited from smaller diameter classes. Declining numbers of small-diameter oaks means fewer trees are available for recruitment into the larger diameter classes. And, while growing conditions in West Virginia do not favor small-diameter trees, the declining portion of oaks in the smaller diameter classes will significantly impact the future oak resource. Oak regeneration may be a particular problem on mesic sites, whereas regeneration on dry sites, such as ridges in the Northern Ridge and Valley ecoregion, may not be as much of a problem.

Generally, current forest practices do not promote the regeneration of oaks, and silvicultural tools to promote oak are not being used. Contributing factors to poor oak regeneration are lack of fire, understory growing conditions that favor more shade-tolerant hardwoods, white-tailed deer preferentially browsing oak seedlings, and low intensity harvesting practices. Most harvests do not create gaps in the forest canopy large enough to promote the reproduction of shade-intolerant species. Long-term changes in forest composition can alter wildlife habitats and affect the value of the forest for timber products.

Currently, West Virginia forests produce an abundant supply of acorns that support a wide variety of wildlife species. Because the bulk of the acorn crop is produced by large-diameter oaks, acorn production could drop quickly as the composition of the overstory shifts away from oak species. This is especially true in the Northern Ridge and Valley ecoregion where half the growing-stock volume is oak species.

Historically, a large portion of West Virginia's lumber production is from oak species. The composition of timber harvests will need to be adjusted to better reflect the composition of the changing resource. Poor oak regeneration has also been observed in Pennsylvania, Ohio, and Maryland, as well as other states in the Northeast (Widmann and McWilliams 2006).

Forest Health Indicators

Gaudineer Knob. Photo courtesy of West Virginia Division of Forestry.

Down Woody Material

Background

Down woody materials, in the form of fallen trees and branches, fill a critical ecological niche in West Virginia's forests. Down woody materials both provide valuable wildlife habitat in the form of coarse woody debris and contribute to forest fire hazards via surface woody fuels. Woody fuels are classified into time-lag classes that predict the time it takes for wet fuels of various sizes to dry.

What we found

The fuel loadings of down woody materials (time-lag fuel classes) are not exceedingly high in West Virginia (Fig. 60). When compared to the nearby states of Ohio and Pennsylvania with similar forest ecosystems, West Virginia's fuel loadings of all time-lag fuel classes are not substantially different (for time-lag definitions, see Woodall and Monleon 2008). The size class distribution of coarse woody debris appears to be heavily skewed (83 percent) toward pieces less than 8.0 inches in diameter at point of intersection with plot sampling transects (Fig. 61A). Coarse woody debris appears to be at moderate stages of decay across the State (decay classes 2, 3, and 4; totaling 92 percent) (Fig. 61B). These decay classes are typified by moderate to heavily decayed logs that are sometimes structurally sound but missing most, if not all, of their bark with extensive sapwood decay. There is no strong trend in coarse woody debris volumes per acre among classes of live tree density (basal area/acre). Most of West Virginia's forests appear to have more than 350 cubic feet of coarse woody debris volume per acre (Fig. 62).

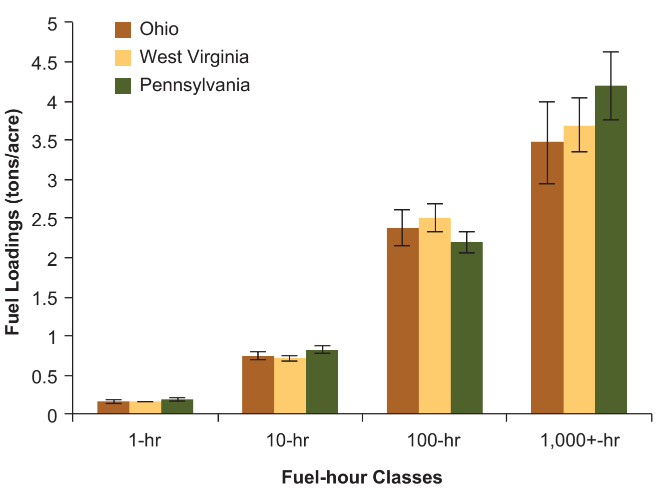


Figure 60.—Means and associated standard errors of fuel loadings (tons/acre, time-lag fuel classes) on forest land in West Virginia and nearby states, 2008.

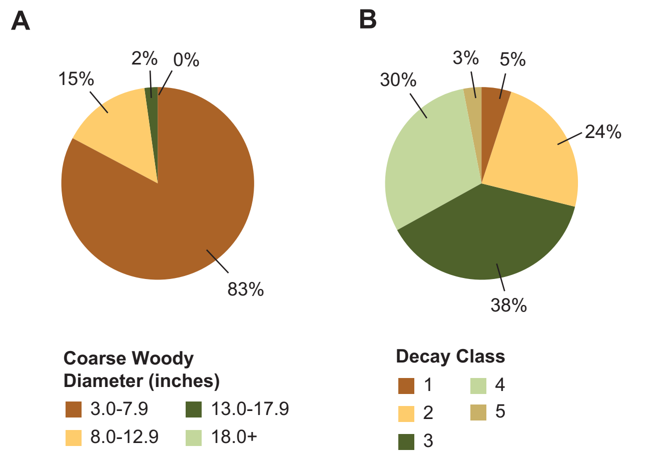


Figure 61.—Mean proportions of coarse woody debris total pieces per acre by (A) transect diameter (inches), and (B) decay classes, on forest land in West Virginia, 2008.

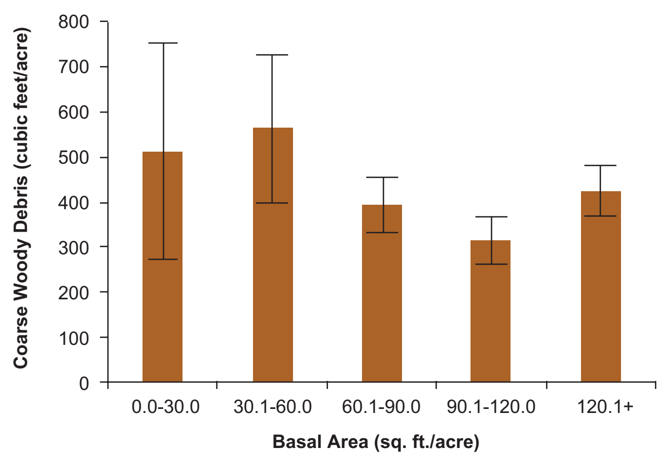


Figure 62.—Means and associated standard errors of coarse woody debris volumes (cubic feet/acre) on forest land in West Virginia, 2008.

What this means

The down woody fuel loadings in West Virginia's forests are not very different from those found in nearby states. Therefore, only in times of extreme drought would these fuel loadings pose a hazard across the State. Of all down woody components, coarse woody debris (i.e., 1,000+-hr fuels) made up the largest amounts. However, coarse woody debris volumes were still relatively low and were represented by small, moderately decayed pieces. The scarcity of large coarse woody debris resources may also indicate a lack of high quality wildlife habitat. Overall, because fuel loadings are not very high across West Virginia, possible fire dangers are outweighed by the benefits of down woody material for providing wildlife habitat and carbon sinks.

Lichens

Background

Lichens are symbiotic, composite organisms made up from members of as many as three kingdoms. The dominant partner is a fungus. Fungi are incapable of producing their own food, so they typically provide for themselves as parasites or decomposers. The lichen fungi (kingdom *Fungi*) cultivate partners that manufacture food by photosynthesis. Sometimes the partners are algae (kingdom *Protista*), other times cyanobacteria (kingdom *Monera*), formerly called blue-green algae. Some enterprising fungi associate with both at once (Brodo et al. 2001).

