Maryland's Forests 2008

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Abstract

The first full annual inventory of Maryland's forests reports approximately 2.5 million acres of forest land, which covers 40 percent of the State's land area and with a total volume of more than 2,100 cubic feet per acre. Nineteen percent of the growing-stock volume is yellow-poplar, followed by red maple (13 percent) and loblolly pine (10 percent). All species of oaks combined account for 26 percent of the total growing-stock volume. Yellow-poplar volume is increasing, particularly in the large-diameter classes. Red maple is the most abundant species in terms of number of trees and the population had been rising through the 1980s and 1990s, but current data show little change in red maple abundance since 1999. Seventy-six percent of forest land consists of large diameter, 14 percent contains medium diameter, and the remainder is in small diameter stand size classes or nonstocked stands. There were approximately 5.9 billion cubic feet of growing-stock volume in 2008, and the average annual growth rate of volume has been approximately 2 percent. Additional information on forest attributes, land-use change, carbon, timber products, and forest health is presented in this report. A DVD included in the report provides information on sampling techniques, estimation procedures, tables of population estimates, raw data, a data summarization tool, and a glossary.

Acknowledgments

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Cover: Puckham Branch riparian area in Dorchester County, MD, 2005. Photo by Jack Perdue, Maryland DNR.

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Maryland's Forests 2008

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Foreword

Our forests remain a critical element in Maryland's landscape. Not only are they environmentally important, but forests also contribute to our economic and social well-being. To know if Maryland's forests are being managed in a sustainable way, we need to be able to take a periodic snapshot (analysis) of the status and trends of the forest resources. The U.S. Forest Service, Forest Inventory & Analysis (FIA) Program, in partnership with the Maryland Department of Natural Resources – Forest Service, has previously inventoried Maryland's forests in 1950, 1964, 1976, 1986 and 1999. In 1999, periodic inventories were replaced with annualized inventories in which a portion of the field plots are inventoried each year, and a full inventory is completed every 5 years. The first full inventory using the annualized data for Maryland was completed in 2008 and covers the period of 2004 to 2008. This report is an analysis of that inventory.

The forests which are vital to our quality of life have been under continual pressure since colonial times. First these threats were the result of unrestricted clearing and harvesting. Land was cleared for farming as the once awe-inspiring forests were seen as obstacles to progress. Wood was the fuel and building material of choice for a young and growing nation. After World War II, the country was growing and forests were lost at an alarming rate to make room for new homes and businesses. Today our forests face new threats —exotic invasive plants and insects such as gypsy moth and emerald ash borer threaten the health and diversity of our forests. Demographic trends continue to change the face of our forests through land-use conversion, forest fragmentation, and parcelization.

Still our forests provide us with many benefits every day which, unfortunately, we have become accustomed to and take for granted. Without healthy forests, we will not have quality air and water to meet our most basic needs. Forest land provides habitat for the wildlife we enjoy and is so vital to the fabric of our planet. Even during this age of technological advances, wood is still our "greenest" and most basic building material, and we are increasingly seeking the forest as a place to escape the pressures of modern life.

This document describes and highlights the current status and trends of Maryland's forests. The trends that have been portrayed in earlier versions of this inventory have led to the Maryland Seed Tree Law and the Forest Conservation Act.

I hope you will look beyond the numbers and figures presented here to come to a more complete appreciation of the grandeur that are our trees and forests and the opportunities and risks we all face together.

Steven W. Koehn
State Forester / Director
Maryland DNR Forest Service

Contents

Highlights

On the Plus Side

There are approximately 2.5 million acres of forest land in Maryland, 95 percent of which is timberland.

The rate of forest loss has decreased since 1964 and current data show no detectable net loss of forest land since 1999. More detailed photointerpretation data indicate that the current rate of forest loss is just over 3,000 acres per year.

There have been some gains in forest land area, 91 percent of which are due to the conversion of agricultural land to forest.

Eighty-seven percent of Maryland's forest land occurs in contiguous blocks that are at least 100 acres in size.

Sixty-six percent of sawtimber volume in Maryland is in higher tree grades (1 or 2).

The amount of sawtimber volume, particularly of hardwoods, is increasing.

More than 200 million tons of carbon are contained in the forests of Maryland, more than half of which is found in live trees and saplings.

Tree growth exceeds losses from mortality and removals in Maryland and the growth to removals ratio has increased to 2.6 in the current inventory.

Tree mortality is only 0.7 percent of total volume, and trees with poor condition crowns generally occur at low levels and evenly across the state.

The loblolly pine population is stable with levels of removals nearly equaling growth as indicated by a growth to removals ratio of 1.1.

Old growth oaks, Garrett County, MD, 2004. Photo by Jack Perdue, Maryland DNR.

Data suggest that the number of oak saplings in the smallest (1 to 3 inch) diameter class has increased steadily since 1986 and that overall there is no change in the number or volume of oaks since 1999.

Maryland's wood products industry generates more than $300 million of economic activity and employs more than 8,000 people.

Seventeen percent of Maryland's forest land is in wetlands which provide many ecosystem services such as water filtration and storage, nutrient cycling, flood and erosion control, carbon sequestration, and habitat for wildlife.

Problem Areas

Forest area loss is not being offset by gains in forest in three counties of Maryland.

Ninety-one percent of the forest loss in Maryland is due to forest conversion to developed uses which is likely permanent forest loss.

Sixty percent of Maryland's forest land is less than 300 feet from an agriculture use or developed edge, which is close enough for the forest land to be influenced or disturbed by the edge.

Localized forest fragmentation, particularly in Carroll and Howard Counties, has led to a relatively high percentage (>30 percent) of the remaining forest in these counties in patches <100 acres in size.

Species composition is shifting toward large diameter yellow-poplar stands, with oaks declining in relative volume in the larger diameter classes. This may have implications for wildlife, including oak-dependant species.

Red maple is the most abundant (in terms of number of trees) species and second most dominant in terms of sawtimber volume, and data suggest that its abundance increased through the late 1990s and is now stabilizing.

In the process of harvesting industrial roundwood, 15.1 million cubic feet of harvest residues were left on the ground. Almost a quarter of the harvest residue generated is from growing-stock sources (wood material that could be used to produce products).

The area of forest in the small diameter size-class has been decreasing, and this could affect wildlife populations that rely on these areas.

Multiflora rose was the most common invasive plant encountered on the invasive inventory plots and was present on over 30 percent of the plots.

Issues to Watch

Ninety-one percent of the gains in forest land are due to agricultural reversion to forest, but as the area of land in agriculture continues to diminish, gross gains in forest land will likely decrease.

Maryland's forests are changing in composition, with yellow-poplar and red maple increasing in the larger diameter classes. These changes will have an impact on Maryland's forest industry and on wildlife populations in the future.

The numbers of trees in the smaller diameter classes and the area of stands in the small stand size classes have been decreasing, while the area of forest in the larger stand size and age classes has been increasing. This, coupled with an increase in stand age, may suggest loss of early successional habitat which is important for some wildlife species in decline (northern bobwhite, field sparrow, prairie warbler, and American woodcock).

A large amount of Maryland's private forests is likely to change hands in the near future as older land owners transfer property to their heirs. It is unclear how these future forest owners will manage and care for their lands.

Invasive plant species are a concern in Maryland, and there is some evidence of lower frequencies of tree seedlings and saplings on plots with higher amounts of these invasives.

The emerald ash borer, an exotic beetle, was found in Maryland and poses a threat to ash trees in both urban and forest environments. Other pests, including gypsy moth and hemlock wooly adelgid, are also expected to cause damage to Maryland's forests. The spread of these pests needs to be carefully watched.

Forest fragmentation is occurring at a higher rate in the previously more intact forests of western Maryland. As population pressures and real estate preferences continue to change, forest loss associated with urbanization will have a greater impact in these counties.

Background

View from Weverton Heights, Washington County, MD, 2006. Photo by Jack Perdue, Maryland DNR.

Data Sources and Techniques

Forest Inventory

Information on the condition and status of forests in Maryland was obtained from the U.S. Forest Service, Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of Maryland's forest resources were completed in 1950 (Northeastern Forest Exp. Stn. 1955), 1964 (Ferguson 1967), 1976 (Powell and Kingsley 1980), 1986 (Frieswyk and DiGiovanni 1988), and 1999 (Frieswyk 2001). This report focuses on data collected from 2004 to 2008, hereafter referred to as the 2008 inventory.

Sampling Phases

The 2008 Maryland inventory was conducted in three phases. In Phase 1 (P1), a geographic information system (GIS) was used to obtain initial land use assessments on each plot, and to obtain stratification information that was used during the estimation process to increase the precision of estimates. In Phase 2 (P2), field crews visited field plots to measure inventory variables such as tree species, diameter, and height. P2 inventory plots have been established throughout Maryland, with approximately one plot for every 6,000 acres (Fig. 1). In Phase 3 (P3), field crews visited a subset of P2 plots to obtain measurements for an additional suite of variables associated with forest and ecosystem health. The three phases of the FIA program as implemented in this inventory are discussed in greater detail in "Maryland's Forests 2008: Statistics, Methods, and Quality Assurance," on the DVD in the inside back cover pocket of this bulletin.

National Woodland Owner Survey

Information about family forest owners is collected annually through the U.S. Forest Service's National Woodland Owner Survey (NWOS). The NWOS was designed to increase our understanding of owner demographics and motivation (Butler et al. 2005). Data presented here are based on survey responses from 88 randomly selected families and individuals who own forest land in Delaware and Maryland. For additional information about the NWOS, visit: www.fia.fs.fed.us/nwos.

Timber Product Output Inventory

This study was a cooperative effort of the Maryland Department of Natural Resources, Forest Service, and the Northern Research Station (NRS). A questionnaire, designed to determine the size and composition of Maryland's forest products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, was filled out for all primary wood-using mills within the state. Completed questionnaires were sent to NRS for editing and processing. As part of data editing and processing, all industrial roundwood volumes reported on the questionnaires were converted to standard units of measure using regional conversion factors. Timber removals by source of material and harvest residues generated during logging were estimated from standard product volumes using factors developed from logging utilization studies previously conducted by NRS.

Frequently Asked Questions

What is a tree?

Trees are perennial woody plants with central stems and distinct crowns. In general, the Forest Inventory and Analysis (FIA) program of the U.S. Department of Agriculture, Forest Service defines a tree as any perennial woody plant species that can attain a height of 15 feet at maturity. A complete list of the tree species (common and scientific names) measured in this inventory can be found in "Maryland's Forests 2008: Statistics, Methods, and Quality Assurance," on the DVD in the inside back cover pocket of this bulletin.

What is a forest?

A forest can come in many forms depending on climate, quality of soils, and the available gene pool for the dispersion of plant species. Forest stands range from very tall, heavily dense, and multi-structured to short, sparsely populated, and single layered. 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. Forest land can exist in urban and agricultural areas as long as it meets the above criteria and doesn't have maintained or mowed understory. Examples of land with tree cover that are not considered forest land by FIA definitions include: pasture land under tree cover that has been grazed, urban parks with a maintained understory, and treed residential areas where underlying grass is maintained.

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

From an FIA perspective, there are three types of forest land: timberland, reserved forest land, and other forest land. In Maryland, 95 percent of forest land is classified as unreserved and productive timberland, nearly 5 percent is reserved and productive forest land, and less than 1 percent is unproductive reserved or unreserved forest land. Timberland is unreserved forest land that meets the minimum productivity requirement of 20 cubic feet per year. Reserved forest land is land withdrawn from timber utilization through legislation or administrative regulation. Other forest land is commonly found on low lying sites or high craggy areas with poor soils where the forest is incapable of producing 20 cubic feet per acre. In earlier inventories, FIA measured trees only on timberland plots and did not report volumes on all forest land. Since the implementation of the new annual inventory in Maryland in 2004, FIA has been reporting volume on all forest land.

The second remeasurement of Maryland is in its third field season, and by 2013, FIA will be able to compare two sets of growth, mortality, and removal data. Much of the trend reporting in this publication is focused on timberland, because comparing current data to data from older periodic inventories requires timberland estimates.

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. Sample trees are felled and measured for length, diameter, and taper. 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 scale.

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 estimate all the forest carbon pools?

FIA does not directly measure the carbon in standing trees; it estimates forest carbon pools by assuming that half the dry biomass in standing live/dead trees consists of carbon. Additional carbon pools (e.g., soil, understory vegetation, belowground biomass) are modeled based on stand/site characteristics (e.g., stand age and forest type).

How do we compare data from different inventories?

Comparing new inventories with older datasets is common to analyze trends or changes in forest growth, mortality, removals, and ownership acreage over time (Powell 1985). 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 will improve 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

Old loblolly pine, Worcester County, MD, 2006. Photo by Jack Perdue, Maryland DNR.

Forest Area

Background

Maryland is at the confluence of a unique range of physiographic, ecological, economic and demographic conditions. Surrounding the Nation's capital and containing a section of the U.S. Interstate 95 corridor, the landscape of the eastern portion of the state is characterized by a mixture of urban and suburban land uses interspersed with agricultural and other human-impacted ecosystems. The Chesapeake Bay is the dominant natural feature in this portion of the state and its social and economic impacts on Maryland are far-reaching. Wetland and riparian forests are also a prominent feature in this portion of Maryland. The State is host to over 300,000 acres of forested wetlands, with the majority of these wetland areas around the Chesapeake Bay and to the east. Further west, forest begins to dominate in the areas that exhibit more topographic relief. These forests, and those that remain in the more developed eastern portions of the State, play a critical role in the protection of water quality, maintenance of biodiversity, generation of wood products, and other ecosystem services that contribute to Maryland's unique role in the mid-Atlantic region.

Maryland can be divided into five physiographic provinces (Fig. 1). The Lower Coastal Plain province, or Maryland's "Eastern Shore", includes land east of the Chesapeake Bay. The forest land here has a large softwood component including the majority of the State's loblolly pine (*Pinus taeda*) resource. The Upper Coastal Plain province includes higher elevation coastal plain land west of the Bay. Moving north, the Piedmont province extends west to the Catoctin Mountain which forms the boundary between the Piedmont and Ridge and Valley province. The rolling hills of the Piedmont were once dominated by an oak/chestnut forest, but now the oak-pine, oak-hickory, and mixed forests exist. The Ridge and Valley province has the greatest topographic relief with mountain ridges 2,000 feet in elevation to river valleys with 200 foot elevations. Here again the oak-hickory forest type dominates. The northern hardwood forest type is found in the Allegheny Plateau province that lies furthest to the west and has the State's highest elevations.

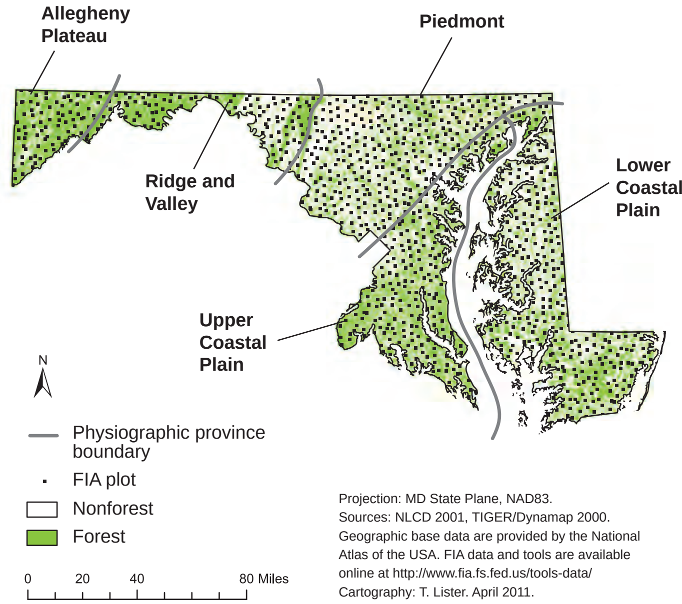


Figure 1.—Distribution of forest land and approximate locations of FIA forest inventory plots in Maryland, 2008.

What we found

FIA data show that there has been an approximate 16 percent loss in forest land area between 1964 and 2008 (Fig. 2). Data indicate that after the high rate of decrease between 1964 and 1976, the rate of forest loss has decreased. Between 1999 and 2008, the trend of forest loss appears to continued, however sampling error is too high to call the change significant at the State level.

An analysis of the changes in percent forest land at the county level show that most of the fluctuation has occurred in the suburbs of Baltimore and Washington, D.C. (Fig. 3).

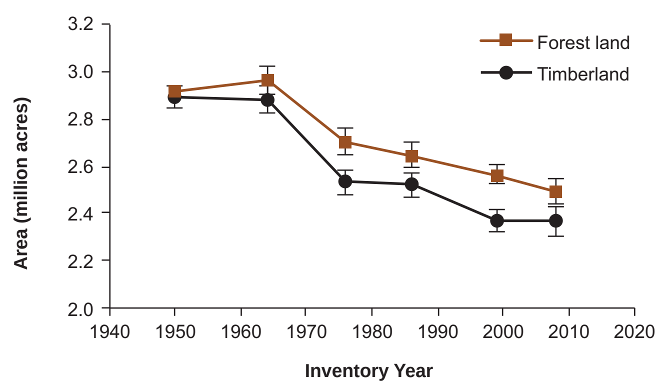


Figure 2.—Area of forest land by inventory year, 1950, 1964, 1976, 1986, 1999, and 2008. (Error bars show 68 percent confidence intervals around the mean.)

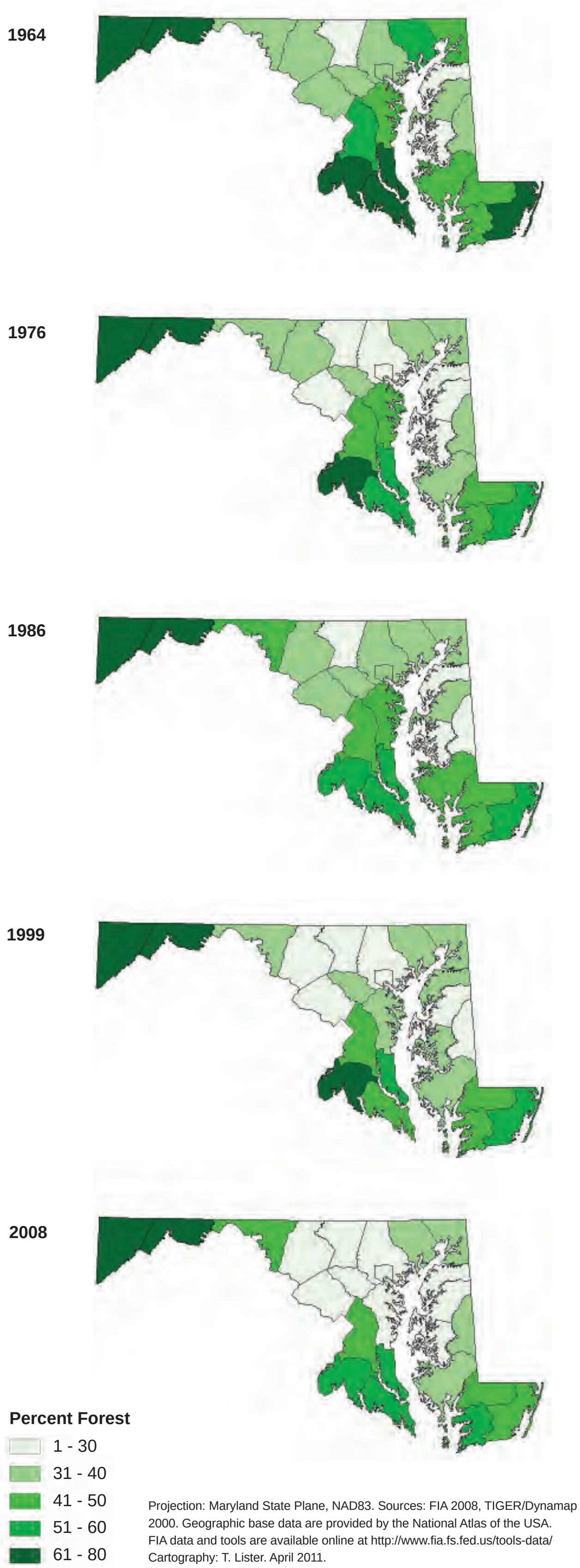


Figure 3.—Forest-land area as a percent of total land area by county and inventory year, Maryland, 1964-2008.

These are the least forested areas of the State so small changes in forest land area have a greater impact on the percent forest in the county. While the 2008 FIA data showed no statistically significant net loss of forest land at the State level, there were some counties where losses and gains appear significant (Fig. 4). Anne Arundel, Allegany, and Garrett Counties each lost forest land between 1986 and 2008 and Somerset County has likely gained forest land since 1999. The loss of forest land in Anne Arundel County is not surprising due to its suburban location between Baltimore and Washington, D.C. Allegany and Garrett Counties, the western-most counties in the State, maintained the highest percentages of forest area, but both lost forest land likely due in part to low density residential growth. Gains in Somerset County may be due in part to its location on the Eastern Shore and its large wetland area.

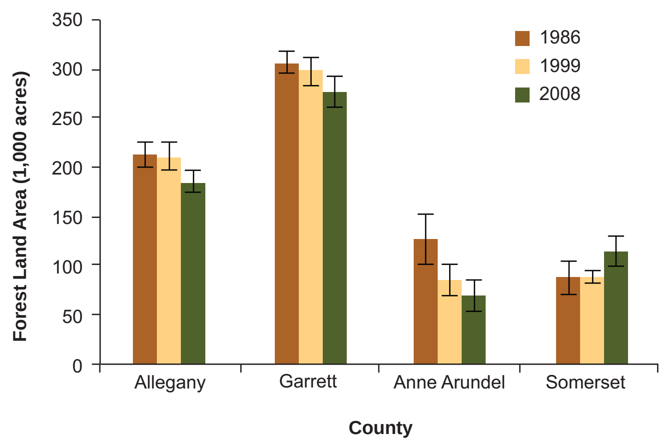


Figure 4.—Trends in forest-land area by select counties, Maryland, 1986, 1999, and 2008. (Error bars show 68 percent confidence intervals around the mean.)

What this means

Forest change dynamics in Maryland are due to a complex interaction of patterns of population growth, land development, reversion of agricultural land to forest, conservation policies and the availability of land open to development. More counties in Maryland exhibited forest loss than showed forest gain. As development continues on some of the central and eastern shore counties, and as conservation rules are enacted, rates of forest area loss may decrease. The increase in rates of development in Allegany and Garrett Counties over the past 10 years is due to population growth and real estate preferences, and make these counties, which have the largest blocks of contiguous forest in the State, vulnerable to habitat fragmentation and associated impacts on wildlife, water quality, and aesthetic value. As land available for development becomes scarcer in the central and eastern counties, it is likely that more pressure will be put on these relatively intact forests to the west.

Land Use Change

Background

Eastern forests offer habitat for forest-dwelling species, protect drinking water, serve as buffers for rivers and bays against sedimentation and nutrient enrichment, and provide economic and other benefits for humans (Sprague et al. 2006). They are, however, under increasing pressure as the demand for housing increases (Claggett et al. 2004). Urban development is occurring at a rapid pace. Nowak et al. (2005) predicted that the area of urban land in the United States will nearly triple from 2000 to 2050.