Lichen community monitoring is included in the FIA P3 inventory to address key assessment issues such as the impact of air pollution on forest resources or spatial and temporal trends in biodiversity. This long-term lichen monitoring program in the U.S. dates back to 1994. The objectives of the lichen indicator are to determine the presence and abundance of lichen species on woody plants and to collect samples. Lichens occur on many different substrates (e.g., rocks), but FIA sampling is restricted to standing trees or branches/twigs that have recently fallen to the ground. Samples are sent to lichen experts for species identification.

A close relationship exists between lichen communities and air pollution, especially acidifying or fertilizing nitrogen, and sulfur-based pollutants. A major reason lichens are so sensitive to air quality is their total reliance on atmospheric sources of nutrition. By contrast, it is difficult to separate tree-growth responses specific to air pollution (McCune 2000).

What we found

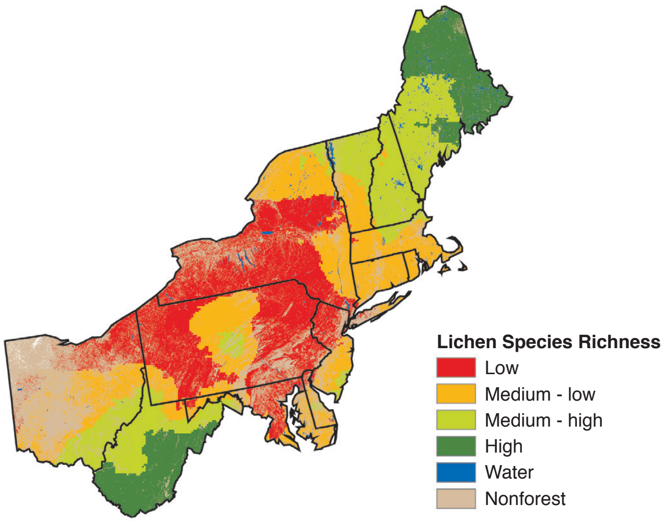
A total of 156 lichen species (gamma diversity) were sampled on the lichen plots in West Virginia. The most common lichen genera, Punctelia, were present on 12 percent of the plots. The genus with the highest number of species sampled was Cladonia (17 species).

The easiest way to measure species diversity is to count the number of species at a site; this measure is termed species richness. However, species richness does not provide a complete picture of diversity in an ecosystem because abundance is excluded. Richness values fell into the low to medium categories across West Virginia (Table 3). The spatial distribution of lichen species richness scores in the Northeast is shown in Figure 63. In general, species richness scores were highest in the southern region of the State. The lichen species richness and diversity scores reported here will serve as baseline estimates for future monitoring at the state and regional level.

Table 3.—Lichen communities summary table for West Virginia, 1995-2003

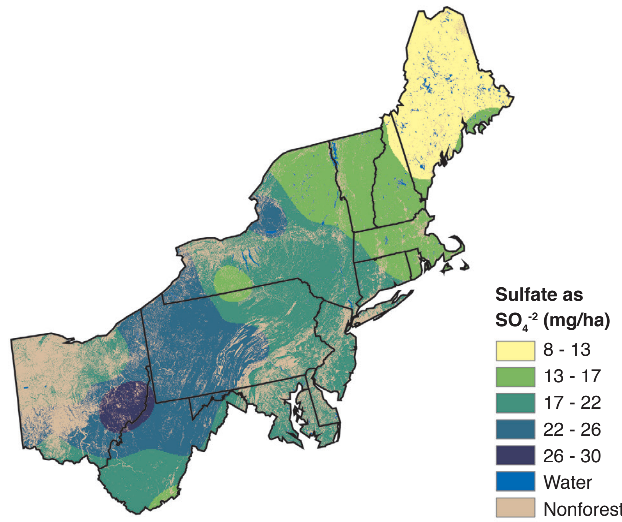
Parameter	West Virginia, 1995-2003
Number of plots surveyed	72
Number of plots by species richness category	
0-6 species (low)	3
7-15 species (medium)	25
>16 species (high)	43
Median	16.5
Range of species richness score per plot (low-high)	4-32
Average species richness score per plot (alpha diversity)	16.1
Standard deviation of species richness score per plot	5.7
Species turnover rate (beta diversity)[a]	9.7
Total number of species per area (gamma diversity)	156

[a]Beta diversity is calculated as gamma diversity divided by alpha diversity.



Projection: Albers, NAD83. Sources: MRLC Consortium 1992, FIA 2003. Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. Dec. 2010

Figure 63.—Estimated lichen species richness, Northeastern U.S., 2000-2003.



Projection: Albers, NAD83.
Sources: MRLC Consortium 1992, NADP 2002. Geographic base data are provided by the National Atlas of the USA. FIA data and Tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. Dec. 2010

Figure 64.—Mean sulfate ion wet deposition, Northeastern U.S., 1994-2002 (source: National Atmospheric Deposition Program).

What this means

Due to the sensitivity of many lichen species to airborne pollution, it is useful to look at acid deposition levels. Showman and Long (1992) reported that mean lichen species richness was significantly lower in areas of high sulfate deposition than in low deposition areas. Sulfate deposition levels are highest in the northern half of West Virginia and are relatively high compared to other areas in the northeastern United States (Fig. 64). A general pattern of lower lichen species richness scores in high deposition areas and vice versa is evident, although in parts of West Virginia, lichen richness appears to be higher than in areas of other states with similar sulfate deposition (Fig. 64). But other factors may affect the distribution of lichen species including intrinsic forest characteristics and long-term changes in climate.

Ozone Bioindicator Plants

Background

Ozone (O_3) is a byproduct of industrial development and is found in the lower atmosphere. Ozone forms when nitrogen oxides and volatile organic compounds go through chemical transformation in the presence of sunlight (Brace et al. 1999). Ground-level ozone is known to have detrimental effects on forest ecosystems. Certain plant species exhibit visible, easily diagnosed foliar symptoms to ozone exposure. Ozone stress in a forest environment can be detected and monitored by using these plants as indicators. The FIA program uses a set of indicator plants to monitor changes in air quality across a region and to evaluate the relationship between ozone air quality and the indicators of forest condition.

The ozone-induced foliar injury on indicator plants is used to describe the risk of impact within the forest environment using a national system of sites (Smith et al. 2003, Smith et al. 2007). These sites are not co-located with FIA samples. Ozone plots are chosen for ease of access and optimal size, species, and plant counts. As such, the ozone plots do not have set boundaries and vary in size. At each plot, between 10 and 30 individual plants of three or more indicator species are evaluated for ozone injury. Each plant is rated for the proportion of leaves with ozone injury and the mean severity of symptoms using break points that correspond to the human eye's ability to distinguish differences. A biosite index is calculated based on amount and severity ratings where the average score (amount * severity) for each species is averaged across all species at each site and multiplied by 1,000 to allow risk to be defined by integers (Smith et al. 2007).

What we found

The majority of the plants sampled were milkweed, spreading dogbane, and blackberry. The findings for West Virginia indicate that risk of foliar injury due to ozone has been trending downward since the mid-1990s (Table 4) as have ozone exposure levels.

What this means

Ozone exposure rates have been decreasing with corresponding decreases in foliar injury. This decrease is in contrast to evidence of medium and high risk in portions of the Mid-Atlantic region (Coulston et al. 2003).

A typical summer O_3 exposure pattern for Region 9 (the Eastern Region of the Forest Service) is shown in Figure 65 (USDA Forest Service 2002). The term SUM06 is defined as the sum of all valid hourly O_3 concentrations that equal or exceed 0.06 ppm. Controlled studies have found that high O_3 levels (shown in orange and red) can lead to measurable growth suppression in sensitive tree species (Chappelka and Samuelson 1998). Smith et al. (2003) reported that even when ambient O_3 exposures are high, the percentage of injured plants can be reduced sharply in dry years.

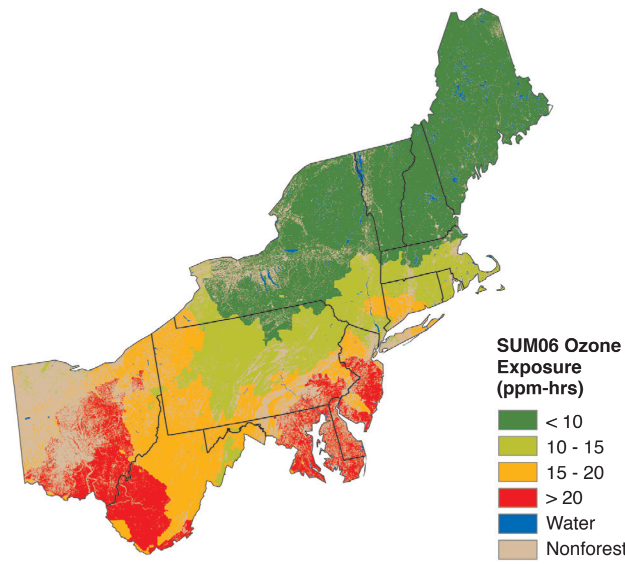


Figure 65.—Typical June through August 12-hour SUM06 ozone exposure rates in the Northeastern U.S., 2000-2006 (source: USDA Forest Service Ozone Biomonitoring Project).

Table 4.—Region-level summary statistics for ozone bioindicator program, West Virginia, 1995-2007

Parameter	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of biosites evaluated	18	23	26	26	14	29	30	27	27	28	28	28	28
Number of biosites with injury	2	11	2	19	2	3	3	13	12	6	6	6	15
Average biosite index score	1.38	14.73	0.61	21.39	1.11	1.61	3.64	10.08	2.06	2.84	0.9	1.62	2.31
Number of plants evaluated	259	759	797	1614	829	1,571	1,831	2,525	2,465	2,640	2,747	2,799	2,558
Number of plants injured	12	109	14	318	17	33	56	157	103	66	47	29	70
Maximum SUM06 value (ppm-hr)[a]	31.71	42.83	40.83	40.76	40.62	20.5	31.35	34.43	18.66	12.36	22.73	19.59	23.41

[a] Averaged from State values.

Forest Soils

Background

Rich soils are the foundation of productive forest land, and they are one of the major carbon banks. Soils develop in response to several factors (climate, local vegetation, topography, parent material, and time), and these factors can be used to identify soil regions related to particular native forests. Today, the forest soil inventory illustrates the unique niches that different forests now occupy to maximize their competitive advantage. By identifying the soil properties associated with various forest types, the data collected by FIA provide critical baseline information to document changes in forest health resulting from natural or human influences.

The study of soil carbon is in its infancy. We need more measurements quantifying the soil carbon pool across different land types, and we need more information on soil carbon flux over time. Annual inventories of FIA soil plots will provide this type of information. The results presented here are based upon observations at 180 plots throughout West Virginia, Ohio, and Pennsylvania.

What we found

Substantial variability exists within the soil regions of West Virginia, Ohio, and Pennsylvania as forest trees compete for and create specialized niches. For example, maple/beech/birch in Pennsylvania and Ohio tended to accumulate more forest floor material than oak/hickory stands, but in West Virginia this was reversed, with oak/hickory stands there having more material than maple/beech/birch stands (Fig. 66). The carbon content of the forest floor in West Virginia is less than that of Pennsylvania in similar forest types (Fig. 67). The differences were more consistent in the mineral soil carbon stocks (Fig. 68). Similar forests types in West Virginia stored more soil carbon than in Pennsylvania and Ohio. In West Virginia, forest floor carbon averages 5 dry tons per acre, and carbon in the mineral soil averages 25 tons per acre, and carbon in all trees and shrubs averages 46 tons per acre.

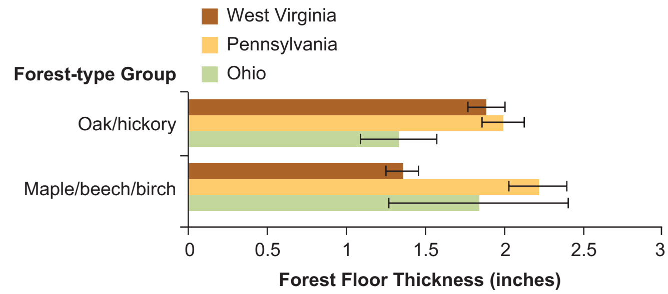


Figure 66.—Mean forest floor thickness by forest-type group (error bars represent 68-percent confidence intervals around estimates).

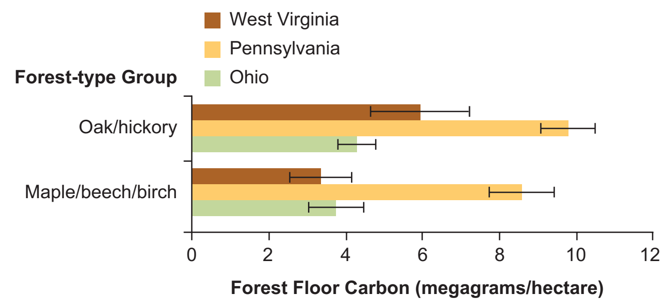


Figure 67.—Mean forest floor carbon by forest-type group (error bars represent 68-percent confidence intervals around estimates).

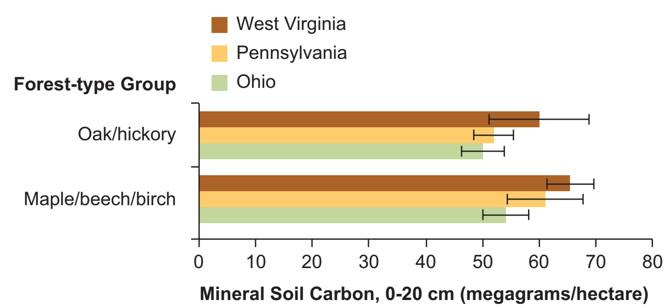


Figure 68.—Mean carbon content of forest soils by forest-type group (error bars represent 68-percent confidence intervals around estimates).

What this means

The forest floor develops from the slow accumulation of organic matter. Carbon is the primary component of soil organic matter, which has a number of important functions. These include increasing water holding capacity and retaining some nutrients. Carbon is also inventoried to track the sequestration of certain greenhouse gases. It traps nutrients and improves water holding capacity. Thicker forest floors contribute toward greater carbon storage. Direct measurements of carbon and the functions it provides are essential in improving our understanding of the carbon cycle. Given the similarities between carbon stocks in West Virginia's two major forest types, there is no incentive to convert one type to another as a means of increasing carbon sequestration.

Forest Understory Vegetation: Diversity and Nonnative Invasive Plants

Background

Understory vegetation, including tree seedlings and saplings and all other plants growing on the forest floor, is a critical component of forested ecosystems in West Virginia. Such communities serve a crucial role in forested areas, providing food sources and habitat for wildlife, augmenting forest biodiversity, and performing ecosystem service functions, such as controlling runoff and regulating soil temperature. Important ecological knowledge is obtained by acquiring data on species diversity, invasive plants, stand density, and regeneration, knowledge that aids forest landowners and managers in understanding their forests and crafting management strategies to meet their goals. Additionally, invasive plant data help determine the ecological risk to the native plant communities. FIA assessed understory vegetation in West Virginia for 2007 and 2008 on both P2 Invasive plots (about 20 percent of field plots) and P3 plots (about 6.25 percent of field plots). For 2007-2008, there were 128 P2 Invasive plots and 48 P3 plots in West Virginia.