Although the area of forest land in 1999 was not statistically different from the forest land estimate in 2008, we can say with confidence that Maryland has had an estimated net loss of more than 450,000 acres of forest land over the last 45 years due in part to population growth and urban development pressures. With continued development in the Washington-Baltimore corridor and suburbs, pressure to expand developed areas remains strong. Figure 2 shows this trend of decreasing forest area, but the dynamics of forest change are more complicated. When we compare forest land estimates between inventories, the difference between the two estimates is the net change in forest land area. The gross amount of forest loss is actually higher, but some of these losses have been offset by gains in forest land in other parts of the State.

In an effort to explore the dynamics of these gross changes in land use, a photo-based inventory of land use change in Maryland was conducted using FIA definitions (Lister et al. 2009). The goal of this special study was to develop a methodology to obtain more precise estimates of the amount of change in forest area than offered by the FIA ground plot data.

What we found

Results of the special study show a net loss (taking into account both losses and gains in forest land) of 28,000 acres of forest land in Maryland from 1998 to 2007, which averages to be more than 3,000 acres per year (Fig. 5). The gross forest loss (66,000 acres) was primarily due to conversion to development, accounting for 91 percent of the total forest loss. Ninety-one percent of the forest gains were from conversion of agricultural land back to forest.

Figure 6 shows the distribution of forest loss in Maryland between 1998 and 2007 based on results of a photo-based inventory. A high proportion of forest loss is in the growing suburbs of Baltimore and Washington, D.C., an area of the State that has experienced the greatest pressure from urban expansion. For example, the highest proportion of forest loss plots (3 percent) is found in Prince George's County, which borders Washington, D.C. From 2000 through 2007, more than 22,000 new housing units were approved for construction, making this one of the fastest growing counties in the State.

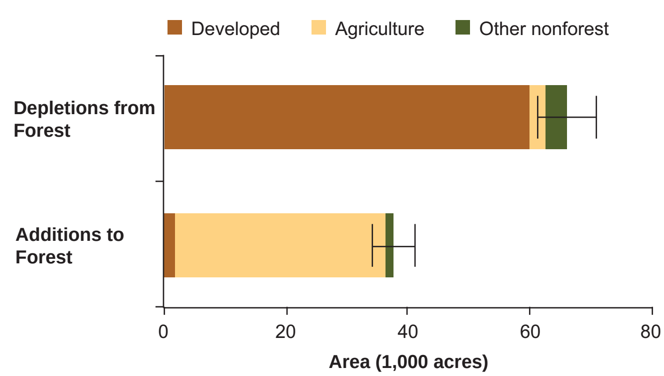
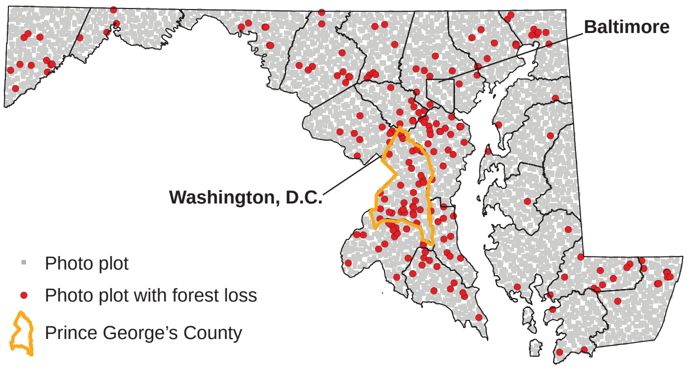


Figure 5.—Estimates of areas of different land-use change categories, Maryland, 1998-2007. (Error bars are for total forest loss and gain and show 68 percent confidence intervals around the mean.)



Projection: Maryland State Plane, NAD83. Sources: Lister et al. 2008, TIGER/Dynamap 2000. 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: T. Lister. April 2011.

Figure 6.—Distribution of land-use plots highlighting forest loss, Maryland, 1998-2007.

What this means

As the population of Maryland continues to grow, forest and agricultural land is likely to be converted to developed uses. Historically, the majority of this new development occurred on agricultural land, but the results of this study indicate that new development is now more likely to occur on forest land than agricultural land. With continued development and urbanization in Maryland, it is likely that there will be more conversion of forest land to developed uses. This situation is compounded by the fact that currently the gains in forest land are coming mostly from agricultural reversion, so not only is there less agriculture land available for development, but there is less agricultural land available for conversion to forest. The end result may be greater net loss of forest land.

Maryland has many policies and programs to promote forest sustainability. For example, the 1991 Forest Conservation Act requires that retention of forest be an important consideration during the planning process for land development projects. In addition, nearly all of Maryland is within the Chesapeake Bay watershed, and there are several initiatives, including the Chesapeake Bay Critical Areas Program, that include forest protection guidelines aimed at improving water quality. Understanding land-use dynamics helps planners ensure that Maryland's forests and the associated ecosystem services they provide are managed sustainably.

Forest Ownership

Background

It is forest land owners who ultimately control the fate of the forest and decide if and how it will be managed. By understanding the priorities of forest land owners, leaders of the forestry and conservation communities can better help these owners meet their needs, and in so doing, help conserve the region's forests for future generations. FIA conducts the National Woodland Owner Survey (NWOS) to better understand who owns the forests, why they own forest land, and how they use the forest land they own (Butler 2008). Data for Maryland and Delaware are combined here because of the small sample size in these states.

What we found

Most forests of Maryland and Delaware are privately owned – 76 percent in Maryland and 92 percent in Delaware (Fig. 7). Of these private acres, 74 percent are owned by families, individuals, and other unincorporated groups, collectively referred to as family forest owners.

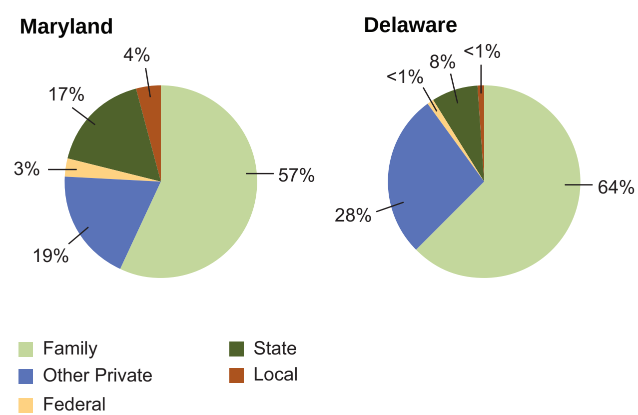


Figure 7.—Forest ownership, Maryland and Delaware, 2006.

One hundred and fifty-six thousand family forest owners in Maryland and an additional 28,000 family forest owners in Delaware control 1.7 million forested acres across the two states. Eighty-three percent of these owners have between 1 and 9 acres of forest land (Fig. 8); the average holding size is 9 acres. The primary reasons for owning forest land are related to aesthetics, the forest land being part of a home site, and nature protection (Fig. 9).

Although timber production is not a major ownership objective, 44 percent of the family forest land is owned by people who have commercially harvested trees. Thirty-three percent of the land is owned by people who have a written management plan, and 41 percent of the land is owned by people who have received management advice.

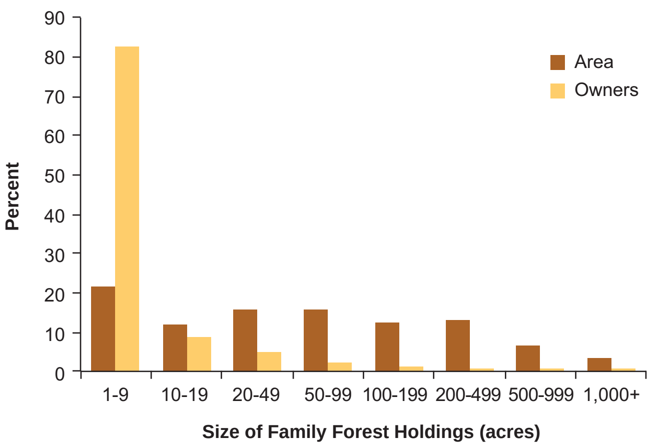


Figure 8.—Percent of total forest land and number of owners distributed across family forest holding size classes, Maryland and Delaware combined, 2006.

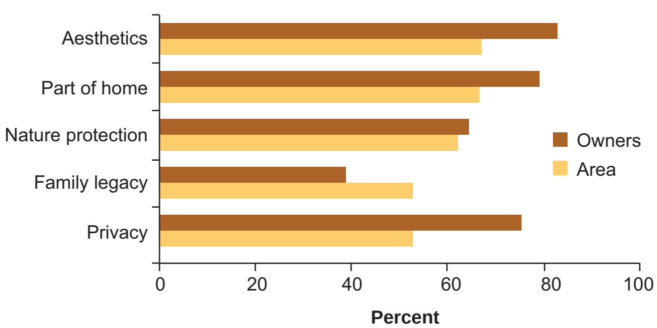


Figure 9.—Primary ownership objectives of family forest owners, Maryland and Delaware, 2006.

What this means

The average parcel size is decreasing and much of this forest land will soon be changing hands; 13 percent of the family forest acres is owned by someone who plans to pass the land onto heirs or sell it in the near future. Family legacy is a major ownership objective and it is also a major concern. What can be done to help the forest owners and the land? It is clear that timber production is not in the forefront of forest owners' minds, but it is also clear that many owners are not averse to harvesting and other activities in the woods. It is important to provide programs that meet the owners' needs.

Urbanization and Fragmentation of Forest Land

Background

The expansion of urban lands that accompanies human population growth often results in forest fragmentation, or the breaking up of large blocks of forest into smaller, isolated patches (Wilcox and Murphy 1985). Forest fragmentation and habitat loss is recognized as a major threat to wildlife populations worldwide (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 (Forman et al. 2003). Forest fragmentation can also affect forest ecosystem processes through changes in micro-climate conditions, and affects the ability of tree species to move in response to climate change (Iverson and Prasad 1998).

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 patches 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. Forest land is also a significant factor in the protection of surface and groundwater, and fragmentation and urbanization of that forest land has been observed to affect both water quality and quantity (e.g., Hunsaker et al. 1992, Riva-Murray et al. 2010).

The metrics presented here relate to some aspects of urbanization or fragmentation which are suspected of, or have been documented to have an effect on the forest, its management, or on 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 the extent of houses intermixed with forest.

What we found

In Maryland, 40 percent of the forest land is greater than 300 feet from an agriculture use or developed edge. This ranges from 10 percent in agricultural Carroll County to more than 60 percent in the western counties of Garrett and Allegany (Table 1). Figures 10 and 11 illustrate where and 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.

Table 1.—Distribution of forest land by urbanization and fragmentation measurements, expressed as a percent of the total forest land area in each county

County	% forest land in county[a]	Forest land with house density > 15.5 per square mile[b]	Forest land > 295 ft (90 m) from an ag or developed edge[c]	Forest land > 980 ft from a road[d]	Forest land located in patches > 100 acres in size[e]	Forest land located in a block with population densities > 150/mi² (57.9/km²)[f]
Allegany	79	36	64	39	97	9
Anne Arundel	47	79	27	20	86	55
Baltimore	34	86	23	24	80	0
Calvert	64	87	35	19	96	58
Caroline	31	43	28	37	84	10
Carroll	23	90	10	30	61	53
Cecil	38	69	31	26	85	34
Charles	64	68	42	30	95	20
Dorchester	35	17	46	49	86	2
Frederick	31	62	41	37	78	18
Garrett	76	28	60	39	95	2
Harford	40	73	27	32	82	41
Howard	28	87	17	25	71	63
Kent	25	35	25	37	80	5
Montgomery	30	68	20	27	76	50
Prince George's	43	69	30	29	85	40
Queen Anne's	27	33	26	36	82	12
St. Mary's	56	84	37	22	94	39
Somerset	42	34	43	42	90	5
Talbot	26	51	24	25	75	10
Washington	39	59	50	33	84	12
Wicomico	42	43	37	38	87	13
Worcester	50	21	48	43	93	3
Maryland	43	55	40	33	87	21

[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.

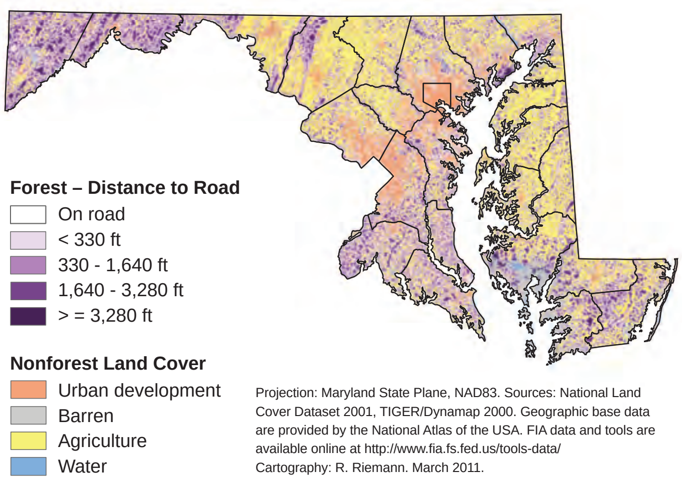


Figure 10.—Distribution of forest land by distance to the nearest road classes (includes all roads), Maryland, 2000-2001.

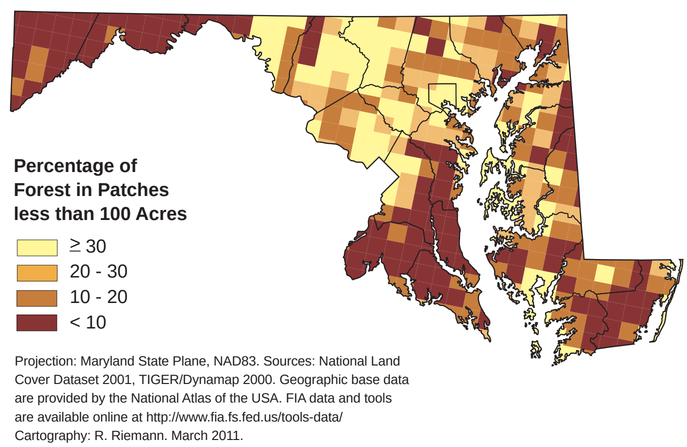


Figure 12.—Forest cover (percent) in patches less than 100 acres, by 62.1-square-mile grid cell, Maryland, 2000.

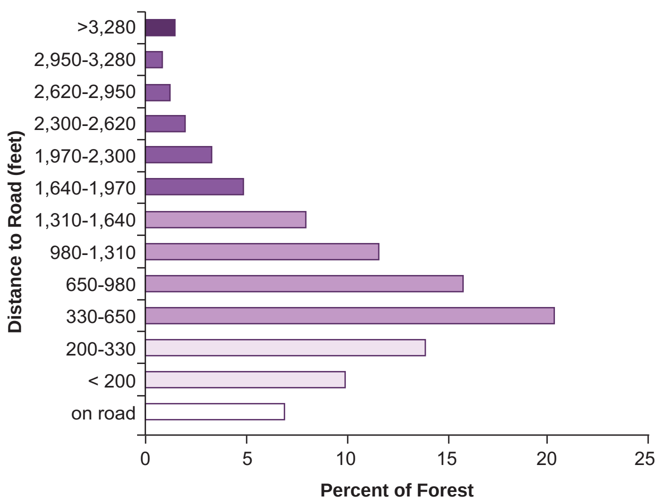


Figure 11.—Distribution of forest land by distance to the nearest road classes (includes all roads), Maryland, 2000-2001.

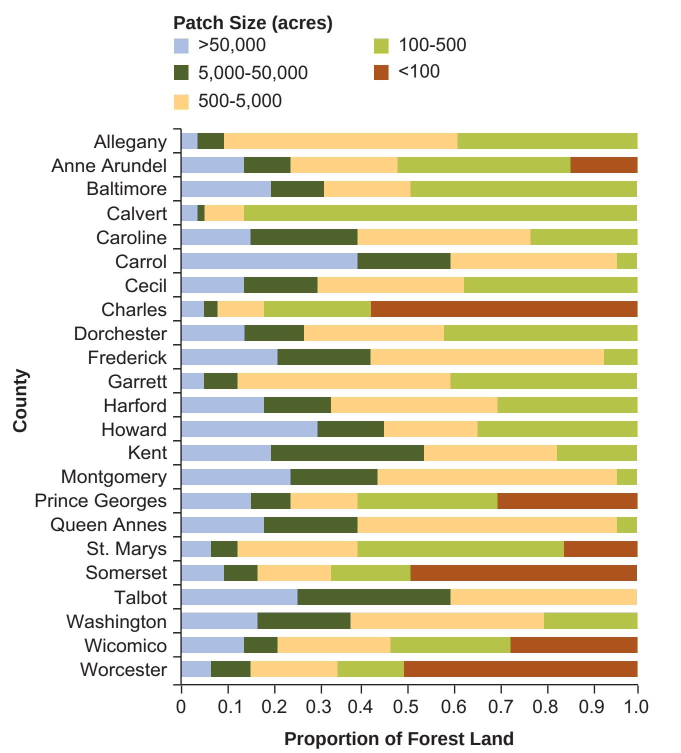


Figure 13.—Distribution of forest land by patch size and county, Maryland, 2000.

Much of the forest land in western and parts of southern Maryland still occurs primarily as a 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 in the more agricultural and urbanized counties in central Maryland (Fig. 12). Carroll and Howard Counties have over 30 percent of their forest land in patches less than 100 acres in size. (Fig. 13). Seven counties in western and southern Maryland have less than 10 percent of their forest land in patches less than 100 acres.

The wildland-urban interface (WUI) is commonly described as the transition zone where human development intermingles with undeveloped wildland vegetation, and is associated with a variety of human-environment conflicts (Radeloff et al. 2005). Radeloff et al. (2005) define this area in terms of the density of houses (greater than 15.5 houses per square mile), the percentage of vegetation coverage, and the proximity of this zone to developed areas. Figure 14 illustrates that 55 percent of the forest land in Maryland has house densities of more than 15.5 houses per square mile. Individual counties range from 21 percent of the forested area (Worcester County) to nearly 90 percent of the forested area (Howard and Carroll Counties) exceeding the 15.5 houses per square mile threshold.

Local human population density near forested areas has been shown to affect the viability of commercial forestry (Wear et al. 1999). In Maryland, 21 percent of the forest land is located in a U.S. census block with population densities above 150 people per square mile (Table 1), however this varies considerably across the region, from 2 percent in southeastern Maryland to 63 percent in Howard County.

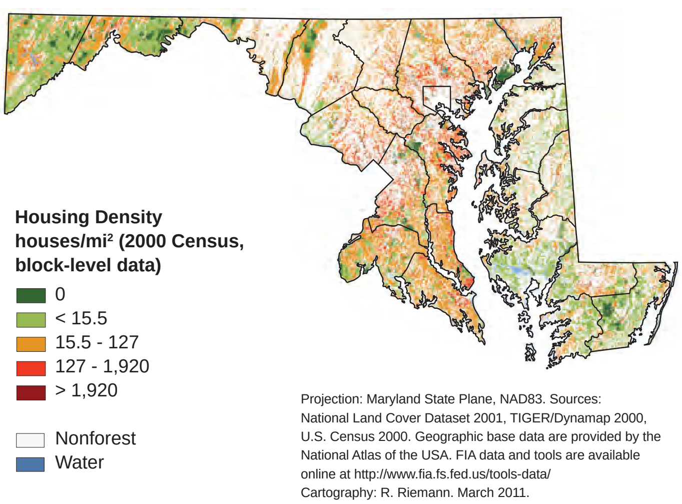


Figure 14.—Housing density, by class, in forested areas of Maryland, 2000-2001.

Table 1 summarizes these factors and shows the extent to which the current forest land base is being influenced by one or more of the factors. For example, in rural Allegany County, which is 79 percent forested, 36 percent of that forest land is potentially affected by house densities greater than 15.5 per square mile, while 64 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 39 percent is greater than 980 feet from a road. In contrast, Calvert County, also with a relatively large proportion of its land area in forest (as seen from the air/satellite classification) presents a very different situation. Calvert County forest land, which occupies 43 percent of the land area, occurs largely mixed with housing densities above 15.5 per square mile (87 percent of the forest land). Ninety-six percent of the forest land present occurs in patches greater than 100 acres in size, but only 35 percent can be considered interior forest and only 19 percent is greater than 980 feet from a road.

What this means

Edge effects vary somewhat with distance from forest edge, depending on the type of effect and species of vegetation or wildlife, (e.g., Chen et al. 1992, Flaspohler et al. 2001, Rosenberg et al. 1999), but 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 pervasiveness of roads in the landscape is also an indicator of forest fragmentation and urbanization (Figs. 11 and 12). Road effects diminish when distances range from about 330 feet for secondary road, 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 result in a variety of effects, including hydrologic, chemical (salt, lead, nutrients), sediment, noise, as pathways for the introduction of invasive species, habitat fragmentation, and increases in human access. These effects impact forest ecosystem processes, wildlife movement and mortality, and human use of the surrounding area. The entire State falls within an area of high road densities, with more than 60 percent of the land area within 1,250 feet of the nearest road (Riitters and Wickham 2003). 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, how pervious road surfaces are, location with respect to important habitat, etc. 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 that are at least 100 acres (Riemann et al. 2008). This patch area is often used as a minimum threshold 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 don't substantially break the tree canopy, 87 percent of Maryland's forest land is in patches larger than 100 acres. Given the pervasiveness of houses and roads within the forest landscape in Maryland, and the high proportion of forest land that is less than 300 feet from an agricultural or forest edge, patch size alone will not be a good indicator of wildlife habitat quality. Patch size is also limited by geography rather than land use pattern and roads in some parts of Maryland. Counties with large tidal rivers (e.g., Talbot, Queen Anne's, Kent) have inherently smaller patches. It is also important to remember that while 87 percent of forest land is in 100 acre or larger blocks, these forest blocks can be heavily parcelized and owned by many individuals.

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). In a Virginia study, Wear et al. (1999) identified a threshold of 150 people per square mile as that population density at which the probability of commercial forestry dropped to practically zero. In Maryland, 21 percent of forest land occurs within census blocks that exceed that threshold of 150 people per square mile.

With population pressures and urban growth increasing in Maryland, it is important to continue to monitor forest fragmentation and urbanization to ensure that the forest resources of the State continue to provide important ecological benefits.

Forest Resources

Pine plantation and regeneration, Garrett County, MD, 2009. Photo by Jack Perdue, Maryland DNR.

Forest Structure and Density

Background

To understand the ecology and economic value of a forest, it is common to describe the structure of the forest in terms of the area in different stand-size, stocking, and age classes. Foresters in our country typically use stem diameter at breast height (d.b.h.), or diameter at 4.5 feet above the ground, as a measure of tree size, and trees per acre as a metric of stem density. FIA defines stand-size class as the predominant d.b.h. class of trees in the stand: small diameter (less than 5.0 inches d.b.h.), medium diameter (5.0 to 8.9 inches d.b.h. for softwoods and 5.0 to 10.9 inches d.b.h. for hardwoods), or large diameter (≥ 9.0 inches for softwoods and ≥ 11.0 d.b.h. for hardwoods). Similarly, stocking, or a measure of site occupancy by trees, is another measure of forest structure that, depending upon how it is calculated, can integrate size and stem density to provide an index of how close to fully utilized the site is by trees. Stocking tables and charts have been created by foresters to aid in the calculation of this index.