What we found

All species

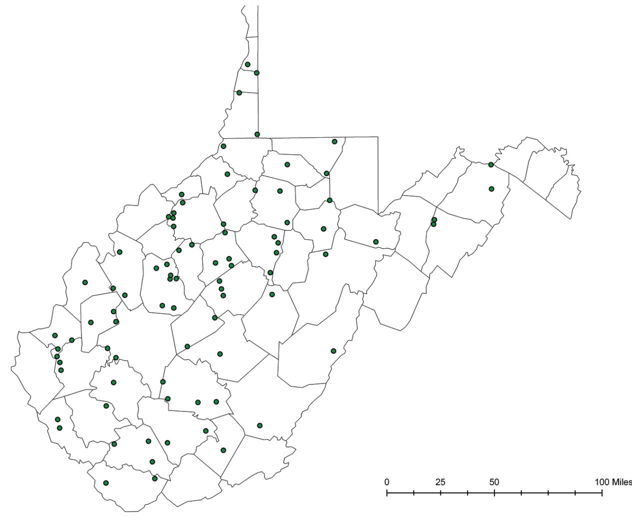
On the P3 plots, a total of 592 species were found with the highest number of species occurring in the forb/herb category according to the classification by the USDA Natural Resources Conservation Service's PLANTS database (available online: http://plants.usda.gov). Analyzing by broad growth habit categories, we found 75 trees, 58 shrubs, 20 vines, and 78 graminoids (grass or grass-like plants). For the P3 plots, 419 (71 percent) of the 592 plant species were native to the U.S. and 52 species (9 percent) were introduced. The most commonly observed species was red maple, found on 40 plots (Table 5), followed by blackberry and sedges, both observed on 39 plots. Of the 30 most commonly observed species, 13 were trees and 1 species was a nonnative invasive plant (multiflora rose; 24 plots). Multiflora rose was the most commonly observed nonnative plant species.

Table 5.—The top 30 identifiable plant species or undifferentiated genera found on West Virginia P3 plots, the number of plots (in parentheses), and the mean number of tree saplings and seedlings per acre on those plots, 2007-2008

Species name	Tree saplings per acre	Tree seedlings per acre
Red maple (40)	352	2,386
Blackberry (39)	335	2,467
Sedge (39)	362	2,530
Black cherry (37)	372	2,644
Virginia creeper (36)	342	2,362
Violet (36)	354	2,375
Tuliptree (33)	359	2,606
Northern red oak (32)	362	2,274
American beech (32)	386	2,734
Christmas fern (31)	360	2,684
Sugar maple (31)	402	2,138
Roundleaf greenbrier (29)	386	2,631
White oak (28)	376	2,601
Grape (28)	395	2,936
Cat greenbrier (28)	422	2,684
Eastern poison ivy (27)	372	2,489
White ash (27)	373	2,482
Goldenrod (27)	406	2,740
Black oak (26)	393	2,876
Sassafras (26)	403	2,723
Multiflora rose (24)	327	2,733
Northern spicebush (22)	389	2,507
Blackgum (22)	407	2,690
Flowering dogwood (20)	356	3,072
White wood aster (20)	365	2,275
Aster (20)	430	2,586
Cucumber-tree (19)	411	2,641
Chestnut oak (19)	419	2,254
Bristly greenbrier (18)	350	2,123
Mapleleaf viburnum (18)	441	2,504

Invasive species

Invasive plants were found throughout West Virginia. On the P2 Invasive plots, 43 invasive species are monitored. Multiflora rose was the most commonly observed species (84 plots) on these plots (Table 6). Multiflora rose was found on the greatest number of plots in the southwest, west, and northwest parts of West Virginia while plots in the southeast, east, and northeast parts of the State were less invaded (Fig. 69). These areas of lower occurrence coincided with more mountainous terrain, mature stands, and national forest land; they also represent areas with less agriculture compared to the rest of the State. A similar trend was found with Japanese siltgrass where there were few occurrences at high elevations and a greater number along roadways, corresponding with its affinity for moist habitat and anthropogenic disturbance (Fig. 70). Figure 71 shows tree-of-heaven, a native to China and a rapid growing tree with prolific seed production. The locations of invaded plots suggest the presence of this tree

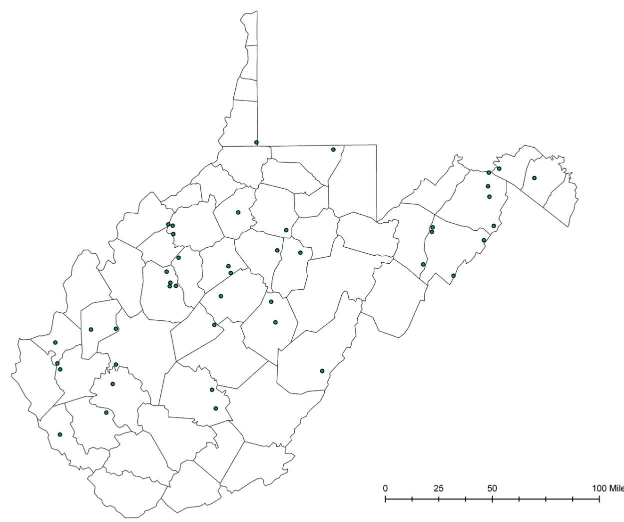


Projection: NAD83, UTM Zone 17 Data Source: USDA Forest Service Forest Inventory and Analysis Program 2005-2009 Phase 2 Invasive and Phase 3 data. State and County layers source: ESRI Data and Maps 2005. Depicted plot locations are approximate. Author: C. Kurtz.

Figure 69.—Distribution of multiflora rose in West Virginia observed on 2007-2008 FIA P2 Invasive and P3 plots, approximate locations depicted.

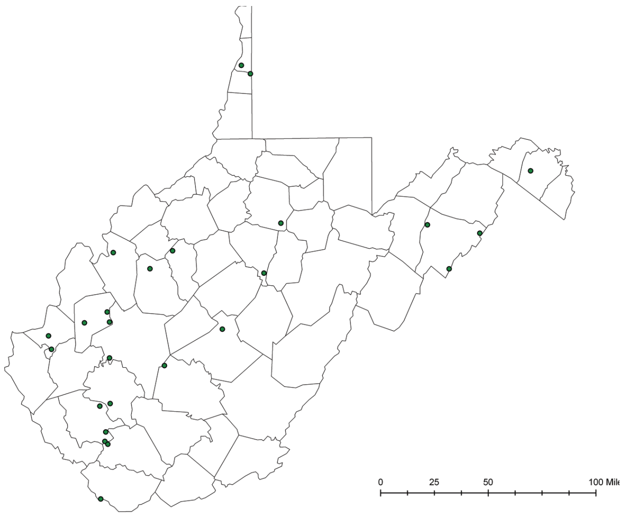
Table 6.—Identifiable invasive plant species found on West Virginia P2 Invasive plots, the number of plots (in parentheses), and the mean number of tree saplings per acre on those plots, 2007-2008

Species name	Tree saplings per acre	Tree seedlings per acre
Multiflora rose (84)	314	2,208
Black locust (63)	331	1,960
Japanese siltgrass (43)	335	1,707
Autumn olive (31)	251	1,769
Tree of heaven (25)	344	2,264
Japanese honeysuckle (22)	351	2,342
Garlic mustard (14)	279	1,172
Japanese barberry (14)	124	1,623
Morrow's honeysuckle (10)	74	2,024
Princesstree (8)	322	1,578
Bull thistle (6)	189	603
Canada thistle (4)	169	1,099
Japanese meadowsweet (4)	356	5,568
Oriental bittersweet (4)	125	1,415
European privet (3)	350	2,299
Japanese knotweed (3)	225	2,300
Reed canarygrass (3)	101	2,271
Amur honeysuckle (2)	75	4,985
Leafy spurge (2)	37	555
Common barberry (1)	1,000	2,599
Common buckthorn (1)	75	75
Creeping jenny (1)	150	900



Projection: NAD83, UTM Zone 17 Data Source: USDA Forest Service Forest Inventory and Analysis Program 2005-2009 Phase 2 Invasive and Phase 3 data. State and County layers source: ESRI Data and Maps 2005. Depicted plot locations are approximate. Author: C. Kurtz.