Five values of the stocking index are reported by FIA: nonstocked (0 to 9 percent), poor (10 to 34 percent), moderate (35 to 59 percent), full (60 to 100 percent) and overstocked (>100 percent). As stands become overstocked, trees become crowded, productivity decreases, more trees die, and stem quality often decreases. Poorly stocked stands are not fully occupied by trees, are less valuable, and might benefit from some silvicultural treatment that improves site occupancy and value. FIA classifies economically valuable trees as growing-stock trees and thus knowledge of stocking values for growing-stock trees, as well as the ratio of growing stock to all live stocking, can help resource specialists manage forests for economic value.

What we found

Large-diameter stands dominate the forest land area (76 percent) in Maryland. The area of small- and medium-sized forest stands in Maryland has decreased by 32 percent from 1999 to 2008, while the area of large-diameter stands increased by 11 percent (Fig. 15).

Data indicate that since 1999, Maryland's forests have become less fully stocked. An estimated 1.1 million acres (46 percent) of Maryland's forests are fully stocked with live trees, which is a nearly 300,000 acre decrease from the area of fully stocked forest in 1999 (Fig. 16). The area of forest in the medium stocking class, increased (42 percent), and the acreage of nonstocked and poorly stocked stands showed little change since 1999. The acreage in the poorly and nonstocked class is relatively small (253,000 acres). A similar pattern is observed when just considering growing-stock trees (Fig. 17).

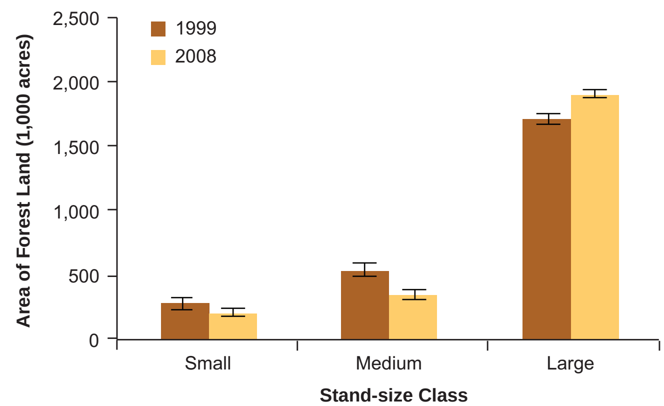


Figure 15.—Area of forest land by stand-size class, Maryland, 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

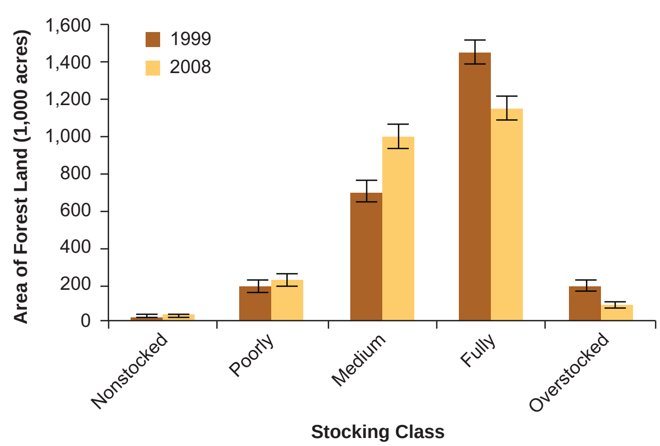


Figure 16.—Area of forest land by stocking class of all live trees, Maryland, 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

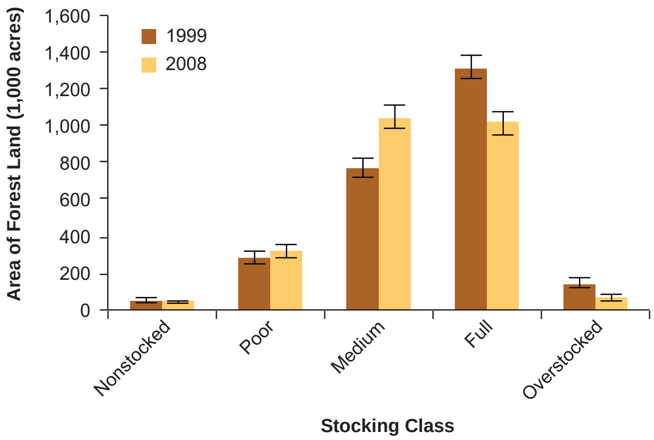


Figure 17.—Area of forest land by stocking class of growing-stock trees, Maryland, 1999, and 2008. (Error bars show 68 percent confidence intervals around the mean.)

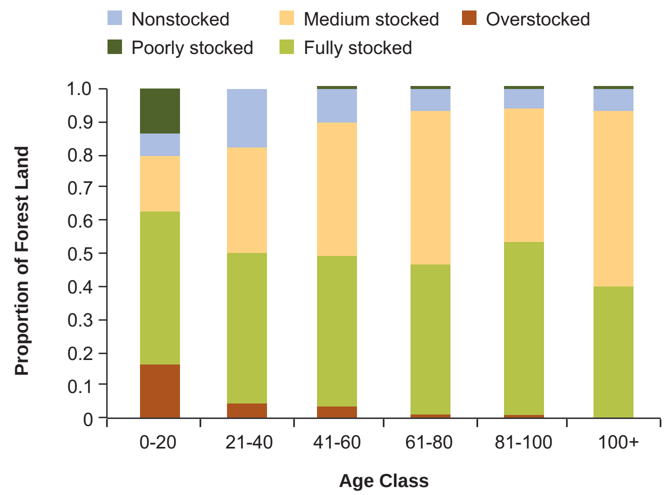


Figure 19.—Distribution of forest land (proportion) by stocking class and age class, Maryland, 2008.

According to the 2008 data, 57 percent of forest stands are at least 61 years old (Fig. 18). The age-class distribution is shifting toward older stands, with significant decreases in the area of forests less than 60 years old and significant increases in the area of forest greater than 60 years old (Fig. 18).

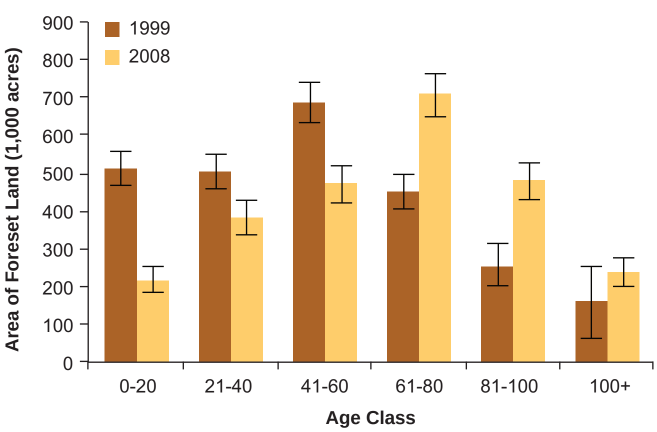


Figure 18.—Distribution of forest land by age class, Maryland 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

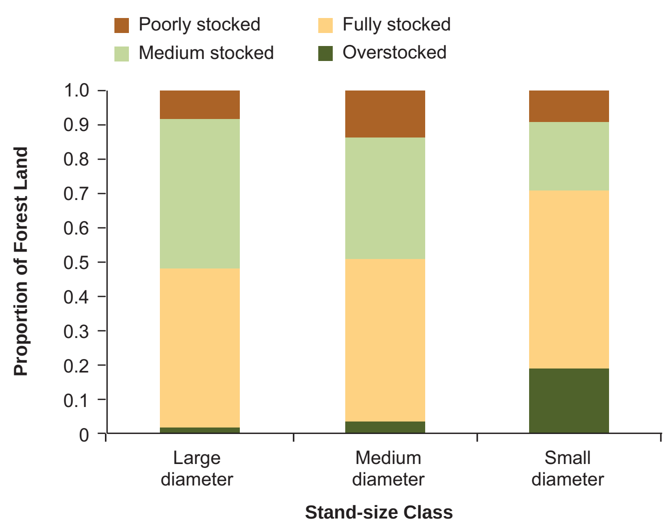


Figure 20.— Distribution of forest land (proportion) in stocking classes by diameter class, Maryland, 2008.

Eighty-eight percent of the nonstocked stands are young (less than 20 years old) and the distribution of overstocked stands is also skewed toward these younger age classes (Fig. 19). Similar patterns can be observed when examining the relationship between the relative area of each stocking class by size class (Fig. 20): younger, small-diameter stands (those generally less than 20 years old) are much more likely to be overstocked than young large diameter stands. The proportion medium-stocked forest tends to increase as both age and diameter class increases. Finally, relatively equal proportions of fully stocked forests occur across all diameter and age classes.

What this means

The forests of Maryland are maturing in terms of age and diameter-class distributions. At the same time, there has been a slight shift from forest land dominated by full and overstocked stands to forest land dominated by poorly and medium-stocked stands, reflecting the loss of area of young, small-diameter stands that tend to be dense and often overstocked. As patterns of land use have changed in Maryland, there are fewer stand replacing activities occurring – relatively more forest is lost to development than is subject to stand removal and subsequent forest regeneration. These changes in size- and age-class structure are thus expected, and will continue unless forest management practices or natural processes, such as fire, or significant tree mortality alter this pattern.

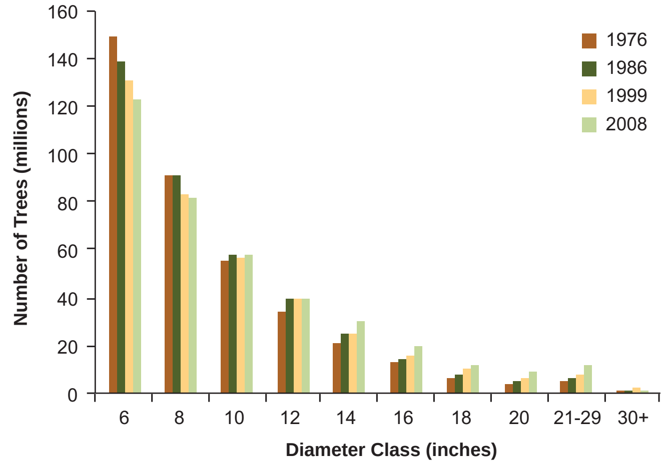


Figure 21.—Number of growing-stock trees on timberland by diameter class, Maryland, 1976, 1986, 1999, and 2008.

Numbers of Trees

Background

Summaries of the number of trees by diameter class and species are useful to forest managers. Not only do these summaries provide information on forest sustainability, but they also inform ecologists interested in topics such as species diversity indices. Changes in diameter distributions lead to changes in forest composition as cohorts of similar sized trees move through the successional process. If, for example, there are not an adequate number of small-diameter trees of a certain species, it is less likely that the species will play a prominent role in the future forest.

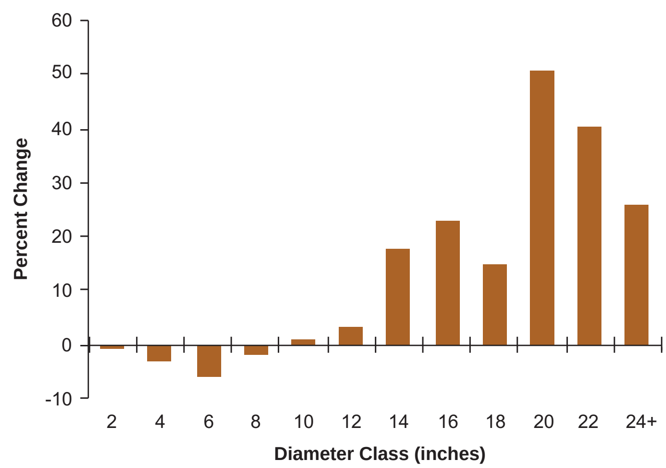


Figure 22.—Percent change in the numbers of growing-stock trees by diameter class, Maryland, 1999-2008.

What we found

There are more than 1.4 billion live trees 1-inch or larger (d.b.h.) on Maryland's timberland, or an average of 606 trees per acre. The overall number of trees has not changed significantly since the last inventory (1999). However there are differences when comparing changes in numbers of trees by diameter class (Figs. 21 and 22). FIA results suggest that relative numbers of trees in the larger size classes increased between 1999 and 2008 and trees less than 9 inches d.b.h. decreased in number (Fig. 22). This trend of decreasing numbers of small-size-class trees and increasing numbers of trees greater than 11 inches d.b.h. has been observed in each successive inventory since 1976. The data indicate that there are more trees in 2008 in the 12 inch and above size class than there have been at any point since 1976 (Fig. 21).

There are 385 million (162 trees per acre) live trees 5 inches d.b.h. or greater and 1.05 billion saplings (443 trees per acre) on timberland in Maryland. Red maple (*Acer rubrum*) is the most common tree species in Maryland, accounting for 19 percent of all saplings and 14 percent of the live trees 5 inches and larger in d.b.h. (Fig. 23). Sweetgum (*Liquidambar styraciflua*) is the second most common tree species, accounting for 12 percent of the saplings and 9 percent of the live trees 5

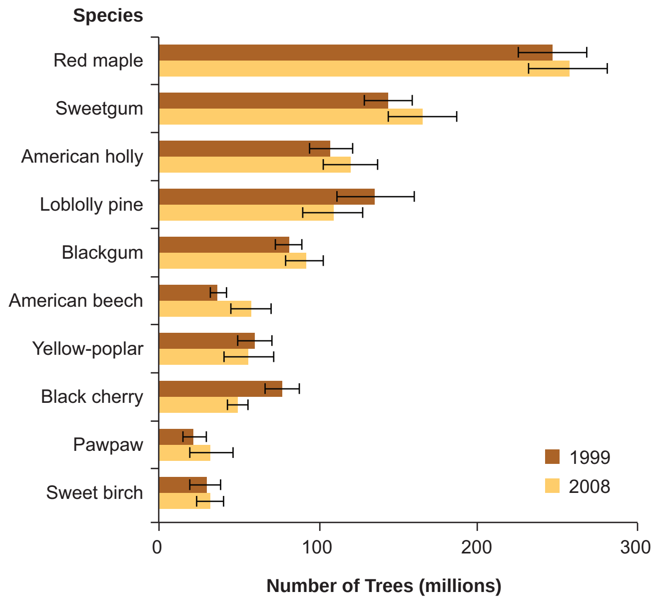


Figure 23.—Number live trees on timberland by species, Maryland, 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

inches d.b.h. or greater. American holly (*Ilex opaca*) is the third most common tree in Maryland due mainly to the abundance of sapling-sized trees of this species; 92 percent of the American holly trees in Maryland are less than 5 inches in diameter. Loblolly pine is fourth with 5 percent of the saplings and 15 percent of the live trees 5 inches and larger. Although the sampling errors are high when looking at tree data by species, there was a notable increase in American beech (*Fagus grandifolia*) trees in Maryland since 1999. Beech frequency increased by 56 percent overall, with a 65 percent increase in the number of sapling-size beech trees and a 29 percent increase in the numbers of trees greater than 5 inches d.b.h. Red maple, which, according to past inventories had been increasing in frequency in Maryland and in other areas of the country, remained stable in terms of numbers of larger trees and has increased only slightly in numbers of saplings from 1999 to 2008.

What this means

A shift in the numbers of trees away from saplings toward trees within the larger diameter classes can be a result of several factors, including the implementation of conservation practices aimed at protecting forests, changes in harvesting rates, natural forest maturation in the absence of disturbance, predation of young trees by deer and the conversion of early successional forests to nonforest land uses. Of these factors, changes in development patterns and conservation practices may have played the strongest roles in the maintenance of larger diameter stands. As open space has become scarcer in the central and Eastern Shore counties and societal values have moved toward forest conservation, particularly in the Chesapeake Bay region, more restrictive land-use regulations have affected land management and development preferences. In the absence of either natural or anthropogenic stand replacing events, this trend of increase in the relative numbers of larger diameter trees will continue.

Species Composition and Distribution

Background

Forest species composition is the result of a number of processes: seed dispersal patterns, the distribution of microsites suitable for seed germination, soil nutrient and moisture status, competition between other plant species for light and resources, predation, and macro scale environmental patterns such as climate and topography. Ecologists and forest managers are very interested in species composition because of the effects it has on wildlife, forest productivity, timber values, and forest health characteristics. The relative volume of oaks (*Quercus* sp.) has been in decline in many areas of the Northeast, and this is of particular concern because of their economic and wildlife values.

What we found

Red maple is by far the most abundant species in Maryland in terms of number of trees, and occurs in roughly the same proportion across all diameter classes (Fig. 24). However, oak and yellow-poplar (*Liriodendron tulipifera*) represent a much higher proportion of the total number of larger diameter trees. Loblolly pine has relatively more medium-sized trees than small or large diameter trees.

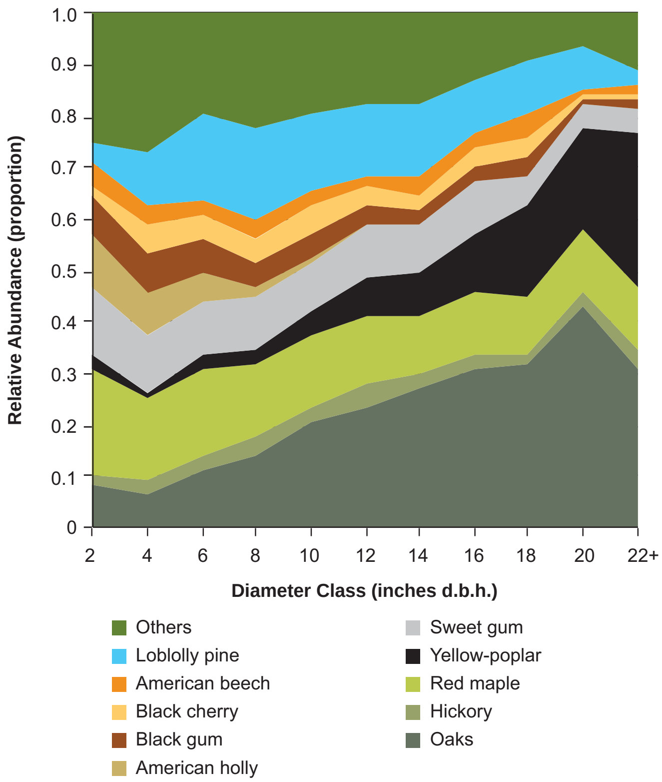


Figure 24.—Relative species abundance by diameter class, Maryland, 2008.

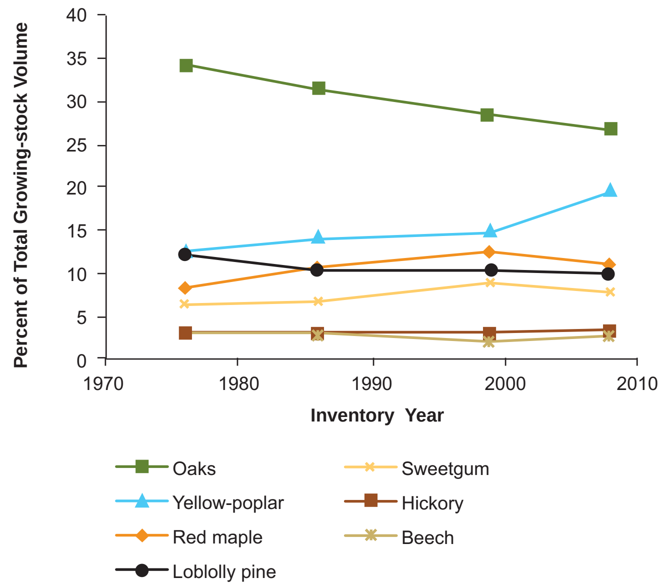


Figure 25.—Change in relative percent of growing-stock volume for select species and species groups, Maryland, 1976, 1986, 1999, and 2008.

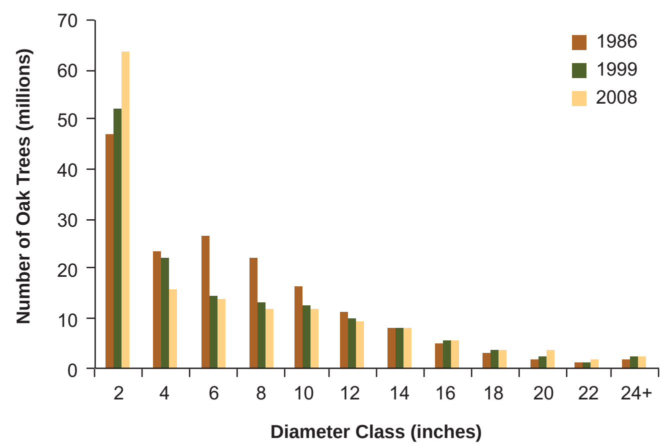


Figure 26.—Number of oak trees on timberland by diameter class and inventory year, Maryland, 1986, 1999, and 2008.

The relative frequency of several important tree species has changed over the years (Fig. 25). The relative frequency of sweetgum and red maple have increased in terms of proportion of growing-stock volume since 1976, however the 2008 estimates show relatively little change from 1999. Data suggest that oaks in particular have shown a steady decline in terms of proportion of growing-stock volume since 1976, while yellow-poplar has increased dramatically. In terms of number of trees, the abundance of oak trees declined significantly from 1986 to 1999, however the current inventory shows no change in the overall abundance or volume of oaks since 1999. Figure 26 shows the diameter distribution for number of oak trees. Although the total number of small-diameter oak saplings has increased, the increase only occurred in the small-sapling-size class (1 to 3 inch d.b.h.); the larger saplings and small-diameter tree classes (3 to 12 inch d.b.h.) all showed decreases in number of trees since 1999 and larger decreases since 1986 (Fig. 26).

Distribution maps of the top five species (in terms of volume) are shown in Figure 27. Red maple is clearly a generalist, with relatively more basal area distributed throughout the state. In the Coastal Plain physiographic region, loblolly pine is a prominent species, and associated species like sweetgum are also relatively dominant as well. Yellow-poplar does not have a high relative dominance in the Coastal Plain, but becomes more prevalent in the Piedmont and further west. White oak, though not as widespread as red maple, shows itself to be a generalist as well, with a relatively high likelihood of occurrence in the Ridge and Valley region and a lower likelihood of occurrence in the eastern Coastal Plain where the soils are sandy.

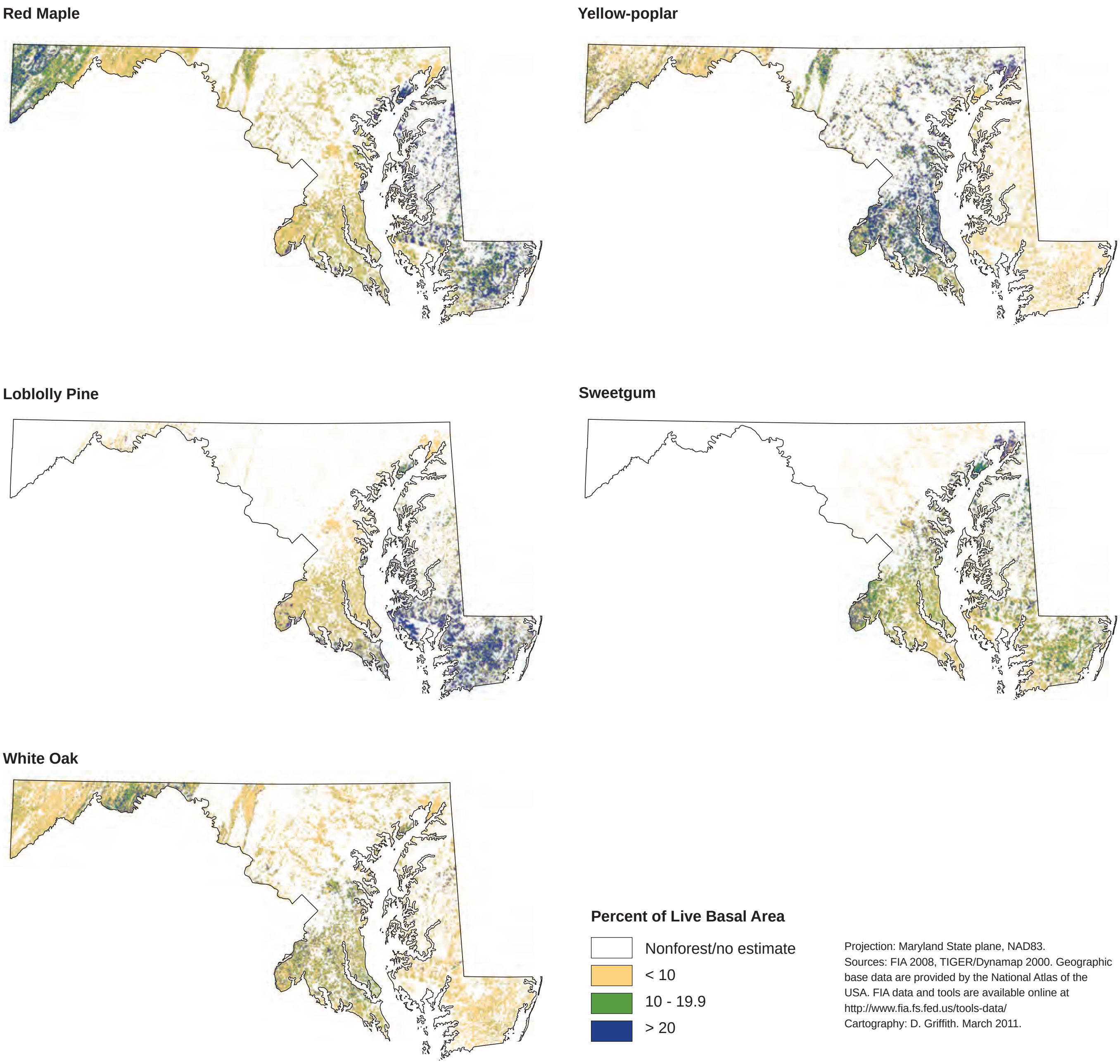


Figure 27.—Species distribution of common trees in terms of basal area (ft^2/acre), Maryland, 2008

What this means

Studying trends in the relative frequency or volume of tree species by diameter class can give some clues about the composition of the future forest. In the case of Maryland, it appears that as large oaks are claimed by mortality or cutting, the gaps created will be susceptible to colonization by red maple, blackgum (*Nyssa sylvatica*), or sweetgum, all of which have been increasing in relative frequency for many years and occupy a relatively larger proportion of the total number of trees in the smaller-diameter classes. Decreases in the oak proportion over time might be attributed to a combination of inadequate regeneration (due to predation by deer, competition in the understory by shade tolerant, generalist species, and lack of fire) and selective cutting of larger, more valuable trees. The future forest might be more heavily dominated by generalist species, particularly red maple, and the oaks may continue to decrease in relative dominance.

Biomass of Live Trees and Forest Carbon

Background

Total aboveground tree biomass is calculated as the sum of the weights of different components of the tree: the bole, stump, top, and limbs. Biomass is a measure of dominance similar to tree volume and is sometimes used as an index of ecological importance. In particular, biomass is of interest to scientists and policymakers who wish to characterize the local, regional, and global carbon cycle and its effect on climate change. Live tree biomass and carbon are directly related to one another because the carbon content of wood and bark is approximately 50 percent of dry biomass. The live tree carbon estimates are derived by dividing the dry biomass weight in half.

Collectively, forest ecosystems represent the largest terrestrial carbon sink on earth. The accumulation of carbon in forests through sequestration helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as forest fires and burning of fossil fuels.

What we found

Aboveground tree carbon is distributed mainly in the Upper Coastal Plain, Alleghany Plateau, and Ridge and Valley provinces (Fig. 28). Forests with the largest amount of tree biomass and carbon are found west of the Chesapeake Bay in the central portion of the Upper Coastal Plain.

Maryland's forests currently contain almost 204 million tons of carbon. Live trees and saplings represent the largest forest ecosystem carbon stock in the State at nearly 105 million tons, followed by soil organic matter (SOM) at more than 70 million tons (Fig. 29). Within the live tree and sapling pool, merchantable boles contain the bulk of the carbon (about 65 million tons, or almost three-quarters of the total aboveground live tree carbon in the State) followed by roots (17 million tons) and tops and limbs (15 million tons).

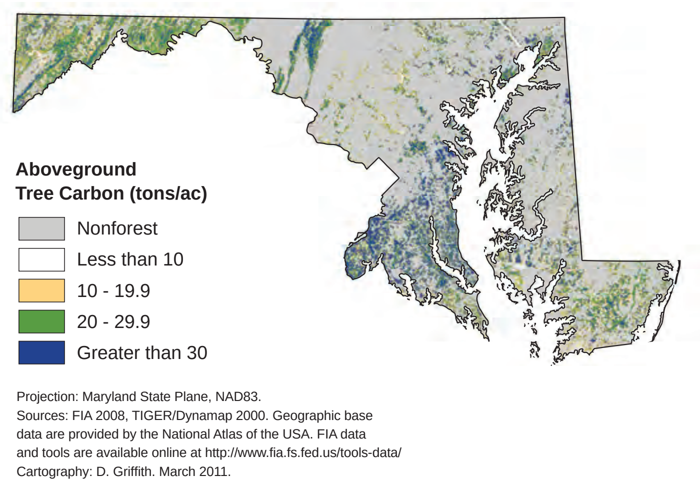


Figure 28.—Distribution of aboveground live tree carbon in Maryland, 2008.

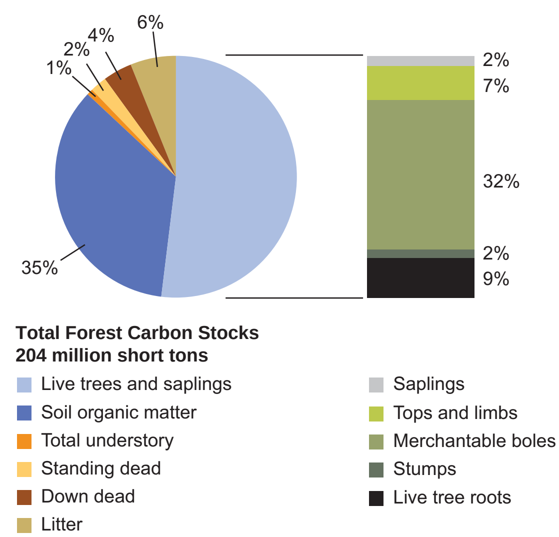


Figure 29.—Estimated total carbon stocks on forest land by component, Maryland, 2008.

The total live tree biomass in Maryland is over 176 million dry tons. Most of this biomass is from hardwood trees, and most is found in trees between 10 and 22 inches d.b.h. (Fig. 30). Saplings and nongrowing-stock boles make up a relatively small amount of the live tree biomass in the state (Fig. 31).

Most of Maryland's forest carbon stocks are found in stands 41 to 100 years old (Fig. 32). Early in stand development, most of forest ecosystem carbon is in the SOM and belowground tree components. As forest stands mature, the ratio of above- to belowground

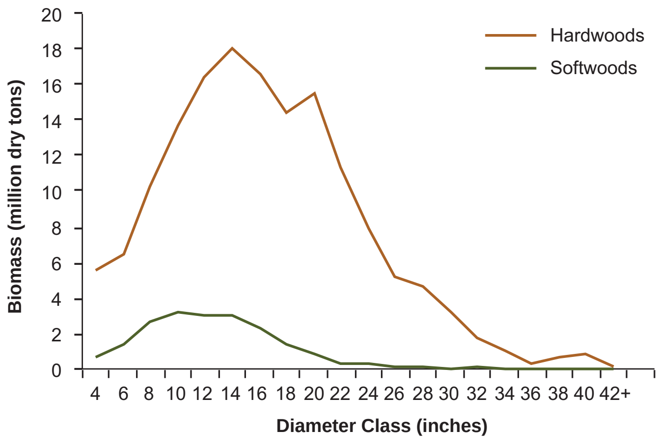


Figure 30.—Distribution of live-tree biomass (trees at least 1 inch d.b.h.) on timberland by species group and 2-inch diameter class, Maryland, 2008.

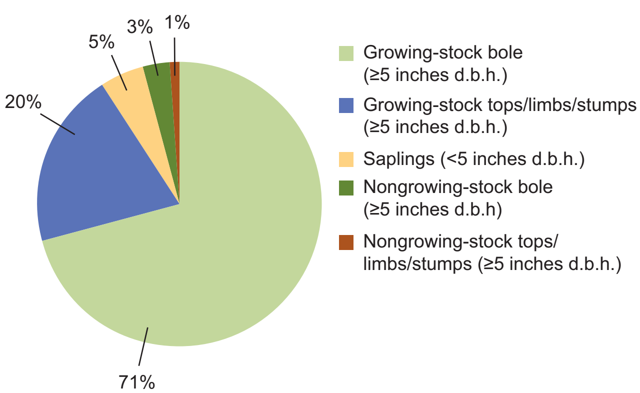


Figure 31.—Percentage of live-tree biomass (trees 1 inch d.b.h. and larger) on forest land by aboveground component, Maryland, 2008.

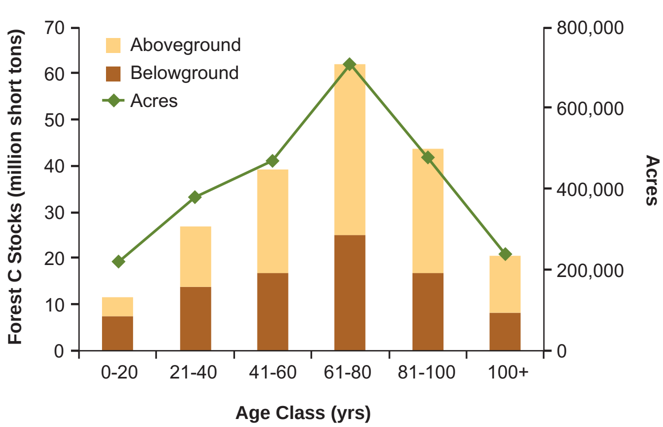


Figure 32.—Above- and belowground carbon stocks on forest land by stand age class and area by stand age, Maryland, 2008.

carbon shifts and by age 41 to 60 years, the aboveground components represent the majority of ecosystem carbon. This trend continues well into stand development as carbon accumulates in live and dead aboveground components. A look at carbon by forest-type group on a per-unit-area basis found that 8 of the 13 groups have between 80 to101 tons of carbon per acre (Fig. 33). Despite the similarity in per-acre estimates, the distribution of forest carbon stocks by forest-type group is quite variable. In the elm/ash/cottonwood group, for example, 53 percent (about 50 tons) of the forest carbon is in the SOM, whereas in the oak/hickory group, only 29 percent is in the SOM.

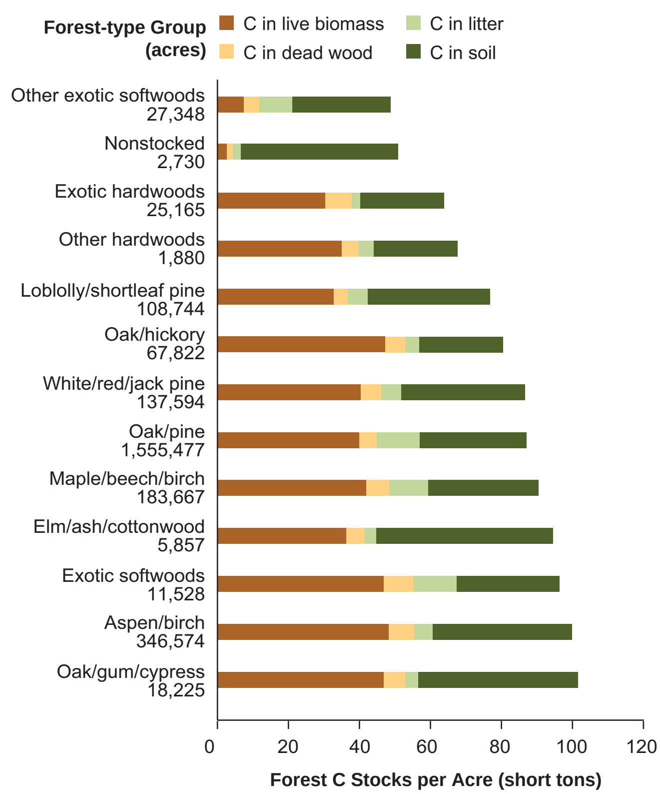


Figure 33.—Carbon stocks on forest land by forest-type group and carbon pool per acre, Maryland, 2008.

What this means

Since the area of forest land changed little since the last inventory, trees with larger diameters and relatively more carbon are increasing in frequency, and total forest volume is increasing, we can conclude that forests in Maryland are accumulating carbon. The majority of forest carbon in the State is found in medium-aged stands dominated by relatively long-lived species. This suggests that Maryland's forest carbon will continue to increase as stands mature and accumulate carbon in above- and belowground components. Biomass and carbon accumulation has implications for acquiring carbon credits through the framework established by the Regional Greenhouse Gas Initiative (of which Maryland is a member), climate change research, and biofuel and other wood product development potential.

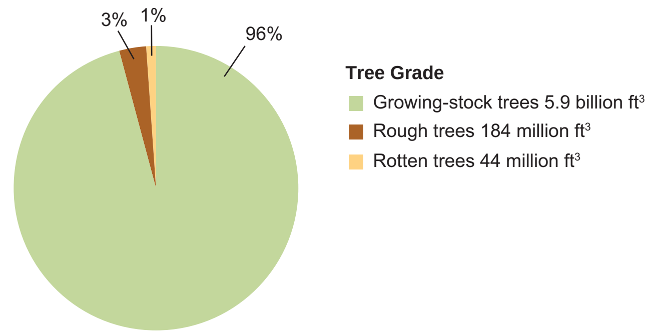


Figure 34.—Volume by components, Maryland, 2008.

Volume of Growing-stock Trees

Background

Growing-stock volume is the amount of sound wood in live, commercially valuable trees. It is a measure of wood that could be put to commercial use and thus gives an indication of potential value. Forest owners and managers need to understand the potential value of forests when evaluating management plans and inventory results with respect to economic implications.

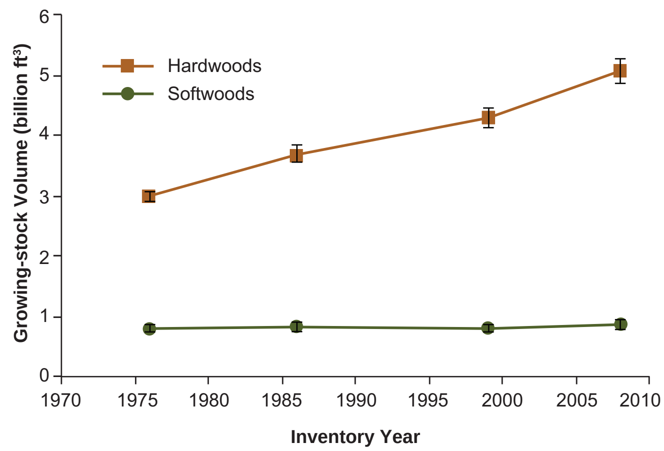


Figure 35.—Growing-stock volume on timberland by species group and inventory year, Maryland, 1976, 1986, 1999, 2008. (Error bars show 68 percent confidence intervals around the mean.)

What we found

Ninety-six percent of the volume in Maryland is in growing-stock trees, which are trees with good form and the species are commercially important. The remaining volume is in cull trees, classified as either rough (3 percent) or rotten (1 percent) (Fig. 34). The volume of growing-stock trees in Maryland is 5.9 billion cubic feet, or 2,153 cubic feet per acre. Volume has increased by16 percent since 1999. This is an estimated annual increase of 1.8 percent per year which is similar to the rate of increase experienced from 1976 to 1986 (1.9 percent per year), but more than the rate of increase that was experienced between 1986 and 1999 (1 percent per year). Hardwood species dominate, accounting for 85 percent of the total growing-stock volume in Maryland and hardwood species are also responsible for the overall growing stock increases as softwood volume has remained relatively constant for the past 30 years (Fig. 35).

Since 1976, there has been a shift in growing-stock volume toward larger trees (Fig. 36). Substantial increases have occurred in the 14-inch diameter class through the 28-inch diameter class. From 1986 to 1999, the growing-stock volume in this diameter class range increased by 25 percent and from 1999 to 2008, there was a 33 percent increase. These changes are consistent with changes in the number of trees by diameter class discussed in a previous section.

Yellow-poplar is the leading species in growing-stock volume, with 1.1 billion cubic feet, or 19 percent of the total. Red maple accounts for 13 percent of the total volume, or 656 million cubic feet, and loblolly pine ranks third with 10 percent of the total (580 million cubic feet) (Fig. 37). The growing-stock

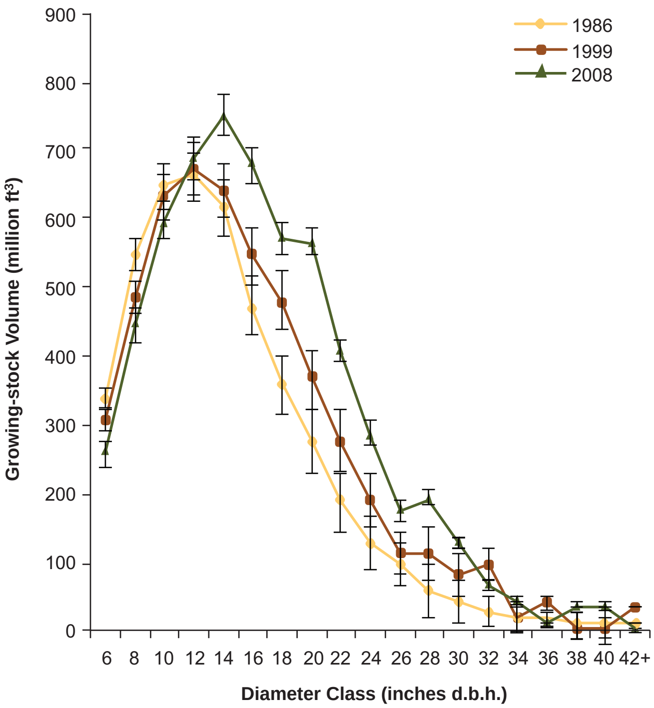


Figure 36.—Growing-stock volume on timberland by diameter class and inventory year, Maryland, 1986, 1999, 2008. (Error bars show 68 percent confidence intervals around the mean.)

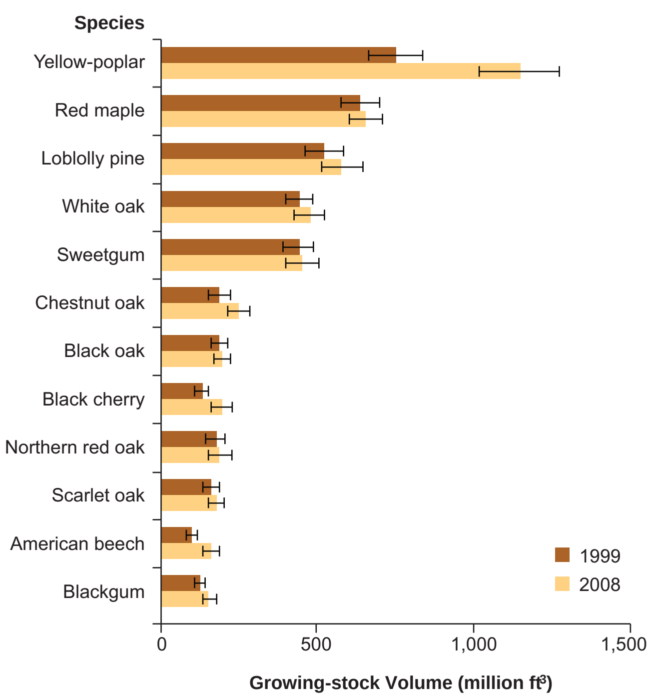


Figure 37.—Growing-stock volume on timberland by species, Maryland, 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

volume of all oak species combined is 1.6 billion cubic feet, representing about 26 percent of the total. Yellow-poplar showed a substantial increase of 50 percent since 1999. Looking at net growth by diameter class, yellow-poplar exhibited more growth than all oaks combined in trees greater than 20 inches d.b.h. (Fig. 38).

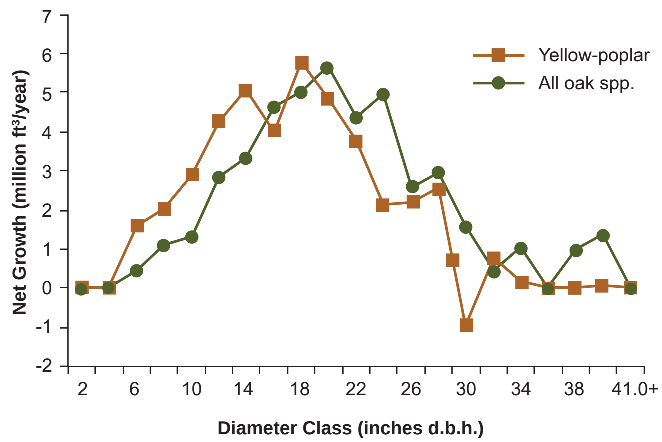


Figure 38.—Net growth of yellow-poplar and oak species growing stock on timberland by diameter class, Maryland, 2008.

What this means

The total volume of hardwood trees in Maryland's forests has increased steadily since 1976, while that of softwoods has remained relatively steady. Total softwood volume, which consists mostly of loblolly pine, is remaining constant due to some combination of timber management strategies, forest loss to development, and volume increase. The stability of the amount of softwood volume through time could be perturbed, however, with unsustainable forest management or increasing forest loss.

Examining the shift in volume by diameter class from one time period to another reveals that Maryland's forests are maturing. In general, relatively more volume is accumulating in larger rather than smaller diameter classes. Sawtimber-size trees (those greater than 11 inches in d.b.h.) are usually found in the canopy, and contain most of the volume. Yellow-poplar is increasing in importance (percentage of total basal area) mostly in the canopy stratum due to its competitive advantage and its frequency in the population within the large-diameter (and volume) -size classes. Oaks are increasing in volume but are becoming relatively less important than yellow-poplar in terms of volume. These changes in species importance will lead to changes in the value of Maryland's forests for wildlife and for the production of timber products. Management of species composition can have an impact on the value of the future forest as Maryland's forests continue to mature and the next generation of trees develops in the understory.