Figure 70.—Distribution of Japanese siltgrass in West Virginia observed on 2007-2008 FIA P2 Invasive and P3 plots, approximate locations depicted.



Projection: NAD83, UTM Zone 17 Data Source: USDA Forest Service Forest Inventory and Analysis Program 2005-2009 Phase 2 Invasive and Phase 3 data. State and County layers source: ESRI Data and Maps 2005. Depicted plot locations are approximate. Author: C. Kurtz.

Figure 71.—Distribution of tree of heaven in West Virginia observed on 2007-2008 FIA P2 Invasive and P3 plots, approximate locations depicted.

is facilitated by humans because it is most likely to be found on forested plots in areas with high development.

When plots had invasive plants present, the data suggest that the number of seedlings per acre declines as invasive plant cover increases, but the number of saplings does not decline (Fig. 72). This poses the question: Were the saplings established before the invasive species cover increased to such a high number? Although the question cannot be answered at this time, remeasurements during the next inventory might provide further information on any relationships.

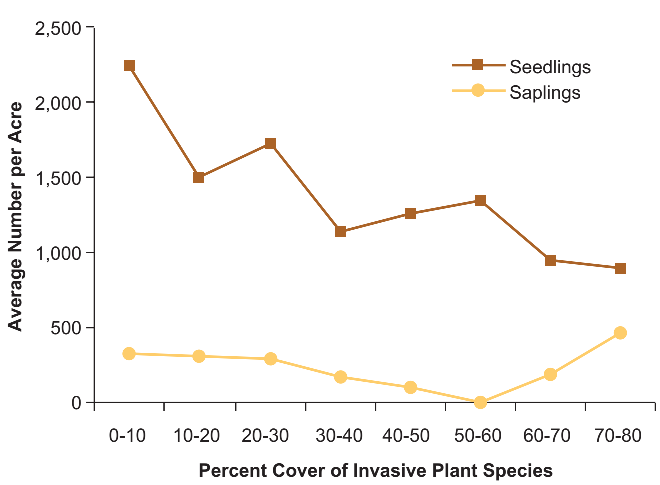


Figure 72.—The influence of invasive plant species cover on the number of seedlings and saplings per acre on forested P2 Invasive and P3 FIA plots.

What this means

West Virginia's forest ecosystems possess a diverse assemblage of plant species classified into five growth habits (forb/herb, graminoid, shrub, tree, and vine). Invasive plants pose a threat to these forested communities by displacing native species and changing resource availability, such as water and nutrient levels. Forest managers should be aware of the presence of invasive species and their interference with stand regeneration after management activities.

Future remeasurement of the P2 Invasive and P3 plots will provide additional information on the distribution and spread of these species. Studies will be able to incorporate site and region characteristics that are important drivers of the presence of these invasive species. Gaining knowledge of influential site and region characteristics will provide insight to factors related to species presence and allow concerned individuals to predict the threat of invasion and future ecosystem response.

Threats to the Health of Important Tree Species in West Virginia

Invasions by exotic diseases and insects are one of the most important threats to the productivity and stability of forest ecosystems around the world (Liebhold et al. 1995, Vitousek et al. 1996). Over the last century, West Virginia forests were affected by well-known exotic and invasive agents such as chestnut blight and gypsy moth (Mattson 1997). Although the mortality rate for West Virginia trees appears to be normal, forests are threatened by insects and diseases that have recently spread into the State. The following discussion looks at three of these pests and their tree host species: emerald ash borer (EAB), beech bark disease (BBD), and hemlock woolly adelgid (HWA).

Ash Resource at Risk from the Emerald Ash Borer

Background

The EAB (*Agrilus planipennis Fairmaire*) is an exotic bark-boring beetle native to Asia that was discovered in Detroit, Michigan, in 2002 (Kovacs 2010). It is especially dangerous because there is no known treatment for EAB infestations. Since 2002, EAB has spread and killed millions of ash trees in Michigan and Ohio. As of November 2010, it had been detected at sites in several West Virginia counties (Raleigh, Nicholas, Fayette, Roane, Calhoun, and Morgan). EAB is a major threat to the State's ash resource. All ash species, regardless of tree vigor, are at risk.

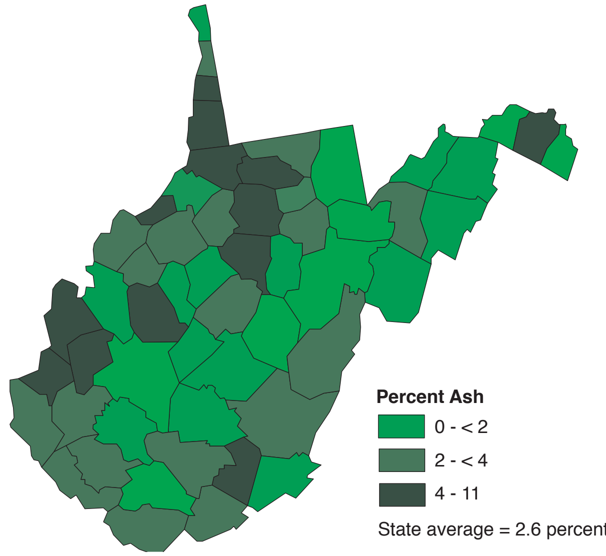


Figure 73—Ash species as a percentage of total live volume by county, West Virginia 2008.

What we found

Ash species are common and well distributed throughout the State, although stands dominated by ash are rare. Ash volume averages 2.6 percent of the total volume of trees 5.0 inches and larger d.b.h. and averages 59 cubic feet of wood per acre on forest land (Figs. 73, 74). Currently, about 12 million board feet (International $^{1}/_{4}$-inch rule) of ash saw logs are harvested annually in the State (7 percent of total harvest). Not included here, but also at risk, are ash shade trees in urban areas.

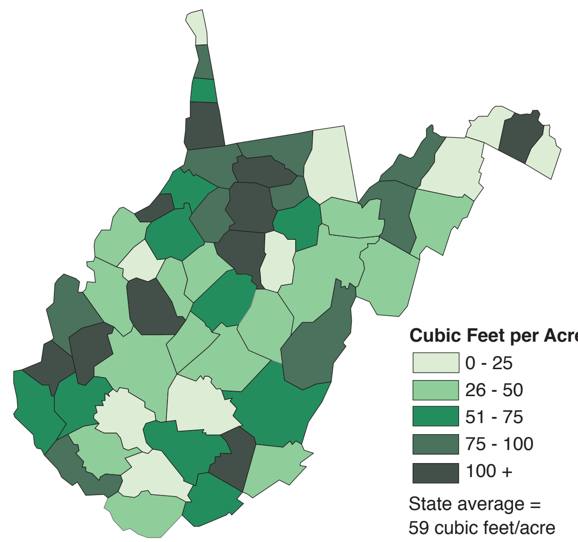


Figure 74—Average cubic-foot volume of ash per acre of forest land by county, West Virginia, 2008.

What this means

When an EAB infestation is found, quarantine procedures are put in place to limit the spread of the pest by human behavior (moving firewood, transporting logs, purchasing infested plants, etc.). Currently, West Virginia is under a quarantine that restricts the export of hardwood firewood of all species to other states and requires a permit to ship ash logs to mills in other states. The movement of firewood is believed to be a major cause for the spread of EAB. By restricting its movement, it is hoped that EAB will be contained until biological controls are found.

Because ash trees typically compose only a small portion of the tree canopy, the loss of ash will probably go unnoticed by the casual observer. Gaps created by ash mortality will likely be filled in by surrounding overstory trees. But the loss of ash will have an impact on wildlife species and the forest products industry. Landowners should be vigilant about the spread of EAB and may choose to harvest valuable ash trees before this infestation reaches their area.