Sawtimber Quality and Volume

Background

Sawtimber trees are live trees of commercial species that contain either one 12-foot or two noncontiguous 8-foot logs that are free of defect. Hardwoods must be at least 11 inches d.b.h. and softwoods must be 9 inches d.b.h. to qualify as sawtimber. Sawtimber volume is defined as the net volume of the saw log portion of live sawtimber, measured in board feet, from a 1-foot stump to minimum top diameter (9 inches for hardwoods and 7 inches for softwoods). Estimates of sawtimber volume, expressed as board feet (International ¼-inch rule), are used to determine the monetary value of wood volume and to identify the quantity of merchantable wood availability.

The amount and quality of merchantable sawtimber in the State has a far-reaching impact on the economics of the State's forest industry. To understand sawtimber quality in Maryland, FIA generates estimates of total volume by tree grade, which is an index of wood quality. Tree grade depends on the species, the amounts of knot-free bole and cull, tree form, and tree diameter, and is typically used to help assess the potential value of the sawtimber resource. Tree grades 1 and 2 yield the highest quality wood for lumber. High quality timber is typically used for making cabinets, furniture, flooring, or other millwork, while lower quality timber is used for pallets, pulpwood, or fuelwood.

What we found

There are 22.6 billion board feet of sawtimber in Maryland which amounts to 9,545 board feet per acre. Sawtimber volume has increased by nearly 40 percent since 1999, the same percentage increase as was estimated between 1986 and 1999. Hardwood species comprise the majority of the sawtimber volume and also account for its increase (Fig. 39). Figure 40 shows the breakdown of sawtimber volume by tree grade. In Maryland, 57 percent of the sawtimber volume is in grades 1 or 2. The board foot volume in grades 2 and 3 has changed very little since 1999, however, the highest quality, grade 1 increased. Yellow-poplar is the top species with 5.8 billion board feet, or 26 percent of the total sawtimber volume, up from 20 percent of total

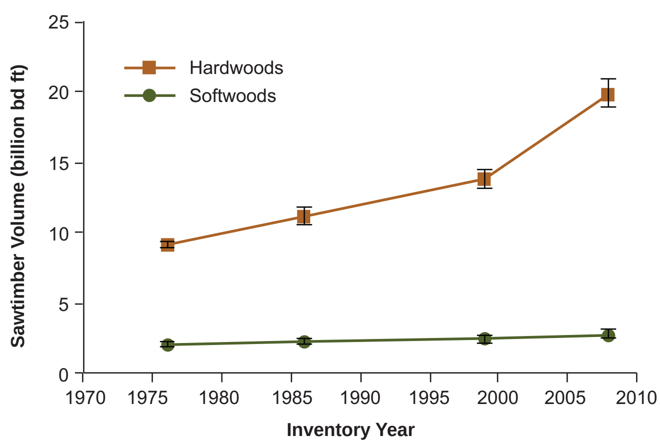


Figure 39.—Sawtimber volume on timberland by species group and inventory year, Maryland, 1976, 1986, 1999, 2008. (Error bars show 68 percent confidence intervals around the mean.)

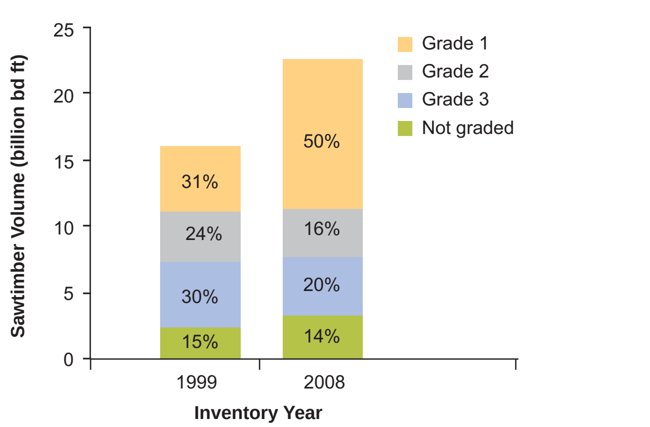


Figure 40.—Sawtimber volume on timberland by tree grade, Maryland, 1999 and 2008.

sawtimber volume in 1999 (Fig. 41). Figure 42 shows the proportion of tree grades for select tree species. In Maryland, loblolly pine has the largest volume in tree grades 1 and 2, followed by yellow-poplar and northern red oak (*Quercus rubra*) (Fig. 42). These species, as well as most other oak species and sweetgum, have at least half of their sawtimber volume in tree grade 2 or better.

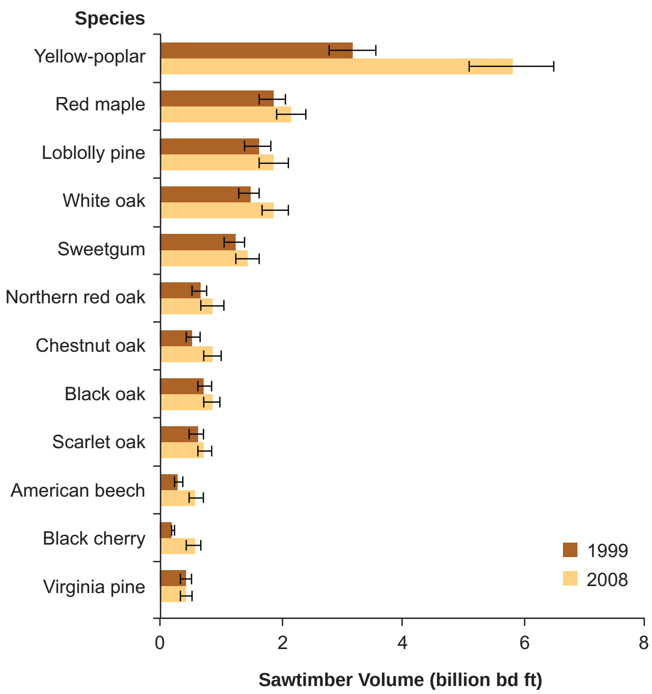


Figure 41.—Volume of sawtimber on timberland for major species, Maryland 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

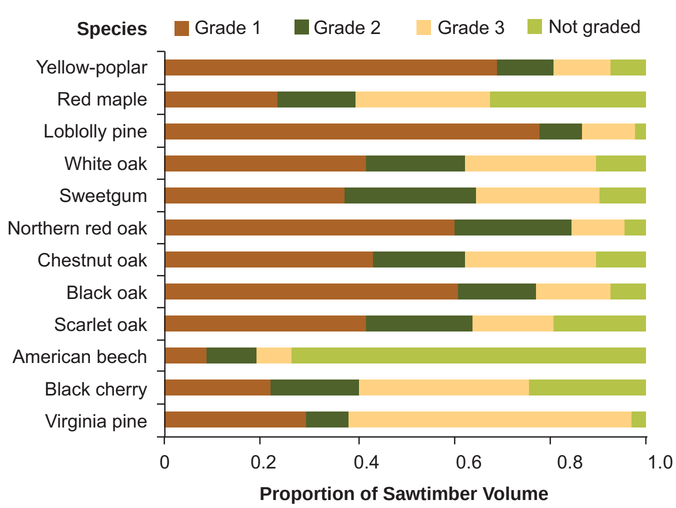


Figure 42.—Proportion of sawtimber volume on timberland by species and tree grade, Maryland, 2008.

Of the other major species in the State, beech had the lowest portion of volume in grades 1 and 2, followed by Virginia pine (*Pinus virginiana*), black cherry (*Prunus serotina*), and red maple. Many beech trees in Maryland 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 and red maple also do not self prune as well as other species such as yellow-poplar.

What this means

Since tree diameter is one of the factors influencing tree grade, the maturing of Maryland's forests (the accumulation of relatively more volume in the higher diameter classes) has led to a simultaneous increase in tree grades and thus potential value. The yellow-poplar resource is clearly increasing in tree grade at a much higher rate than other species due to its rapid growth rate and straight form, especially for trees that have reached codominant status. Softwood sawtimber volume, most of which is loblolly pine, has stayed relatively flat since 1976. This is due in part to an equilibrium of several factors: forest loss in areas where loblolly pine dominates, increase in volume in larger diameter classes, and timber management practices that promote sustainable harvests. As species composition in sawtimber-size classes and higher quality tree grades changes, so, too, will the economics of the forest industry in Maryland. Ideally, management practices and cutting preferences will adapt to promote the maintenance of a sustainable supply of high quality sawtimber.

Growth, Removals, and Mortality

Background

The concept of forest sustainability has many parts: the maintenance of forest cover, ecological and economic value, and forest productivity. One way to understand the status of forest sustainability is to look at the components of volume change: growth, removals, and mortality. Growth is the increase in volume over a specific time period. Removals harvested trees, trees on timberland that has been reclassified to reserved forest land (e.g., by the establishment of a protected area), or trees on forest land lost to a nonforest land use. Mortality is the loss of live volume that occurs when a tree dies. Growth, removals, and mortality data are collected on each remeasured tree in each inventory cycle, so trends in these metrics can be calculated over time.

What we found

In Maryland, tree growth has exceeded losses from mortality and removals. Figure 43 shows the components of annual volume change. The average annual net growth of growing stock on timberland is 138.9 million cubic feet, or 75 cubic feet per acre per year. Losses due to mortality average 44 million cubic feet annually, and removals averaged 67 million cubic feet annually. These components result in an annual net gain of 110 million cubic feet. Removals include tree volume that was harvested but the land will likely remain in forest (64 percent), tree volume lost due to a change to nonforest use (27 percent), and tree volume that remains in forest but is now reserved or protected from harvest removal (9 percent).

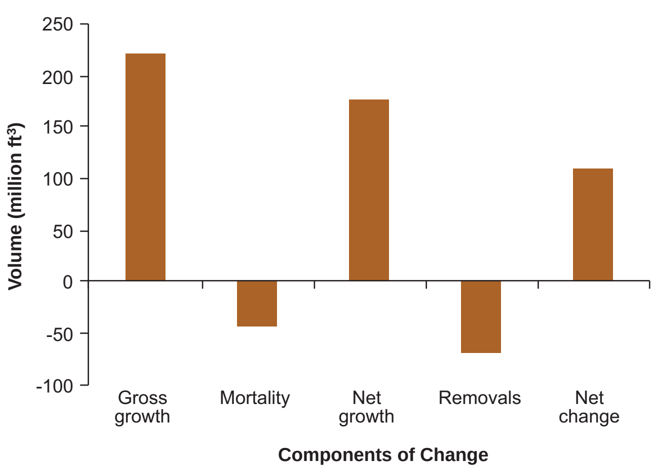


Figure 43.—Components of average annual change in growing-stock volume, Maryland, 1999-2008.

Figure 44 shows how growth (as a percentage of total growing-stock volume) increased from 2.1 to 3.0 percent between 1999 and 2008, and while removals and mortality changed little. The overall growth-to-removals ratio (G:R) doubled between 1999 and 2008 from 1.3 to 2.6. The hardwood G:R nearly tripled during this same time period (1.3 to 3.6).

Yellow-poplar has one of the highest G:R at 6.1 (Fig. 45). Loblolly pine, the species with the second highest growth rate (and 30 percent of all removals), has a G:R of only 1.1, indicating that the population is relatively stable. Oaks, as a group, which represent 17 percent of all removals, have a G:R of 3.5. However, several species, including Virginia pine, flowering dogwood, and yellow birch, have negative growth estimates. A loss of growth can occur on live trees due to damage, rot, or other causes.

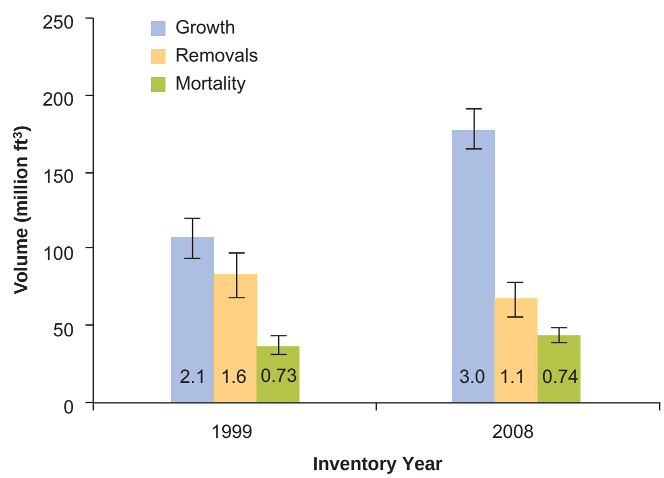


Figure 44.—Average annual net growth, removals, and mortality on timberland and as a proportion of total growing-stock volume, Maryland, 1999 and 2008. (Error bars show 68 percent confidence intervals around the mean.)

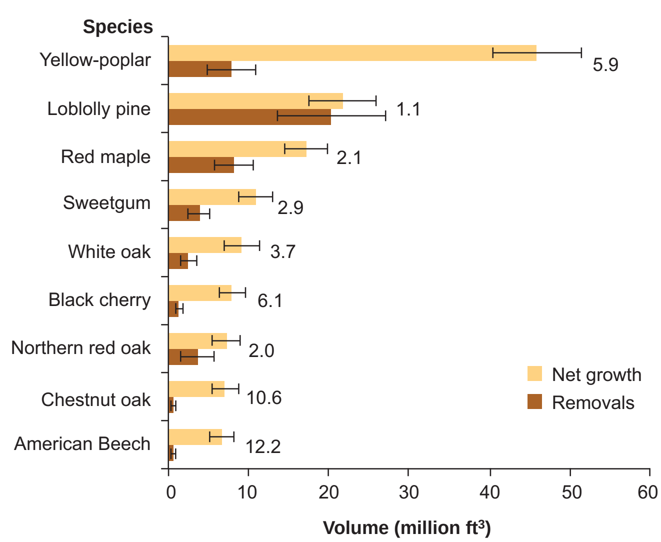


Figure 45.—Average annual net growth, removals, and growth-to-removals (G:R) ratio for major species, Maryland, 2008. G:R for all species is 2.6. (Error bars show 68 percent confidence intervals around the mean.)

What this means

FIA data suggest that net growth has been increasing over time. Substantial increases appear to have been driven by the growth of yellow-poplar. The G:R of this species far exceeds that of oaks, suggesting that the yellow-poplar component of Maryland's forests will become more important in the future.

Loblolly pine is an important commercial species in Maryland and the impressive growth of this species may be due to improved management. After the 1986 FIA inventory results showed decreases in pine volumes, the Maryland Department of Natural Resources (MD DNR) formed the Loblolly Pine Task Force to address the issue. The current inventory results indicate that loblolly pine growth has increased and that growth exceeds removals with a G:R of 1.1.

The slow growth that some species such as Virginia pine exhibit may be partially due to shifts in competitive advantage as Maryland's forests mature and shade-intolerant species become less prevalent. As the population of Virginia pine trees get older, they become more susceptible to environmental stressors, growth rates decline, and mortality rates increase (Burkman and Bechtold 2000). These cyclical patterns in forest composition have occurred in the past and are likely to occur in the future. Maryland's hardwood forests are more susceptible to the variations of ecological processes that occur in unmanaged natural systems where competition and successional patterns determine competitive advantage and floristic dominance.

Mortality

Background

The loss of tree volume to mortality is a natural process. Excessive mortality, however, can be an indicator of poor forest health and can be caused by insects, disease, humans or other animals, competing vegetation, weather events, old age, or a combination of these factors. In very dense stands, more trees die due to competition for resources. In open, sparse stands, trees might be more susceptible to extremes in wind and precipitation, or prone to damage by animals. In addition to per-species diameter-class and volume distributions, per-species mortality estimates can give a clue to the composition of the future forest.

What we found

In Maryland, the average annual mortality was 44 million cubic feet, or 18 cubic feet per acre per year. Although the data suggest that mortality has been increasing since the 1986 inventory, it is still only 0.7 percent of the total growing-stock volume. Although the total mortality of softwoods is lower than that of hardwoods, total softwood mortality relative to the softwood growing-stock volume (known as relative mortality) is much higher than that of hardwoods relative to hardwood volume (Fig. 46). In 1999 and 2008, most mortality consisted of trees greater than 11 inches d.b.h.

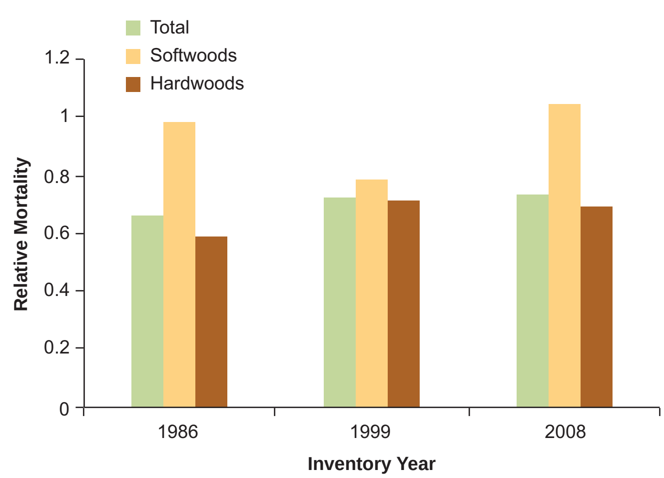


Figure 46.—Average annual mortality as a proportion of growing-stock volume on timberland by species group and inventory year, Maryland, 1986, 1999, and 2008.

The only dominant species that shows a significant change (in this case, a decrease) in mortality between 1999 and 2008 is sweetgum (Fig. 47). All of the other dominant species show similar levels of volume in the two time periods. Red maple shows the largest relative mortality (proportion of the total current volume of that species) of the nine most dominant species (Fig. 48). Several of the oak species have some of the higher relative mortality values. Yellow-poplar, a species that has been increasing in dominance, exhibits low relative mortality.

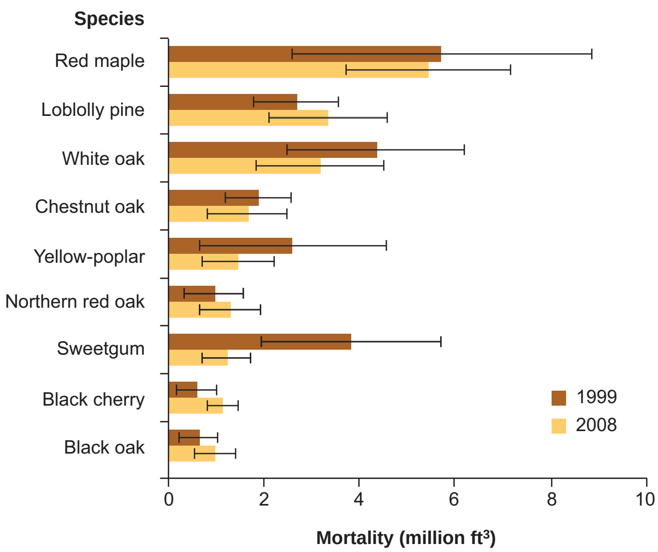


Figure 47.—Average mortality for major species, Maryland, 1999 to 2008. (Error bars show 68 percent confidence intervals around the mean.)

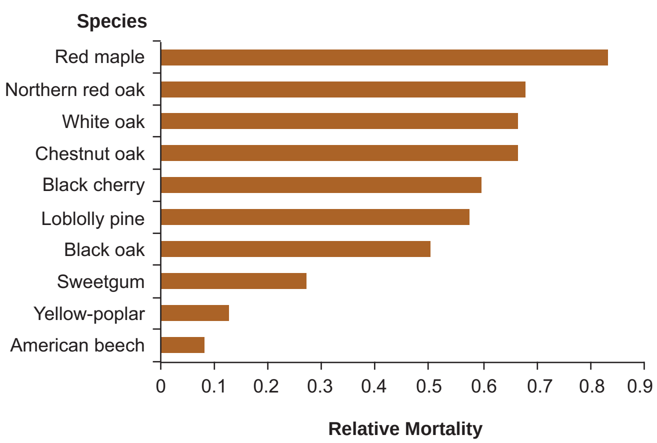


Figure 48.—Mortality as a proportion of total growing-stock volume for major species, Maryland, 1999 to 2008. Average relative mortality for all species is 0.7.

What this means

Mortality levels are generally at or below 1 percent for all species across the State. These mortality levels do not indicate any dramatic deviations from that expected from natural processes such as succession, periodic loss of vigor and death from insect or physical damage, or competition with other individuals for resources. The higher relative level of mortality of red maple and several of the oak species is not surprising. Red maple is not very resistant to physical damage from weather events and once this damage occurs, the trees become more vulnerable to insect or disease attack, loss of vigor, and death. With respect to the oaks, the distribution of oaks tends toward the large-diameter classes. These larger, more mature trees might be, as a group, reaching the end of their natural life span, and are becoming more susceptible to the aforementioned damaging agents. Yellow-poplar, on the other hand, with some of the lower relative mortality, tends as a group toward some of the early to mid-successional size classes. Trees at this stage in their life cycle tend to be more vigorous and resistant. As insects and disease threats emerge, managers should continue to monitor mortality rates of susceptible species like ash (*Fraxinus* spp.), flowering dogwood (*Cornus florida*), and oaks.

Timber Products

Background

The harvesting and processing of timber products produces a stream of income shared by timber owners, managers, marketers, loggers, truckers, and processors. In 2007, the wood products and paper manufacturing industries in Maryland employed 8,290 people, with an average annual payroll of $319 million (U.S. Census Bureau 2007). To better manage the State's forests, it is important to know the species, amount, and location of timber being harvested.

Surveys of Maryland's wood-processing mills are conducted periodically to estimate the amount of wood volume that is processed into products. This is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from Maryland. These data include information from four common mill types: sawmills which make wood planks and boards, pulp mills which make fibrous pulp used to make paper and other products, cooperage mills that make barrels, casks and tanks and excelsior mills which make wood shavings commonly used as packing material.

What we found

In 2008, 20 saw mills, 1 pulp mill, 1 cooperage mill, and 1 excelsior/shavings mill were surveyed to determine what species were processed and where the wood material came from. These mills processed 45.9 million cubic feet of industrial roundwood. Less than half of the processed roundwood was actually harvested from Maryland's forest land. The remainder was brought in from neighboring states.

In 2008, 27.4 million cubic feet of industrial roundwood was harvested from Maryland's forest land. Saw logs and pulpwood each accounted for 46 percent of the total industrial roundwood harvested (Fig. 49). Other products harvested included excelsior, post, poles, pilings, veneer logs, and cooperage. Loblolly and shortleaf pine accounted for almost a third of the total industrial roundwood harvest (Fig. 50). Other important species groups harvested were the yellow-poplar, oaks, maples, and black cherry.

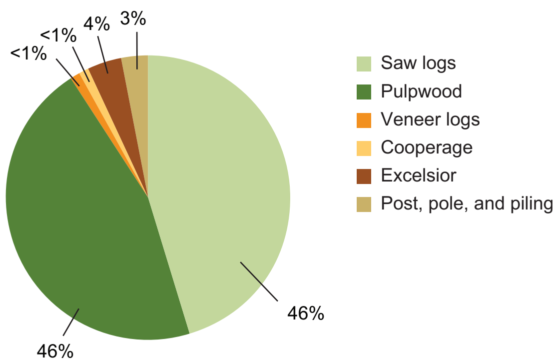


Figure 49.—Industrial roundwood and fuelwood production by product, Maryland, 2008.