Beech Bark Disease and American Beech

Background

American beech is a major component of the maple/beech/birch forest-type group, which makes up 18 percent of the forest resource in West Virginia. Forests with the highest proportion of American beech basal area are in the most mountainous portions of the State (Fig. 75). American beech is an important wildlife and pulpwood species. BBD is an insect-fungus complex involving the beech scale insect (*Cryptococcus fagisuga* Lind.) and the exotic canker fungus Neonectria coccinea (Pers.:Fr.) var. faginata Lohm. or the native Neonectria galligena Bres. that kills or injures American beech. Three phases of BBD are generally recognized: 1) the "advancing front," which corresponds to areas recently invaded by scale populations; 2) the "killing front," which represents areas where fungal invasion has occurred (typically 3 to 5 years after the scale insects appear, but sometimes as long as 20 years) and tree mortality begins; 3) the "aftermath forest," which are areas where the disease is endemic (Houston 1994, Shigo 1972).

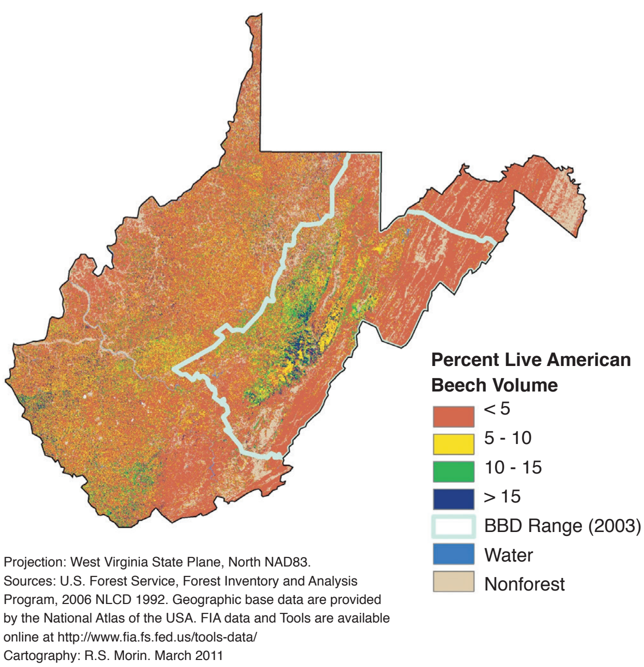


Figure 75.—Percent American beech volume, West Virginia, 2006, and range of beech bark disease infestation, West Virginia, 2003.

What we found

The scale insect was first observed in the State at the Gaudineer Scenic Area, Greenbrier District, Monongahela National Forest in 1981 (Meilke et al. 1982). By 2003, the disease complex had been discovered in 12 West Virginia counties (Fig. 75). Currently, significant amounts of standing dead beech are present in much of the 12 county area of West Virginia inside the range of BBD infestation (Fig. 76). Annual mortality rates for American beech are six times higher in the counties that have been infested with BBD for longer than 10 years. By contrast, counties that have been infested with BBD for less than 10 years appear not to have suffered increased mortality yet (Fig. 77).

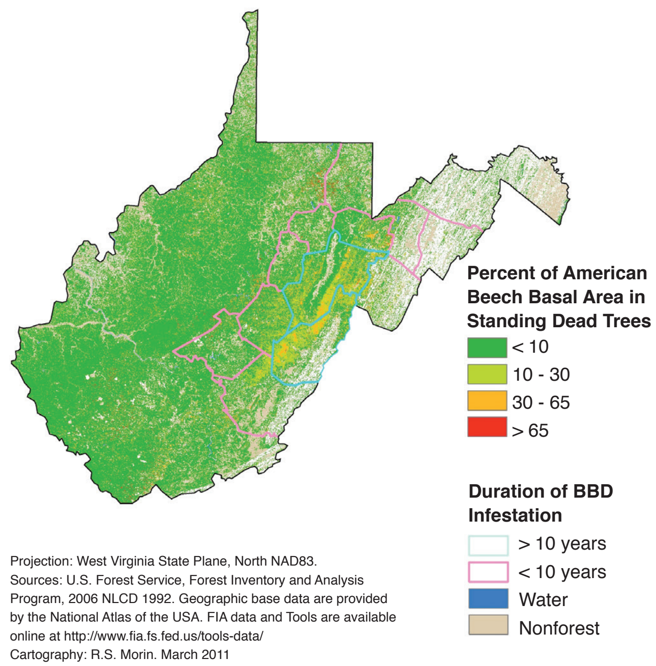


Figure 76.—Percent of American beech basal area that is standing dead, West Virginia, 2006, and range of beech bark disease infestation, West Virginia, 2003.

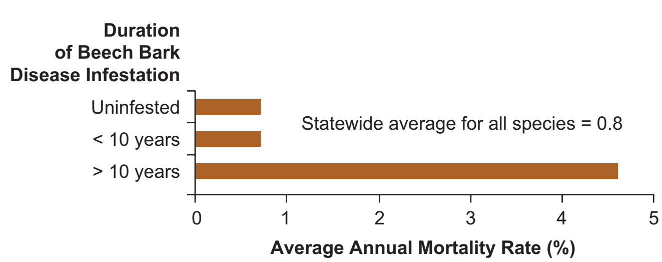


Figure 77.—Average annual mortality rate for American beech in counties infested with beech bark disease for more than 10 years (2 counties), less than 10 years (10 counties), and uninfested (43 counties) areas, West Virginia, 2008.

What this means

The two-county area that is currently experiencing increased levels of American beech mortality is in the killing front phase of BBD. Morin et al. (2007) estimated that the beech scale is spreading at a rate of about 14.7 km/year. Therefore, the advancing front of BBD is expected to continue spreading into the rest of the West Virginia over the next two decades. Significant densities of American beech trees are present in the uninfested southwestern portion of West Virginia. As the scale insect spreads, monitoring should continue for fungal invasion and subsequent tree mortality.

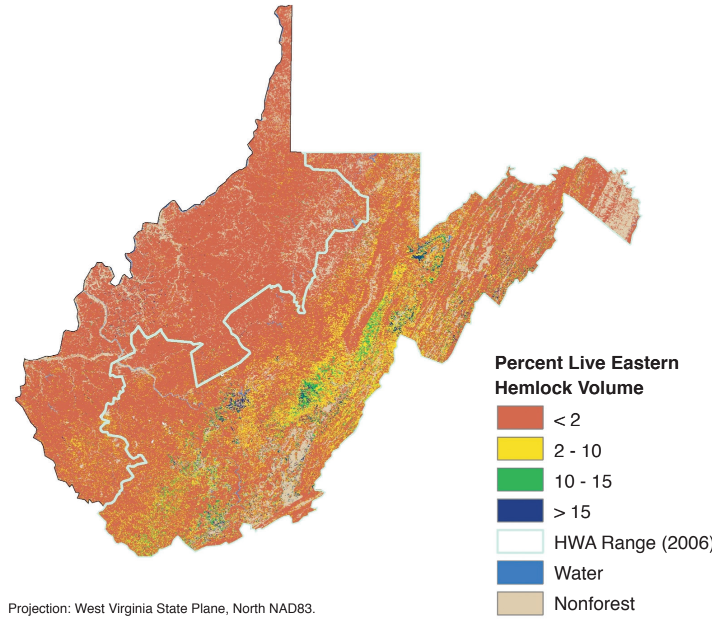


Figure 78.—Percent eastern hemlock volume, West Virginia, 2006, and range of hemlock woolly adelgid infestation, West Virginia, 2006.

Eastern Hemlock and the Hemlock Woolly Adelgid

Background

Eastern hemlock (*Tsuga Canadensis* L.) is a minor component of the forest resource in West Virginia, but due to its value for wildlife habitat and the unique niche it fills in riparian areas, it is an ecologically important species. Forests with the highest proportion of hemlock basal area are in the most mountainous portions of the State (Fig. 78). Hemlock woolly adelgid (HWA) is native to East Asia and was first noticed in the eastern United States in the 1950s (Ward et al. 2004). Since then, it has slowly expanded its range. HWA has caused widespread defoliation and sometimes mortality of eastern hemlock in areas where it has become established (McClure et al. 2001, Orwig et al. 2002).