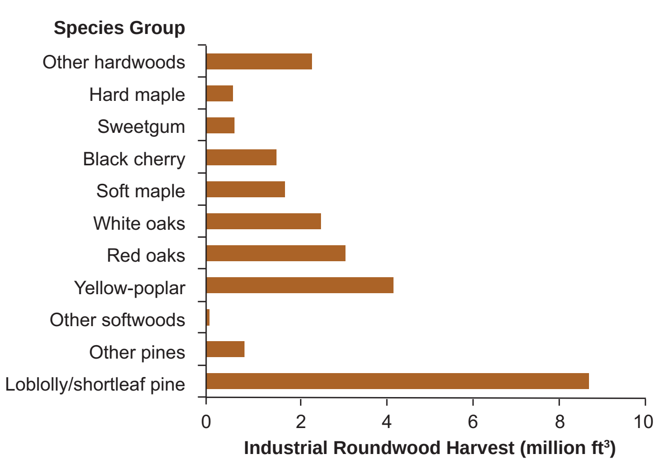


Figure 50.—Industrial roundwood harvested by species group, Maryland, 2008.

In the process of harvesting industrial roundwood, 15.1 million cubic feet of harvest residues were left on the ground. More than three-fourths of the logging residue came from nongrowing-stock sources (logging slash), such as crooked or rotten trees, nonforest trees, tops and limbs, and dead trees (Fig. 51). The processing of industrial roundwood by the State's primary wood-using mills generated another 413,600 dry tons of wood and bark residues. More than 55 percent of the mill residues generated were used for miscellaneous products such as animal bedding and small dimension products. Another 20 percent of the mill residues were used for mulch, and 17 percent were used for fiber products. Less than 1 percent of the mill residues were not used for other products (Fig. 52).

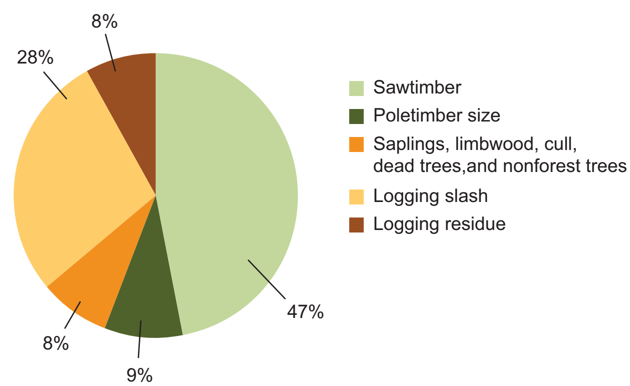


Figure 51.—Residue generated by industrial roundwood harvesting by growing stock and nongrowing stock, and used for product and harvest residue, Maryland, 2008.

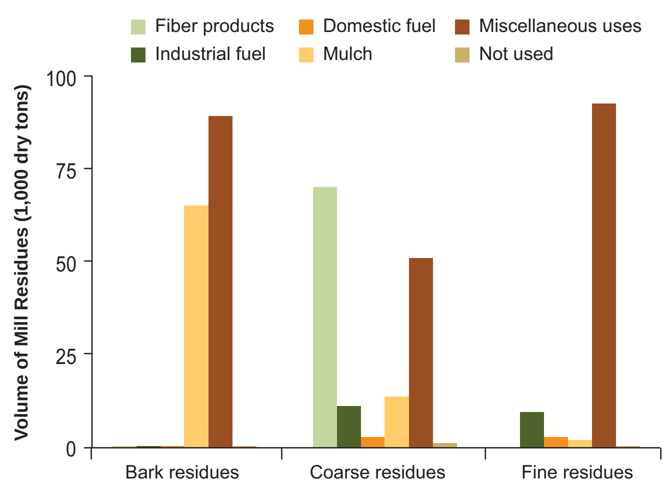


Figure 52.—Disposition results of mill residues generated by primary wood-using mills, Maryland, 2008.

What this means

The demand for wood products is likely to increase, placing a greater demand on the resource. An important consideration for the future of the primary wood-products industry is its ability to retain industrial roundwood processing facilities. The number of wood processing mills has been steadily declining. The loss of processing facilities makes it harder for landowners to find markets for the timber harvested from management activities on their forest land.

Another important issue is the volume of harvest residues that are generated but go unused. Almost a quarter of the harvest residue generated is from growing-stock sources (wood material that could be used to produce products). Industrial fuelwood or increased pulpwood markets could lead to better utilization of merchantable trees. The use of logging slash for industrial fuelwood at cogeneration facilities and pellet mills could also result in better utilization of the forest resource. The desire to utilize all harvested material however must be balanced by the ecological value of leaving some behind at the logging site. Logging slash that prevents erosion and soil loss and later recycles nutrients back into the soil is a valuable use of some harvest residues.

Forest Health

Light seeping through a hardwood canopy, New Germany State Park, Garrett County, MD, 2009. Photo by Jack Perdue, Maryland DNR.

Young Forest Habitat

Background

Maryland's forests provide habitat for numerous species of mammals, birds, reptiles, and amphibians, as well as for fish, invertebrates, and plants. Several indicators of wildlife habitat abundance can be derived from FIA data. Forest composition and structure affect the suitability of habitat for each species. Some species depend upon early successional forests or the ecotone (edge) between different forest stages. Yet other species require old growth forests or interior forests. Many species require multiple structural stages of forests to meet their needs during different phases of their life history. Abundance and trends in these structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001).

According to the Maryland Wildlife Diversity Conservation Plan (MD DNR 2005), there is a critical need to maintain a diversity of natural communities including natural shrublands, old fields, and other forms of early successional habitat. Several of Maryland's species of greatest conservation need are associated with young forests, like American woodcock (*Scolopax minor*) and golden-winged warblers (*Vermivora chrysoptera*), both of which are showing alarming declines in population during the past several decades.

Other species require interior forest, which is discussed in the 'Forest Fragmentation and Urbanization' section, or old-growth forest, which was once a dominant feature throughout most of the Maryland landscape but is currently scattered and rare in the state and region.

What we found

Peak distribution of small-diameter stand-size class, which is an indicator of early successional stages, occurred during 1950 (22 percent), falling below 10 percent of all forest land during the 1986 and current inventories (Fig. 53). Concurrently, distribution of large-diameter stand-size class has increased steadily from less than 50 percent during 1950 to 76 percent during the current inventory, with medium diameter forest showing the opposite trend, decreasing from about 26 percent during 1950 to 14 percent in the current inventory (Fig. 53). Most Maryland forest land is in stand-age classes over 40 years, and a small fraction is older than 150 years. Small-diameter stand-size class comprises only minor fractions of forests older than 20 years, but predominates young forests (0 to20 years) (Fig. 54).

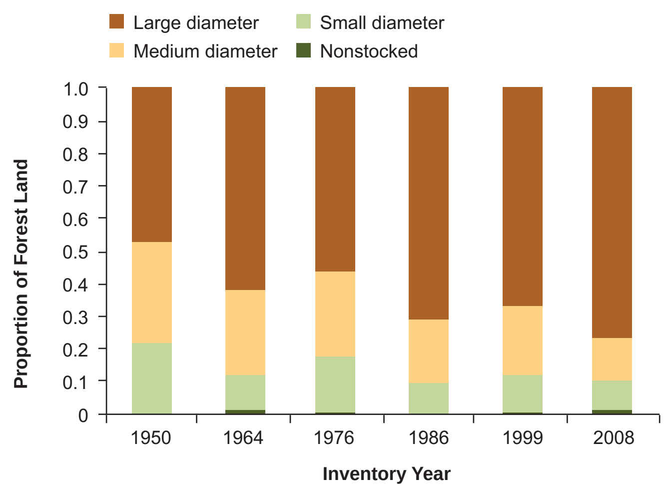


Figure 53.—Proportion of forest land by stand-size class, Maryland, 1950-2008.

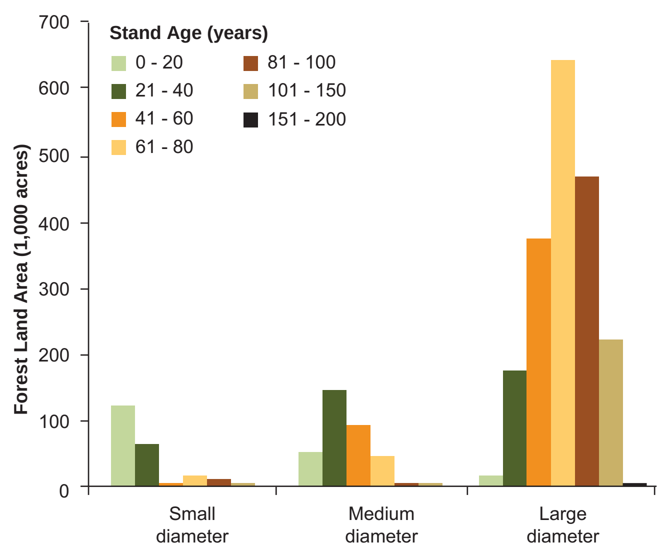


Figure 54.—Area of forest land by age class and stand-size class, Maryland, 2008.

What this means

Decreasing abundance of small- and medium-diameter stand-size classes is offset by increasing abundance in large-diameter class. Most of the large-diameter class is less than 100 years of age. While both stand-size class and stand-age class are indicators of successional stages of forests, the two attributes are not interchangeable and are best used in combination. The data suggest that the amount of early successional habitat in Maryland may be decreasing. Early successional habitat is a critical component of Maryland's forests. Not only does a healthy, sustainable forest depend upon an adequate quantity of young trees, but many species of wildlife use this habitat type, including several species that are considered to be in need of conservation. These include bird species such as the northern bobwhite (*Colinus virginianus*), field sparrow (*Spizella pusilla*), prairie warbler (*Dendroica discolor*), and American woodcock (*Scolopax minor*). There is a need to maintain forest conditions in multiple stand-size and age classes to provide habitats for all forest-associated species.

Standing Dead Trees

Background

Nesting cavities and standing dead trees (at least 5 inches d.b.h) provide critical habitat components for many forest-associated wildlife species. Standing dead trees that are large enough to meet habitat requirements for wildlife are referred to as 'snags'. Standing dead trees serve as important indicators not only of wildlife habitat, but also for past mortality events and carbon storage. The number and density of standing dead trees, together with decay classes, species, and sizes, define an important wildlife habitat feature across Maryland's forests.

What we found

More than 35 million standing dead trees are present on Maryland forest land. This represents an overall density of 14.2 standing dead trees per acre of forest land. Ten species groups each contributed more than 1 million standing dead trees, with the top group, 'other eastern hard hardwoods' exceeding 4.7 million (Fig. 55). Species in this group include black locust, oak, birch, dogwood, common persimmon, American holly and white mulberry. Relative to the total number of live trees in each species group, seven species groups exceeded five standing dead trees per 100 live trees, four of which exceeded 10 standing dead trees per 100 live trees, with 'other yellow pines' leading all groups with more than 21 standing dead trees per 100 live trees (Fig. 56). Eighty-six percent of standing dead trees were smaller than 11 inches d.b.h., with more than 40 percent between 5 and 6.9 inches d.b.h. (Fig. 57). Most standing dead trees were classified in the three intermediate decay classes, with the fewest number in the class of most decay. This pattern was consistent across most decay classes (Fig. 57).

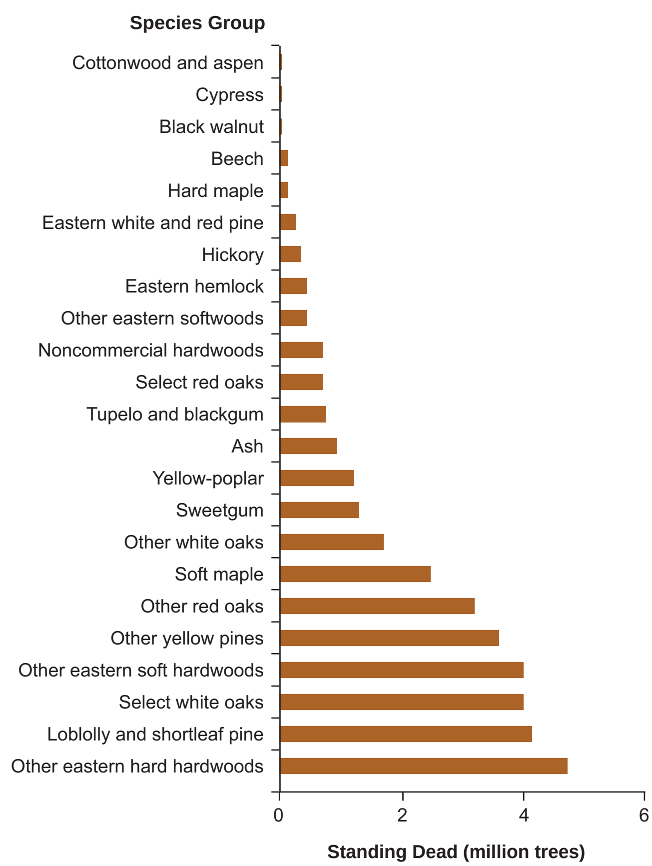


Figure 55.—Number of standing dead trees by species group, Maryland, 2008.

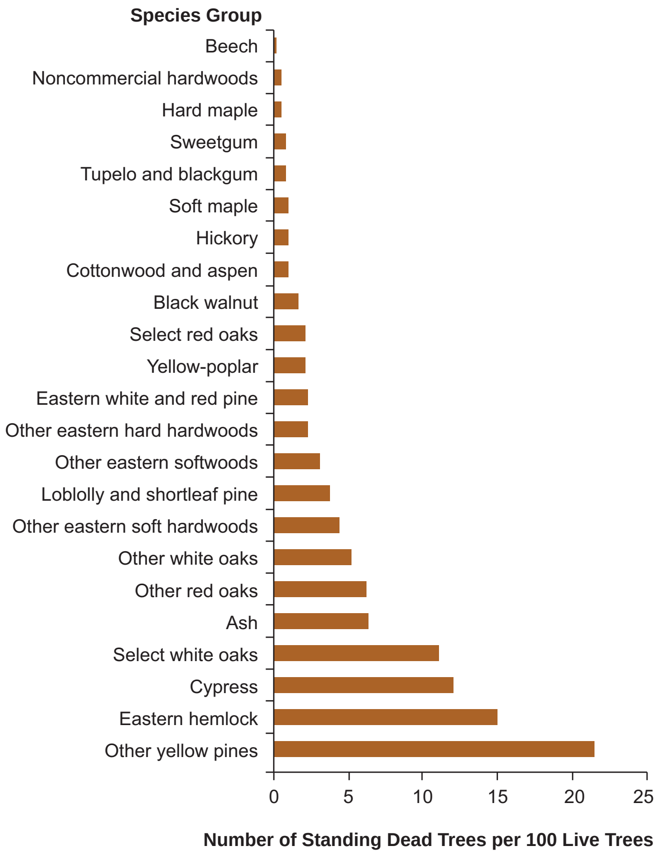


Figure 56.—Number of standing dead trees per 100 live trees by species group, Maryland, 2008.

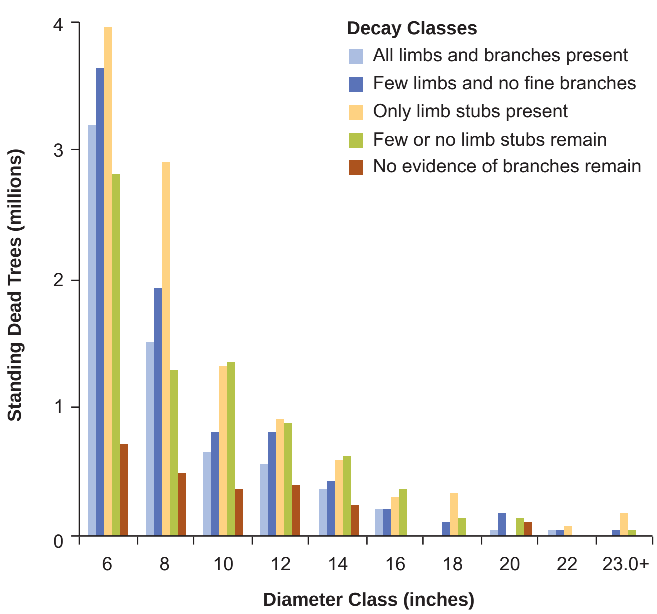


Figure 57.—Distribution of standing dead trees by decay and diameter classes for standing dead trees, Maryland, 2008.

What this means

Snags result from a variety of causes, including diseases and insects, weather damage, fire, flooding, drought, and competition, and other factors. 'Other yellow pines' species group had the highest density of standing dead trees per 100 live trees, attributable mostly to Virginia pine, which accounted for more than 90 percent of standing dead trees in this species group. Compared to live trees, the number of standing dead trees is small, but they contain significantly more cavities than occur in live trees (Fan et al. 2003). Standing dead trees provide areas for foraging, nesting, roosting, hunting perches, and cavity excavation for wildlife, from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles. Most cavity nesting birds are insectivores that help to control insect populations.

Providing a variety of forest structural stages and retaining specific features like snags on both private and public lands are ways that forest managers maintain the abundance and quality of habitat for forest-associated wildlife species in Maryland.

Forested Wetlands

Background

Wetlands are transitional areas between terrestrial and aquatic ecosystems characterized by some combination of water above or near the soil surface, wet soil types, and plants that only grow in wet conditions. Wetlands have unique plant and animal communities that have adapted to these conditions and offer many ecosystem services such as water filtration and storage, nutrient cycling, flood and erosion control, carbon sequestration, and providing habitat for wildlife, including, in the case of estuarine wetlands, many commercial marine species. Wetlands are extensive in Maryland, especially in coastal areas in and around the Chesapeake Bay (Tiner and Burke 1995).

The U.S. Fish and Wildlife Service conducts the National Wetlands Inventory (NWI) using the Cowardin wetland classification system (Cowardin et al. 1979) to map the nation's wetlands. FIA uses a geographic information system to layer the Cowardin wetland classes to spatially corresponding Maryland FIA plots. FIA then uses the wetland category as a classification variable in the data summaries presented in this report.

What we found

Seventeen percent of Maryland's forest land falls in wetland areas. Sixty-one percent of the forested wetland area is concentrated in the lower Eastern Shore in Caroline, Dorchester, Wicomico, Worcester, and Somerset Counties (Fig. 58). The large stand-size class dominants both the forested wetland and non-wetland areas in Maryland, however there appears to be a greater acreage of small-size class stands in the wetland areas (Fig. 59). Species composition is similar among forested wetland and non-wetland areas in Maryland as the most abundant species 5 inches in d.b.h. and greater in wetland areas are the same as in non-wetland areas (red maple, American holly, blackgum, and loblolly pine; Fig. 60). However, the relative dominance, in terms of numbers of trees, is different. Blackgum and loblolly pine show greater abundance in Maryland wetland areas due to the fact that these species can grow in wetter environments and are more salt-tolerant than some of their competitors, allowing them to exist in higher numbers in brackish estuarine wetland.

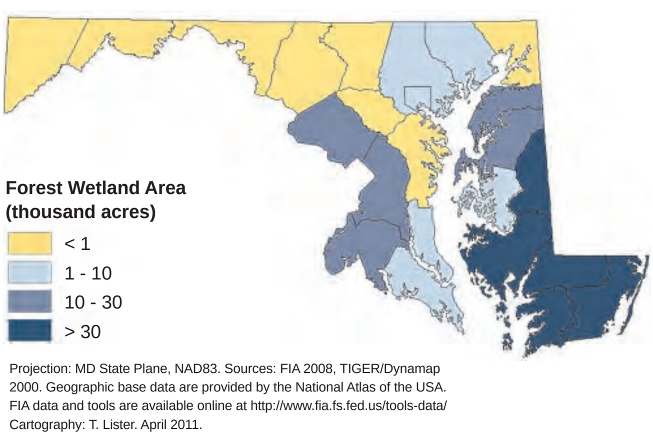


Figure 58.—Area of forested wetland by county, Maryland, 2008.

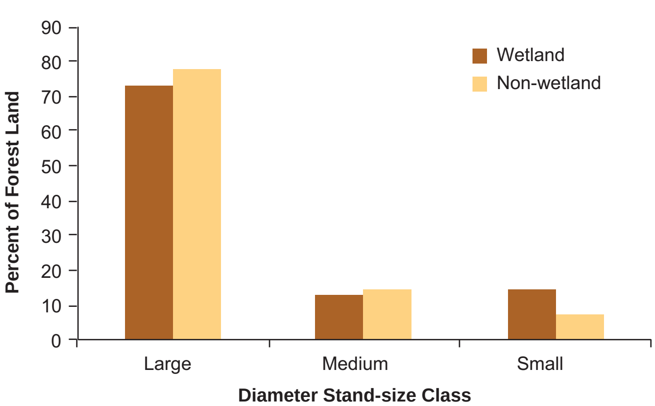


Figure 59.—Percent of forest land by diameter size class in wetland and nonwetland areas, Maryland, 2008.

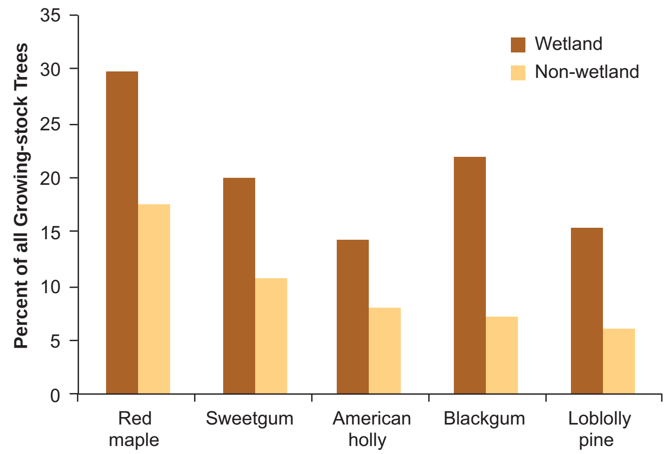


Figure 60.—Percent of total number of growing-stock trees in each class for select species on wetland and non-wetland forest, Maryland, 2008.

What it means

Maryland's unique location surrounding the central portion of the Chesapeake Bay creates a wetland-rich environment that is one of the State's natural treasures. The lower Eastern Shore hosts the majority of the State's forested wetlands and there are a number of wildlife refuges in the area, including the Black Water National Wildlife Refuge, that have been designated to help protect these important ecosystems and the associated wildlife that frequent there. These include three forest-dependant species that are considered "recovering species": the endangered Delmarva fox squirrel (*Sciurus niger cinereus*), the threatened American bald eagle (*Haliaeetus leucocephalus*), and the recently delisted migrant peregrine falcon (*Falco peregrinus*). It is thus important to monitor these areas, looking for shifts in acreage, species composition, and forest health. As FIA begins its first cycle of remeasurement under the annual system and the U.S. Fish and Wildlife Service wetland maps continue to be improved and updated, the integration of FIA and wetlands data will provide opportunities for this monitoring.

Down Woody Materials

Background

Down woody materials, in the form of fallen trees and branches, fulfill a critical ecological niche in Maryland's forests by providing valuable wildlife habitat. Down woody material also contributes to forest fire hazards via surface woody fuels.

Since dried wood is a greater fire hazard risk, one way to determine down woody material's fire hazard potential is to classify it by the amount of time it take for the material to dry out. These classes are called time-lag fuel classes. Larger coarse woody debris takes longer to dry out than smaller fine woody pieces. For example, time-lag fuel classes for small fine woody debris equal 1 hour, medium woody debris equal 10 hours, large fine woody debris equal 100 hours, and coarse woody debris equal 1,000+ hours (Woodall and Monleon 2008).

What we found

The fuel loadings of down woody materials (time-lag fuel classes) are not exceedingly high in Maryland (Fig. 61). When compared to the neighboring states of New Jersey and Delaware, Maryland's fuel loadings of all time-lag fuel classes are not substantially different. The size-class distribution of coarse woody debris appears to be heavily skewed (85 percent) toward pieces less than 8 inches in diameter at point of intersection with plot sampling transects (Fig. 62A). With regard to decay-class distribution of coarse woody debris, 78 percent of coarse woody debris pieces are in decay class 3 and 4 (Fig. 62B), typified by moderate- to heavily-decayed logs that are sometimes structurally sound but missing most or all of their bark and with extensive sapwood decay. Coarse woody debris volume per acre decreases slightly as live-tree density (basal area per acre) increases. Stands with the greatest volumes of coarse woody debris were more often those with low levels of standing live tree basal area (Fig. 63).

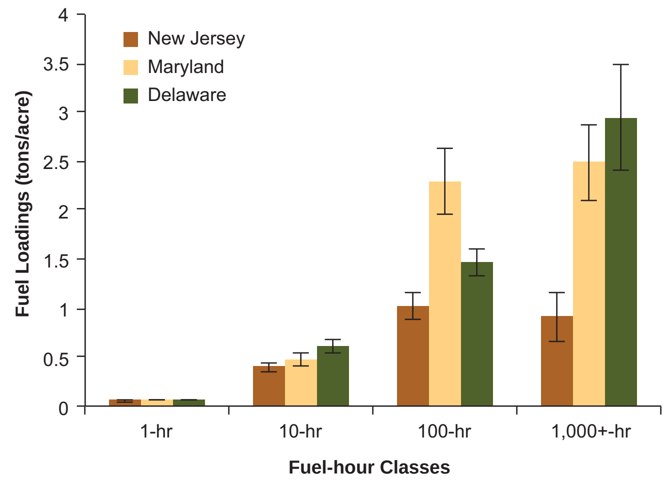


Figure 61.—Means and associated standard errors of fuel loadings (tons/acre, time-lag fuel classes) on forest land in Maryland and neighboring states, 2008. (Error bars show 68 percent confidence intervals around the mean.)

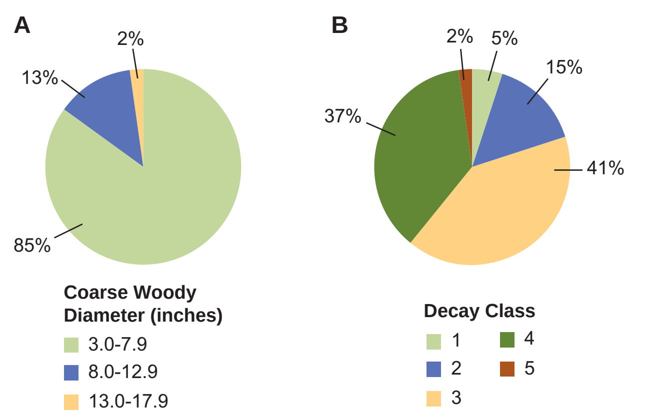


Figure 62.—Mean percentage of coarse woody debris pieces per acre by transect diameter (inches) (A) and decay classes (B) on forest land in Maryland, 2008.

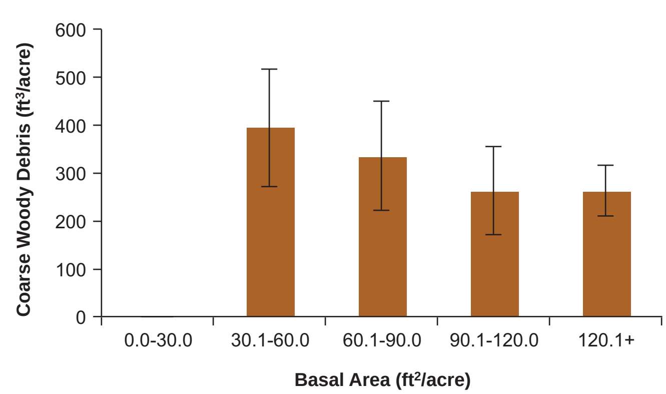


Figure 63.—Means coarse woody debris volumes (ft^3/acre) on forest land in Maryland, 2008. (Error bars show 68 percent confidence intervals around the mean.)

What this means

Only in times of extreme drought in Maryland would these low amounts of fuels pose a hazard across the state. Of all down woody components, the largest amount was in coarse woody debris (i.e., 1,000+-hr fuels). 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. Because fuel loadings are not exceedingly high across Maryland, potential fire dangers are outweighed by the benefits of down woody material for wildlife habitat and carbon sinks.

Lichen Communities

Background

Lichens are symbiotic, composite organisms of members of as many as three kingdoms. The dominant partner, in terms of biomass, 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 Phase 3 (P3) inventory to assess the impact of air pollution on forest resources, or spatial and temporal trends in biodiversity. This long-term lichen monitoring program in the United States dates back to 1994. The objective of collecting lichen data is to determine the presence and abundance of lichen species on woody plants. Lichens occur on many different substrates (e.g., rocks), but FIA sampling is limited to standing trees or branches that have recently fallen to the ground.

A close relationship exists between lichen communities and air pollution, especially acidifying 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 from other stressors (McCune 2000).

What we found

Eighty-four lichen species (gamma diversity) were sampled on lichen plots in Maryland (Table 2). The most common lichen genus, *Punctelia*, was present on 17 percent of the plots (Table 3). The genus with the highest number of species sampled was Cladonia (7 species).

Lichen diversity is estimated by the number of species found at a site; this measure is termed species richness. Richness values fell into the low to medium categories across Maryland (Table 2). Figure 64 shows the spatial distribution of lichen species richness scores.

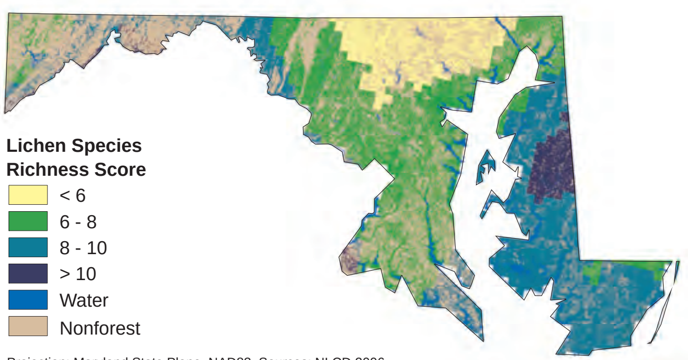
Table 2.—Lichen community summary table for Maryland, 1994-2003

Parameter	
Number of plots surveyed	12
Number of plots by species richness category	
0-6 species (low)	4
7-15 species (medium)	8
16-25 species (high)	0
Median	9
Range of species richness score per plot (low-high)	5-13
Average species richness score per plot (alpha diversity)	8.8
Standard deviation of species richness score per plot	3
Species turnover rate (beta diversity)[a]	9.5
Total number of species per area (gamma diversity)	84

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

Table 3.—Percentage of specimens and number of species for lichen sampled, Maryland, 1994-2003

Genus	All Specimens (percent)	Species (count)
Punctelia	17.0	5
Phaeophyscia	15.0	2
Physcia	14.3	4
Cladonia	9.5	7
Flavoparmelia	8.2	1
Myelochroa	6.8	3
Parmotrema	6.1	6
Pyxine	4.1	2
Parmelia	3.4	3
Canoparmelia	2.7	2
Hypotrachyna	2.0	2
Parmelinopsis	2.0	2
Usnea	2.0	3
Heterodermia	1.4	2
Hyperphyscia	1.4	1
Candelaria	0.7	1
Cetraria	0.7	1
Flavopunctelia	0.7	1
Hypogymnia	0.7	1
Physciella	0.7	1
Rimelia	0.7	1
Total	100	51

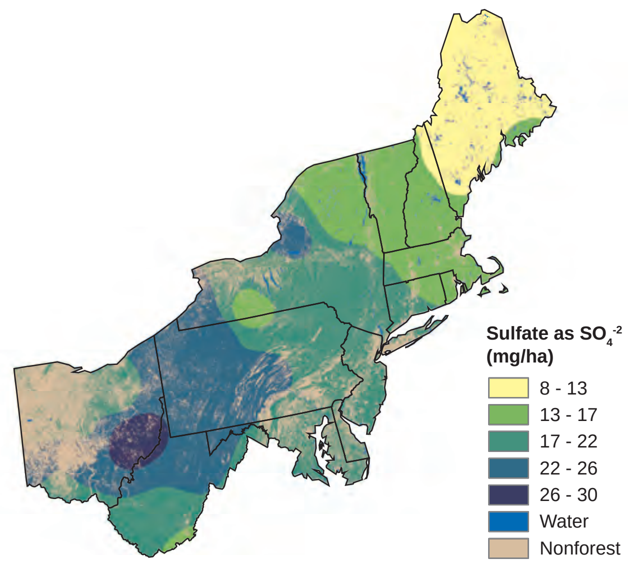


Projection: Maryland State Plane, NAD83. Sources: NLCD 2006, FIA 2003. Geographic base data are provided by the National Atlas of the USA. FIA data and tools are available online at http://www.fia.fs.fed.us/tools-data/
Cartography: R.S. Morin. Feb. 2011

Figure 64.—Estimated lichen species richness, Maryland, 2000-2003.

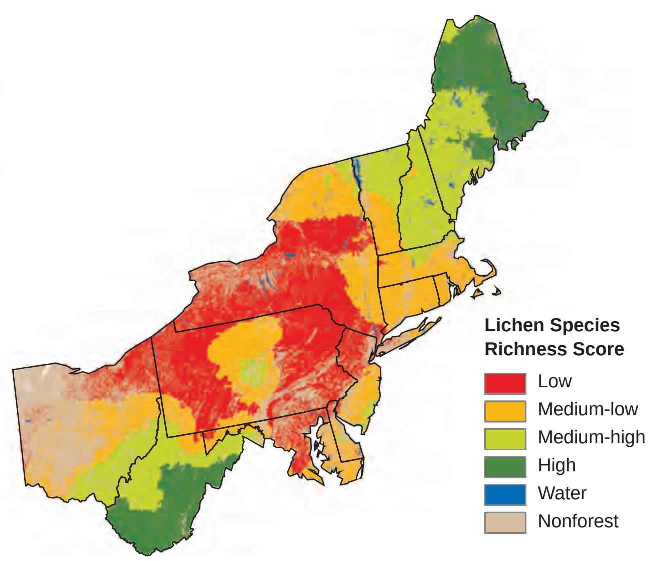
What this means

In general, species richness scores were highest in the western, mountainous region of the State and the eastern Piedmont region. Showman and Long (1992) reported that mean lichen species richness was significantly lower in areas of high sulfate deposition compared to low deposition areas. Sulfate deposition levels have been relatively homogenous across Maryland and are moderate compared to other areas in the northeastern United States (Fig. 65). In the northeastern United States, there is a general pattern of lower lichen species richness scores in high deposition areas and vice versa (Fig. 66). Other factors may affect the distribution of lichen species, including intrinsic forest characteristics and long-term changes in climate. The lichen species richness scores reported here will serve as baseline estimates for future monitoring at the State and regional level.



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 65.—Mean sulfate ion wet deposition, northeastern U.S., 1994-2002.



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

Figure 66.—Estimated lichen species richness, northeastern U.S., 2000-2003.

Crown Health

Background

The crown condition of trees is influenced by various biotic and abiotic stressors. Abiotic stressors include drought, flooding, cold temperatures or freeze injury, nutrient deficiencies, soil physical properties affecting soil moisture and aeration, and toxic pollutants. Biotic stressors include native or introduced insects, diseases, invasive plant species, and animals.

Seasonal or prolonged drought has been a significant and historical stressor in Maryland. Droughts have occurred in some regions of the State during 1999 and 2002; alternatively, some of the wettest years on record were recorded in 2003 and 2004 (NCDC 2010). These extreme precipitation events can produce conditions that facilitate insect and disease outbreaks and can be even more devastating to trees that are already stressed by pest damage or other agents.

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, Pimentel et al. 2000, Vitousak et al. 1996). Over the last century, Maryland's forests have suffered the effects of well known exotic and invasive agents such as Dutch elm disease (*Ophiostoma ulmi*), chestnut blight (*Cryphonectria parasitica*), European gypsy moth (*Lymantria dispar*), beech bark disease complex, and hemlock woolly adelgid (*Adelges tsugae*). Another important invader that is currently invading Maryland's forests is emerald ash borer (*Agrilus planipennis*).

Tree-level crown measurements are collected on P3 plots. They include vigor class, crown ratio, light exposure, crown position, crown density, crown dieback, and foliage transparency. Three factors were used to determine the condition of tree crowns: crown dieback, crown density, and foliage transparency. Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of recent stresses on a tree. Crown density is defined as the amount of crown branches, foliage, and reproductive structures that block light visibility through the crown and can serve as a predictor of growth in the near future. Finally, foliage transparency is the amount of skylight visible through the live, normally foliated portion of the crown. Changes in foliage transparency can also occur because of defoliation or from reduced foliage resulting from stresses during preceding years. A crown was labeled as 'poor' if crown dieback was greater than 20 percent, crown density was less than 35 percent, or foliage transparency was greater than 35 percent. These three thresholds were based on preliminary findings by Steinman (2000) that associated crown ratings with tree mortality.

What we found

The occurrence of poor crowns in Maryland was very low and evenly distributed across the State (Fig. 67). The only species with greater than 10 percent of live basal area containing poor crowns is red maple (Table 4). The highest proportion of red maple basal area containing poor crowns was found in the southeastern part of Maryland (Fig. 68).

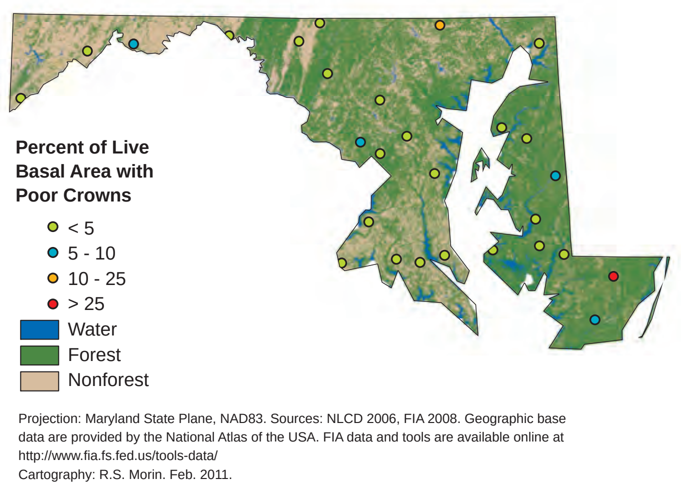
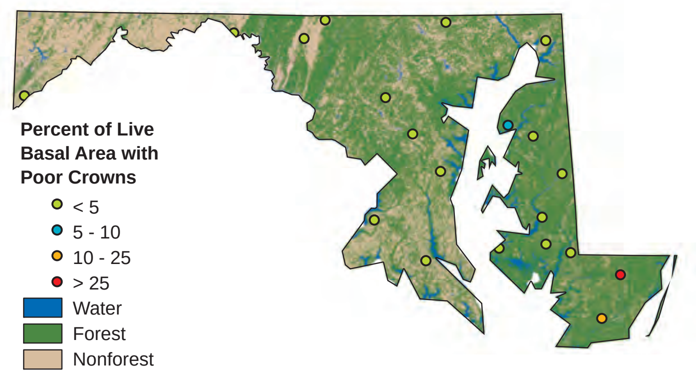


Figure 67.—Percent of live basal area with poor crowns, Maryland, 2008.

Table 4.—Percent of live basal area with poor crowns, Maryland, 2008

Species	Percent of Basal Area with Poor Crowns
Red maple	11
Loblolly pine	1
Yellow-poplar	<1
White oak	<1
Sweetgum	<1
Chestnut oak	<1
Northern red oak	<1
Black cherry	<1
Black oak	<1
Scarlet oak	<1



Projection: Maryland State Plane, NAD83. Sources: NLCD 2006, FIA 2008. 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. Feb. 2011.

Figure 68.—Percent of red maple live basal area with poor crowns, Maryland, 2008.

What this means

Red maple is the most numerous tree species in Maryland and contains the second highest volume of wood. It is an important species due to its value as a timber and pulp species and its attractive fall foliage. Red maple mortality has remained stable since the 1999 inventory (Fig. 47). The occurrence of poor crowns is unlikely to be related to a forest health problem. Many insects and diseases occur on red maple but none of them typically have major impacts. Maryland's Eastern Shore had the highest proportion of red maple with poor crowns, an area of the state that also has the highest concentration of fresh and brackish wetlands. Poor red maple crowns in this area might be due in part to stress from saturated soils or the tree's sensitivity to salt.

Ozone Bioindicator Plants

Background

Ozone (O_3) is a byproduct of industrial operations 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 of ozone exposure. Ozone stress in a forest environment can be detected and monitored by using these plants as indicators. FIA uses a set of these 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). Ozone plots were monitored in Maryland between 1994 and 2007.

What we found

Ozone indicator plants sampled are listed in Table 5; the most common plants sampled are blackberry (*Rubus* spp.), sweetgum, and spreading dogbane (*Apocynum androsaemifolium*) (Table 5). Blackberry

Table 5.—Plants species sampled for ozone injury by severity and amount of injury, Maryland, 1994-2007

Species	Number of plants sampled	Injury severity (percent)	Injury amount (percent)
Blackberry	2,420	19.0	24.2
Big leaf aster	30	9.1	30.0
White ash	471	6.1	15.8
Black cherry	851	5.7	5.1
Spreading dogbane	1,188	4.9	6.8
Sweetgum	1,391	4.8	5.1
Milkweed	937	4.2	13.0
Yellow-poplar	691	0.7	2.2
Pin cherry	23	0.0	0.0
Sassafras	1,078	0.0	0.0
Unknown	90	0.0	0.0

had the greatest severity of injury while big leaf aster (*Eurybia macrophylla*) had the greatest amount of injury. Maryland data indicate that risk of foliar injury due to ozone has been moderately variable, but on a downward trend since the mid 1990s (Table 6 and Fig. 69) as have ozone exposure levels (Fig. 70).

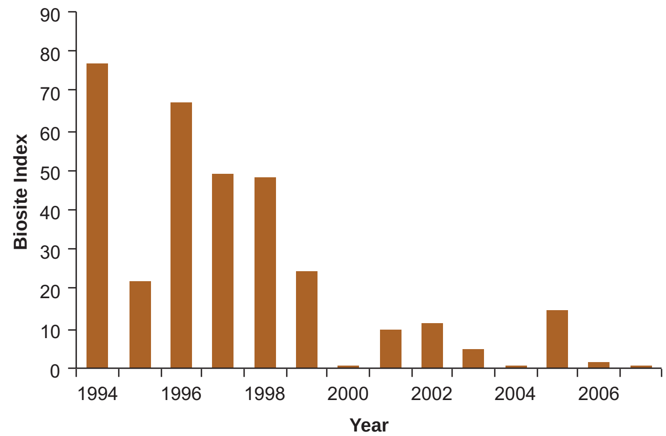


Figure 69.—Biosite index, Maryland, 1994-2007. See corresponding text for description of biosite index.

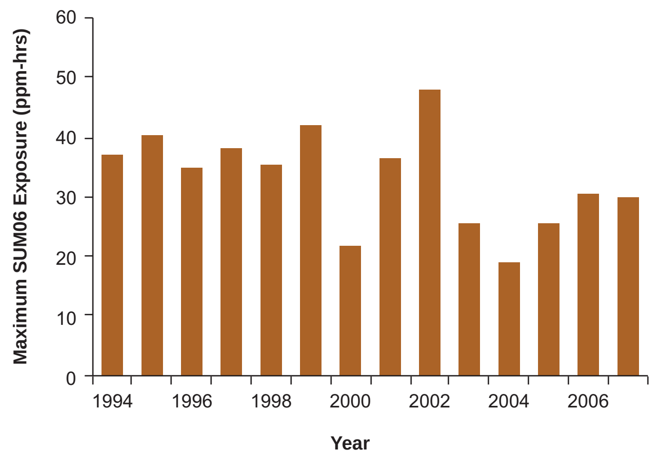


Figure 70.—Maximum SUM06 exposure levels (ppm-hrs), Maryland, 1994-2007. See text for description of SUM06.

Table 6.—Regional summary statistics for ozone bioindicator program, Maryland, 1994-2007

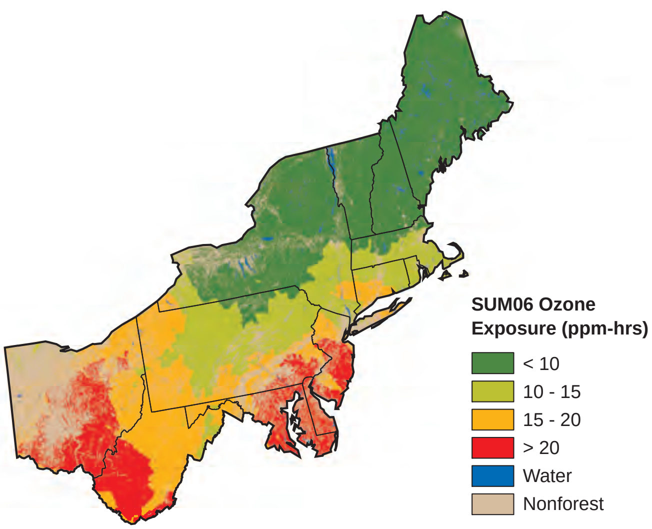
Sample year	Number of biosites evaluated	Number of biosites with injury	Average biosite index	Number of plants evaluated	Number of plants injured	Maximum SUM06 value[a] (ppm-hrs)
1994	9	9	76.5	392	202	37.1
1995	9	9	21.6	316	79	40.4
1996	5	5	66.8	248	76	34.9
1997	5	4	48.8	240	57	38.1
1998	12	21	48.1	414	86	35.1
1999	10	3	24.8	338	29	42.2
2000	7	2	.4	261	27	21.8
2001	27	16	9.5	1,820	143	36.3
2002	8	3	11.0	1,109	49	48.1
2003	9	2	4.9	762	31	25.6
2004	9	3	1.0	833	35	19.1
2005	9	9	14.7	671	94	25.7
2006	9	5	1.2	844	18	30.6
2007	8	4	.2	922	16	30.2

[a] Averaged from state values

What this means

Ozone exposure rates have been decreasing slightly with corresponding decreases in foliar injury. This is in contrast to evidence of medium and high risk reported by others in portions of the mid-Atlantic region (e.g., Coulston et al. 2003).