What we found

HWA was first observed in the four eastern panhandle counties in 1992. By 2006, the insect had been discovered in 29 West Virginia counties (Fig. 78). Currently, pockets of standing dead eastern hemlock trees are present in the area inside the range of HWA (Fig. 79). The annual mortality rate for eastern hemlock is nearly four times greater in the

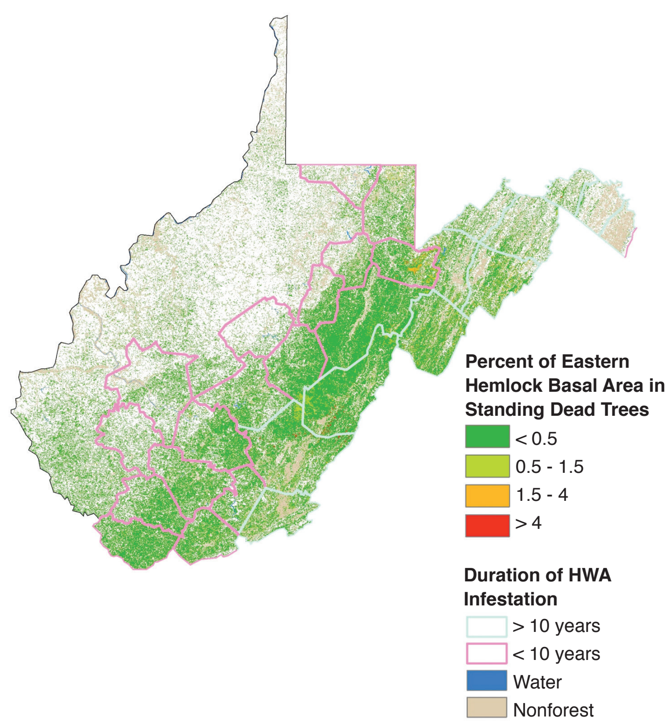


Figure 79.—Percent of eastern hemlock basal area that is standing dead, West Virginia, 2006, and range of hemlock woolly adelgid infestation, West Virginia, 2006.

counties that have been infested with HWA for more than 10 years than in the uninfested areas (Fig. 80). By contrast, the annual mortality rate for eastern hemlock in the counties that have been infested with HWA for less than 10 years is lower than in the uninfested area.

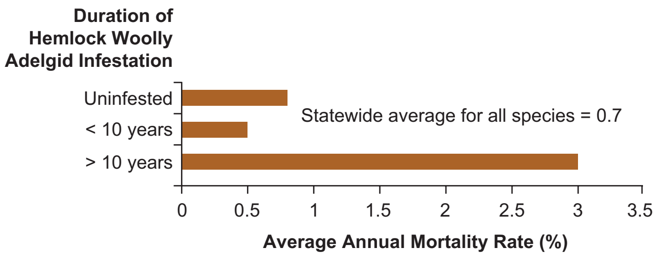


Figure 80.—Average annual mortality rate for eastern hemlock in counties infested with hemlock woolly adelgid for more than 10 years (11 counties), less than 10 years (18 counties), and uninfested (26 counties), West Virginia, 2008.

What this means

Morin et al. (2009) estimated that HWA is spreading at a rate of about 9.4 km per year in a westerly direction. Although HWA is expected to continue spreading into the rest of the State over the next two decades, densities of eastern hemlock are relatively low in the uninfested portion of West Virginia. It will be important to continue monitoring mortality rates in the high density eastern hemlock forests over the coming decade.

Timber Products

Canaan Valley. Photo courtesy of West Virginia Division of Forestry.

Timber Products

Background

Timber harvesting produces economic benefits for persons involved in timber ownership, management, marketing, harvesting, hauling, and distribution to processing mills. In 2007, more than 8,700 people were employed in wood product manufacturing in West Virginia (2007 Bureau of Census NAICS code 321) with an additional 617 employed in paper manufacturing (2007 NAICS code 322). Total payroll for these two sectors of the West Virginia forest economy is estimated at $292.4 million (16 percent of all manufacturing in West Virginia, 2007 Bureau of Census NAICS codes 31-33). The value of forest product shipments from West Virginia was estimated at $2.0 billion in 2007 (U.S. Census Bureau 2010).

FIA, in conjunction with other research units, canvassed primary wood processors to enumerate the amount of roundwood harvested for products in West Virginia, the types of products made, and the species utilized. To better manage the State's forests, it is important to know the quantity, species, and disposition by product of wood harvested in West Virginia. The last survey was conducted in 2007 (Piva and Cook 2011). This report was supplemented by the most recent surveys conducted in surrounding states that processed wood harvested from West Virginia forests.

What we found

In West Virginia, there were 86 saw mills, 11 post and pole mills, 10 mine timber mills, 3 composite panel mills, 2 veneer mills, and 4 miscellaneous products mills. These mills processed 172.9 million cubic feet of industrial roundwood, 80 percent of which came from the State. Sixty percent of the imported industrial roundwood came from Virginia. In 2007, there were 60 fewer operating mills than 2000.

Of the 188.5 million cubic feet of industrial roundwood harvested in West Virginia, 138.8 million cubic feet stayed in the State for processing by West Virginia mills. Saw logs accounted for 55 percent of the total industrial roundwood harvested, followed by pulpwood and composite panel mills at 35 percent, and veneer logs at 7 percent (Fig 81). Other industrial roundwood products harvested included post and poles, mine timbers, handles, cooperage, and cabin logs. Yellow-poplar made up 31 percent of the total industrial roundwood harvest (Fig. 82). Other important species groups harvested were red oaks, white oaks, soft maple, hard maple, and black cherry. Softwoods made up only 5 percent of the total volume harvested, and most of this was shipped to out-of-State pulp mills.

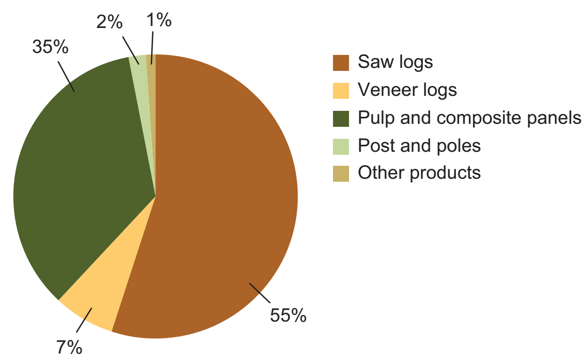


Figure 81.—Industrial roundwood production by product, West Virginia, 2007.

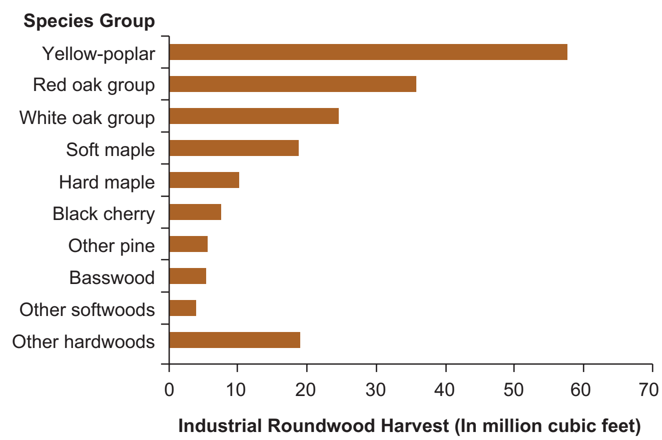


Figure 82.—Industrial roundwood production by species group, West Virginia, 2007.

The saw log harvest in West Virginia decreased by 22 percent between 2000 and 2007, from 803 million board feet (International 1/4-inch rule) in 2000 to 623 million board feet in 2007. Nearly all of the saw log harvest is hardwood species and is predominantly made up of red oaks, yellow-poplar, white oaks, sugar maple, and red maple 29, 24, 17, 8, and 8 percent of the total saw log harvest, respectively (Fig. 83). Since 1994, the portion of the saw log harvest made up of oak species has remained at 46 percent while the portion made up of maples has increased from 9 to 16 percent.

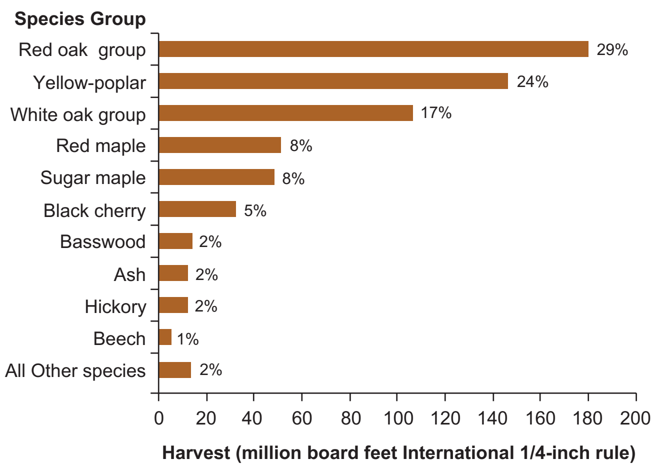


Figure 83.—Saw log harvest and percentage of total by major species group, West Virginia 2007.

In the process of harvesting industrial roundwood, 100.3 cubic feet of harvest residues were left on the ground. Without a prominent pulpwood market in the State, much of the upper bole of trees goes unused because it is too small for saw logs or veneer logs. The processing of industrial roundwood in the State's primary wood-using mills generated another 87,000 cubic feet (2.1 million green tons) of wood and bark residues. Only 1 percent of the mill residues were not used for fiber products, fuelwood, mulch, small dimension lumber, or other uses (Fig. 84).

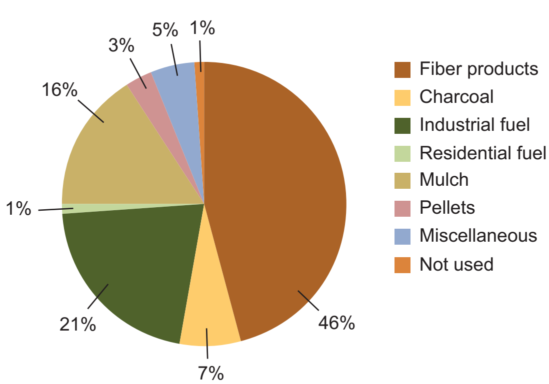


Figure 84.—Disposition of mill residues generated by primary wood-using mills, West Virginia, 2007.

What this means

Most of the wood-processing facilities in West Virginia are sawmills processing State-grown saw logs. These mills provide woodland owners with an outlet to sell timber and provide jobs. An important consideration for the future of West Virginia's primary wood-products industry is its ability to retain and process the industrial roundwood harvested, leading to value-added production in the State. Currently, almost a quarter of the industrial roundwood harvested in West Virginia is sent to other states for processing, providing less of a benefit to West Virginia's economy.

The shift in the species composition of the saw log harvest to more maple reflects changes in the forest resource. To remain sustainable, the composition of the harvest will need to continue to shift with changes in the resource. Currently, oak species represent 46 percent of the saw log harvest, but only 18 percent of the standing board-foot volume. Fortunately, customer tastes have been changing toward using lighter colored woods, such as the maples, for cabinets and flooring.

Another important issue is the volume of unused logging residue that is generated in the State. Economically viable utilization of this resource through the use of logging residues for industrial fuelwood at co-generation facilities or other bioenergy products is a possible solution for this problem. Each type of residue should be utilized to produce the highest value product it is suited for.

Having markets for wood is essential to forest management. Despite the loss of some sawmills, West Virginia's mills continue to provide landowners a competitive market for their timber. The income landowners receive from selling timber is an incentive to keep land in forest. It can help pay property taxes and fund forest management activities such as wildlife habitat improvements and control of invasive species.

Data Sources and Techniques

Forest Inventory

The FIA sampling design is based on a grid of hexagons superimposed on a map of the United States with each hexagon approximately 6,000 acres in size and at least one permanent plot established in each hexagon. In P1 of FIA's multi-phase inventory, the population of interest is stratified and plots are assigned to strata to increase the precision of estimates. In P2, tree and site attributes are measured for forested plots established in each hexagon. P2 plots consist of four 24-foot fixed-radius subplots on which standing trees are inventoried. During P3, forest health indicators are measured on a 1/16th subset of the entire FIA ground plot network so that each plot represents approximately 96,000 acres. The forest health indicators are tree crown condition, lichen communities, forest soils, vegetation diversity, down woody material, and ozone injury.

A detailed set of tables, along with information on statistical reliability, are included in the Statistics and Quality Assurance part of this report on the DVD attached to the inside back cover. Tools to access data, previous reports, and additional information are available at: www.nrs.fs.fed.us/fia

National Woodland Owner Survey

The National Woodland Owner survey (www.fia.fs.fed.us/nwos) is conducted annually by the Forest Service to increase our understanding of private woodland owners—the critical link between society and forests. Questionnaires are mailed to individuals and private groups who own the woodlands where FIA has established inventory plots (Butler 2008). About 6,000 owners are contacted each year. Results in West Virginia are based on 245 responses received during 2002-2006.

Timber Products Inventory

The timber products inventory study was a cooperative effort between the West Virginia Division of Forestry, Department of Commerce and the Northern Research Station (Piva and Cook 2011). The study canvassed all primary wood-using mills within the State, using mail questionnaires designed to determine the size and composition of West Virginia's primary wood-using industry, its use of roundwood, and its generation and disposition of wood residues. Division of Forestry personnel contacted nonresponding mills through additional mailings, telephone calls, and personal contacts. Data on West Virginia's industrial roundwood receipts have been added to a regional timber removals database and supplemented with data on out-of-Sate uses of State roundwood to provide a complete assessment of West Virginia's timber product output.

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DVD Contents

West Virginia's Forests 2008 (PDF)

West Virginia's Forests: Statistics and Quality Assurance (PDF)

West Virginia Inventory Database (CSV file folder)

West Virginia Inventory Database (Access file)

Field guides that describe inventory procedures (PDF)

Database User Guides (PDF)

Widmann, Richard H.; Cook, Gregory W.; Barnett, Charles J.; Butler, Brett J.; Griffith, Douglas M.; Hatfield, Mark A.; Kurtz, Cassandra M.; Morin, Randall S.; Moser, W. Keith; Perry, Charles H.; Piva, Ronald J.; Riemann, Rachel; Woodall, Christopher W. 2012. **West Virginia's Forests 2008.** Resour. Bull. NRS-61 Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 64 p. [DVD included].

The first full annual inventory of West Virginia's forests reports 12.0 million acres of forest land or 78 percent of the State's land area. The area of forest land has changed little since 2000. Of this land, 7.2 million acres (60 percent) are held by family forest owners. The current growing-stock inventory is 25 billion cubic feet—12 percent more than in 2000—and averages 2,136 cubic feet per acre. Yellow-poplar continues to lead in volume followed by white and chestnut oaks. Since 2000, the saw log portion of growing-stock volume has increased by 23 percent to 88 billion board feet. In the latest inventory, net growth exceeded removals for all major species. Detailed information on forest inventory methods and data quality estimates is included in a DVD at the back of this report. Tables of population estimates and a glossary are also included.

KEY WORDS: forest resources, forest health, forest products, volume, biomass

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