A typical summer O_3 exposure pattern for the northeastern United States is shown in Figure 71. 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 Fig. 71 as 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.



Projection: Albers, NAD83. Sources: NLCD 1992, EPA 2006. 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. April 2011.

Figure 71.—Typical June through August 12-hour SUM06 ozone exposure rates in northeastern U.S., 2000-2006.

Forest Soils

Background

FIA collects data to evaluate soil physical and chemical properties on P3 plots. Soils are an important component of the forest ecosystem. They supply water, oxygen, heat, and physical support to vegetation. Soils also play a role in cycling carbon through the forest. Carbon stocks in soils are important long-term stores of carbon accumulated in woody biomass and foliage. Accumulating and decaying leaf litter stores carbon on the forest floor. Measurements of current carbon stocks throughout the forest help managers understand the importance of different forest types and landscapes in the carbon cycle.

The soils that sustain forests are influenced by a number of factors, including climate; the trees, shrubs, herbs, and animals living there; landscape position; elevation; and the passage of time. Climate-soil interactions are one significant way that humans influence the character and quality of the soil and indirectly affect the forest. For example, industrial emissions of sulfur and nitrogen oxides lead to "acid rain." The deposition of acids strips the soil of important nutrients, notably calcium and magnesium. The loss of calcium and magnesium results in a shifting balance of soil elements toward aluminum, which is toxic to plants in high concentrations. We can use the ratio of aluminum to calcium and magnesium as measures of the impact of acid deposition on forest soils; larger ratios suggest a shift towards more aluminum.

What we found

Carbon stocks in the forest soil were modeled using data from throughout the mid-Atlantic region (Delaware, Pennsylvania, Maryland, New Jersey, Virginia, and West Virginia). Forest floor carbon in this region is well modeled by three factors: ecological section (a broad landscape of similar geology and vegetation), latitude, and longitude. Due to the dominance of oak/hickory forests in the region, forest-type group is not a strong predictor of forest floor carbon. The largest amounts of forest floor carbon are near the Atlantic Ocean and forests in the western mountains store only moderate amounts. Forest floor carbon generally increases from northwest to southeast (Fig. 72). Similarly, carbon in the forest mineral soil is strongly correlated with ecological province and longitude (Fig. 73). The carbon stocks in mineral soil also have a strong gradient from west to east.

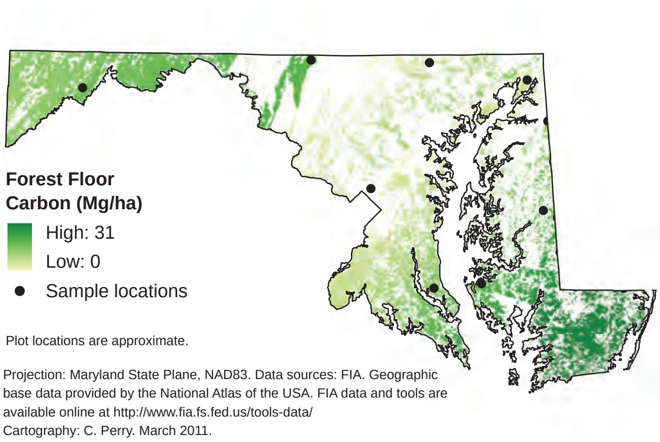


Figure 72.—Modeled forest floor carbon storage (Mg/ha), Maryland, 2004-2006.

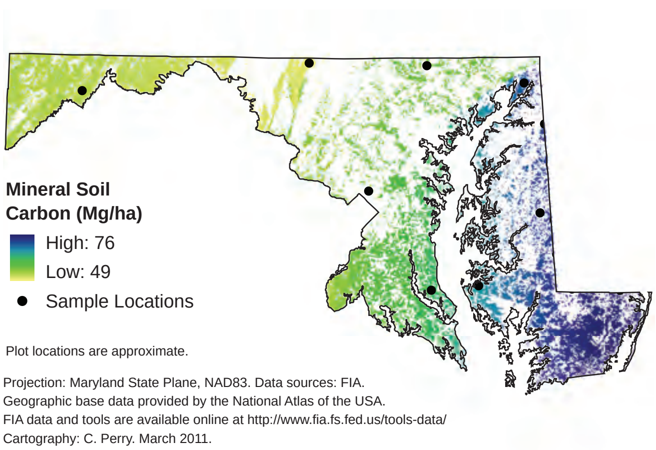


Figure 73.—Carbon storage in the shallow mineral soil (0-20 cm), Mg/ha, Maryland, 2004-2006.

Data collected from P3 plots affirms that elemental ratios in soil are useful predictors of tree vigor, but the effect of these elements varies across species. For instance, it has been shown that the crown-to-tree height ratio of white oaks increases with the aluminum-to-calcium ratio (Fig. 74), but decreases with the aluminum-to-magnesium ratio (Fig. 75). By contrast, the uncompacted live crown ratio of black cherry declines with increases in aluminum relative to these two elements (Figs. 74, 75). Data indicate that yellow-poplar and red maple do not appear to be affected by changes in these elemental ratios.

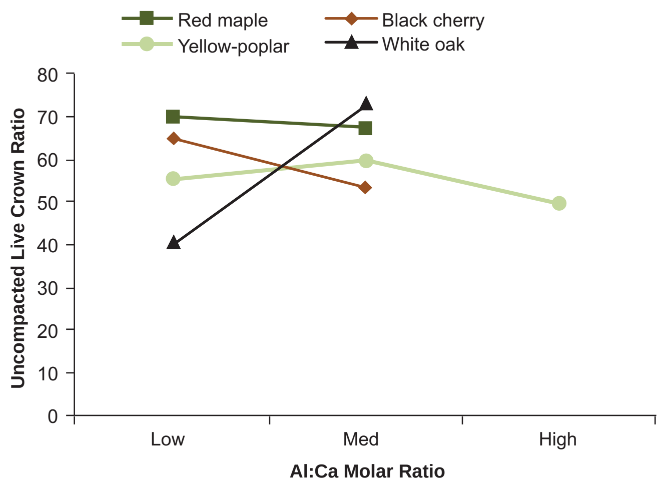


Figure 74.—The Al:Ca molar ratio compared to uncompacted crown ratio, Outer Coastal Plane Mixed Province.

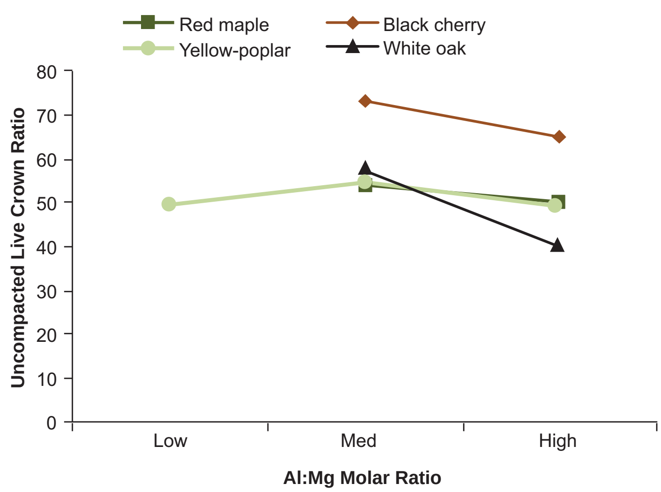


Figure 75.—The Al:Mg molar ratio compared to uncompacted crown ratio, Outer Coastal Plane Mixed Province.

What it means

Tree species occupy different niches in the landscape. This provides a competitive advantage for colonization, growth, and reproduction. Atmospheric deposition can change the soil substrate through additions and/or removals of nutrients and pollutants. These changes in the soil influence the ability of existing trees to thrive and reproduce in their current locations, and can alter the ability of other trees to colonize new landscapes. For example, our observations suggest that red maple and yellow-poplar have a competitive advantage in landscapes altered by acid deposition. It is important to document and understand natural and anthropogenic processes in the soil since they profoundly influence the current forest and success of future forest management plans. In turn, these changes in tree species composition across the landscape influence carbon sequestration rates by forests.

Understory Vegetation

Background

Forest understory vegetation enhances soil stability, provides nutrition and shelter for wildlife, regulates microclimate, and adds economic and aesthetic value to the forest. Assessments of the forest understory plant community provide information on forest structure, health, site quality, and other site characteristics. Botanical data can reveal the locations of rare and endangered species, as well as of invasive and nonnative species. In 2007 and 2008, detailed understory floristic data were collected on nine P3 plots and invasive plant data were collected on 46 P2 invasive plots in Maryland. Both types of plots are used to assess the presence and cover of plant species on forest land. P3 plots consist of a complete assessment of the understory vegetation while on P2 invasive plots the vegetation evaluation is limited to the 43 target invasive plant species listed in Table 7. The species on the target list were selected based on stakeholder interest and regional occurrence data. To maintain regional consistency, the target list was not customized specifically for the State of Maryland and as a result, some species on the list including black locust (*Robinia pseudoacacia*), may be arguably native in some parts of the State and not in others.

Table 7.—Invasive plant species target list for P2 invasive plots, 2007 to present

Tree Species
Black locust *(Robinia pseudoacacia)*
Chinaberry *(Melia azedarach)*
Norway maple *(Acer platanoides)*
Princesstree *(Paulownia tomentosa)*
Punktree *(Melaleuca quinquenervia)*
Russian olive *(Elaeagnus angustifolia)*
Saltcedar *(Tamarix ramosissima)*
Siberian elm *(Ulmus pumila)*
Silktree *(Albizia julibrissin)*
Tallow tree *(Triadica sebifera)*
Tree of heaven *(Ailanthus altissima)*
Shrub Species
Amur honeysuckle *(Lonicera maackii)*
Autumn olive *(Elaeagnus umbellata)*
Common barberry *(Berberis vulgaris)*
Common buckthorn *(Rhamnus cathartica)*
European cranberrybush *(Viburnum opulus)*
European privet *(Ligustrum vulgare)*
Glossy buckthorn *(Frangula alnus)*
Japanese barberry *(Berberis thunbergii)*
Japanese meadowsweet *(Spiraea japonica)*
Morrow's honeysuckle *(Lonicera morrowii)*
Multiflora rose *(Rosa multiflora)*
Showy fly honeysuckle *(Lonicera x bella)*
Tatarian bush honeysuckle *(Lonicera tatarica)*
Vine Species
English ivy *(Hedera helix)*
Japanese honeysuckle *(Lonicera japonica)*
Oriental bittersweet *(Celastrus orbiculatus)*
Herbaceous Species
Black swallow-wort *(Cynanchum louiseae)*
Bohemian knotweed *(Polygonum x bohemicum)*
Bull thistle *(Cirsium vulgare)*
Canada thistle *(Cirsium arvense)*
Creeping jenny *(Lysimachia nummularia)*
Dames rocket *(Hesperis matronalis)*
European swallow-wort *(Cynanchum rossicum)*
Garlic mustard *(Alliaria petiolata)*
Giant knotweed *(Polygonum sachalinense)*
Japanese knotweed *(Polygonum cuspidatum)*
Leafy spurge *(Euphorbia esula)*
Purple loosestrife *(Lythrum salicaria)*
Spotted knapweed *(Centaurea biebersteinii)*
Grass Species
Common reed *(Phragmites australis)*
Nepalese browntop *(Microstegium vimineum)*
Reed canarygrass *(Phalaris arundinacea)*

What we found

P3 vegetation data were collected in 2007 through 2008 from nine plots, where 113 plant species were observed. Species were broadly categorized based on the classification system of the USDA Natural Resources Conservation Service PLANTS database (NRCS 2011). The greatest number of classified species were categorized as trees (33), followed by forb/herbs (23) (Table 8). Of these species, 87 were native to the United States and 11 were introduced (Table 9). The most commonly observed species was red maple, which occurred on 89 percent of the plots (Table 10), followed by blackgum (*Nyssa sylvatica*), virginia creeper (*Parthenocissus quinquefolia*), and white oak (*Quercus alba*), all of which were observed on 78 percent of the plots. Of the 16 most commonly observed species, 15 were of woody growth form, and none belonged to the list of 43 target invasive plant species. Garlic mustard (*Alliaria petiolata*) and Japanese barberry (*Berberis thunbergii*) were the most common nonnative plant species, each occurring on 33 percent of the P3 plots (Table 11).

Table 8.—Number of species on Maryland P3 plots by growth habit (NRCS 2011), 2007-2008

Growth Habit	Number of Species or Undifferentiated Genuses
Forb/herb	23
Graminoid	6
Shrub	8
Shrub, subshrub, vine	4
Subshrub, shrub	3
Subshrub, shrub, forb/herb	1
Tree	33
Tree, shrub	13
Tree, shrub, subshrub	1
Vine	5
Vine, forb/herb	1
Vine, shrub	1
Unclassified	14
Total	113

Table 9.—Number of species on Maryland P3 plots by domestic or foreign origin (NRCS 2011), 2007-2008

Origin	Number of Species	Percent
Introduced to the U.S.	11	9.7
Native and introduced to the U.S.	1	0.9
Native to the U.S.	87	77
Unclassified	14	12.4

On the 46 P2 Invasive plots, 20 of the 43 target invasive species were detected. Multiflora rose (*Rosa multiflora*) and Japanese honeysuckle (*Lonicera japonica*) were the most commonly recorded species, found on 35 and 33 percent of the 46 plots, respectively (Table 12).

Data suggest that many invasive plant species are distributed fairly homogeneously across Maryland. For example, the occurrence of multiflora rose and Japanese

Table 10.—Top 16 identifiable plant species or undifferentiated genera found on Maryland P3 plots, the percent of the plots where the species occurred (in brackets), and the mean number of all tree seedlings and sapling species per acre on the plots, 2007-2008

Species	Tree Seedlings per acre	Tree Saplings per acre
Red maple (*Acer rubrum* [89])	990	764
Blackgum (*Nyssa sylvatica* [78])	910	632
Virginia creeper (*Parthenocissus quinquefolia* [78])	864	723
White oak (*Quercus alba* [78])	1,110	809
Roundleaf greenbrier (*Smilax rotundifolia* [67])	800	662
American holly (*Ilex opaca* [56])	1,464	1,013
Eastern poison ivy (*Toxicodendron radicans* [56])	225	255
Sweetgum (*Liquidambar styraciflua* [56])	1,464	1,013
White ash (*Fraxinus americana* [56])	1,330	1,028
American beech (*Fagus grandifolia* [44])	1,662	1,172
Black cherry (*Prunus serotina* [44])	319	356
Eastern redcedar (*Juniperus virginiana* [44])	1,624	1,172
Partridgeberry (*Mitchella repens* [44])	1,331	806
Sassafras (*Sassafras albidum* [44])	650	723
Scarlet oak (*Quercus coccinea* [44])	712	356
Sedge (*Carex* spp. [44])	1,031	900

Table 11.—Nonnative plant species found on Maryland P3 plots, the percent of the plots where the species occurred (in brackets), and the mean number of all tree seedlings and sapling species per acre on the plots

Species	Tree Seedlings per acre	Tree Saplings per acre
Garlic mustard (*Alliaria petiolata* [33])	250	200
Japanese barberry (*Berberis thunbergii* [33])	200	350
Burningbush (*Euonymus alata* [22])	1,987	1,349
Multiflora rose (*Rosa multiflora* [22])	300	300
Tree of heaven (*Ailanthus altissima* [22])	300	300
Asian bittersweet (*Celastrus orbiculata* [11])	450	150
Golden clover (*Trifolium aureum* [11])	1,550	1,691
Japanese honeysuckle (*Lonicera japonica* [11])	225	225
Princesstree (*Paulownia tomentosa* [11])	450	150
Sweet cherry (*Prunus avium* [11])	450	150
Tall oatgrass (*Arrhenatherum elatius* [11])	0	450

Table 12.—Invasive species found on Maryland P2 invasive plots, the percent of the plots where the species occurred (in brackets), and the mean number of all tree seedlings and sapling species per acre on the plots, 2007-2008. Twenty of the 43 invasive species FIA monitors were recorded

Species	Tree Seedlings per acre	Tree Saplings per acre
Multiflora rose (*Rosa multiflora* [35])	1,423	421
Japanese honeysuckle (*Lonicera japonica* [33])	1,399	473
Garlic mustard (*Alliaria petiolata* [26])	605	281
Japanese barberry (*Berberis thunbergii* [21])	290	353
Black locust (*Robinia pseudoacacia* [19])	492	290
Nepalese browntop (*Microstegium vimineum* [19])	1,052	285
Tree of heaven (*Ailanthus altissima* [9])	768	431
Autumn olive (*Elaeagnus umbellata* [7])	2,474	299
Oriental bittersweet (*Celastrus orbiculatus* [7])	2,250	299
Morrow's honeysuckle (*Lonicera morrowii* [5])	256	384
Norway maple (*Acer platanoides* [5])	1,231	646
Amur honeysuckle (*Lonicera maackii* [2])	300	375
Canada thistle (*Cirsium arvense* [2])	300	375
Common buckthorn (*Rhamnus cathartica* [2])	0	0
Common reed (*Phragmites australis* [2])	0	0
Creeping jenny (*Lysimachia nummularia* [2])	1,574	0
English ivy (*Hedera helix* [2])	0	0
Princesstree (*Paulownia tomentosa* [2])	450	150
Siberian elm (*Ulmus pumila* [2])	5,337	130
Tatarian honeysuckle (*Lonicera tatarica* [2])	0	0

honeysuckle on P2 invasive plots is shown in Figures 76 and 77. Many invasive plant species have similar site preferences, such as open, disturbed areas that are exposed to seed sources from other nearby populations of plants. Figure 78 shows that an invaded plot often has more than one invasive species present.

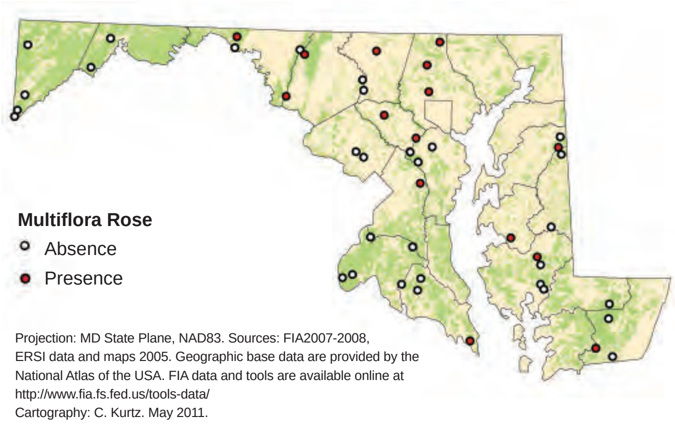


Figure 76.—Presence or absence of multiflora rose (*Rosa multiflora*) in Maryland observed on P2 invasive plots, 2007-2008.

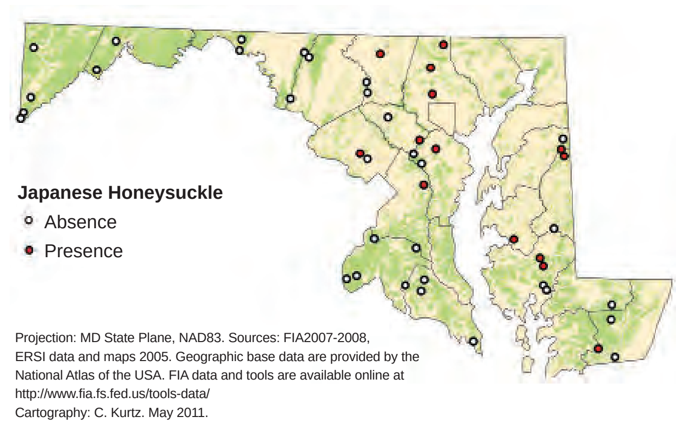


Figure 77.—Presence or absence of Japanese honeysuckle (*Lonicera japonica*) in Maryland observed on P2 invasive plots, 2007-2008.

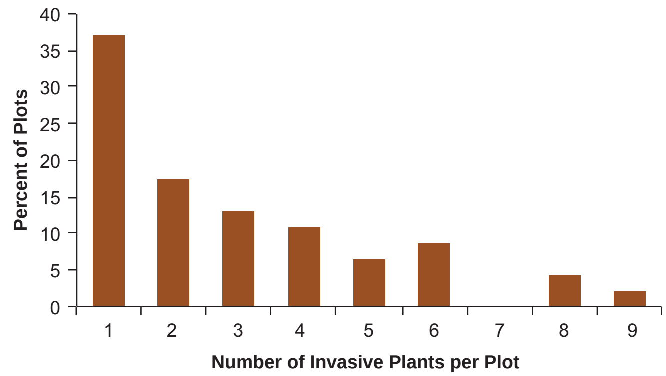


Figure 78.—Number of invasive plant species present on each plot for P2 invasive plots in Maryland, 2007-2008.

What this means

The majority of plants in Maryland are native and represent a diverse mix of species of various growth forms. Ten percent of the plants sampled were nonnative. Some of these nonnative species are listed as invasive plants that have the potential to negatively affect the native plant community. Invasive plants can physically displace native plants by outcompeting them for space and other resources, and, like the common buckthorn (*Rhamnus cathartica*), can change soil chemistry and thus alter the suitability of a site for native species.

In Maryland, forest managers are concerned about the prevalence of invasive species, including multiflora rose, as these shrubs form dense mats that can survive across a broad range of light levels ranging from full sun to shade. Once established in the forest, multiflora rose can outcompete native vegetation, creating a homogeneous, species-poor understory. Seedling and sapling density data suggest that areas with more cover of invasives generally have lower numbers of tree seedlings and saplings than areas with less invasive cover, but one must be cautious in drawing conclusions from this data due to the small sample size.

Emerald Ash Borer

Background

The emerald ash borer (*Agrilus planipennis*) (EAB) is a wood-boring beetle native to Asia. In North America, EAB has been identified as an invasive pest of ash species (Poland and McCullough 2006). Trees and branches as small as 1-inch diameter have been attacked, and while stressed trees may be preferred, healthy trees are also susceptible (Cappaert et al. 2005). In areas with a high density of EAB, tree mortality generally occurs 1 to 2 years after infestation for small trees and after 3 to 4 years for large trees (Poland and McCullough 2006). The spread of EAB has been facilitated by human transportation of infested ash material.

EAB was first introduced to Maryland's Prince George's County from Michigan via infested nursery stock in 2003 (Sargent et al. 2009). Infested trees were later found near the nursery, so nursery stock and all ash trees within one-half mile of the site were destroyed. EAB was not detected again in Maryland until 2006 (Sargent et al. 2009).

What we found

Ash is distributed across Maryland with major concentrations occurring in the central and western portions of the State (Fig. 79). An estimated 14.2 million ash trees (greater than 1-inch in diameter) are found on forest land, which amounts to 130.4 million cubic feet of volume. White ash is the most dominant ash species, making up 68 percent of the total. Present on nearly 81,000 acres, or 4 percent of forest land, ash is rarely the most abundant species. Ash generally represents less than 25 percent of total live-tree basal area (Fig. 80).

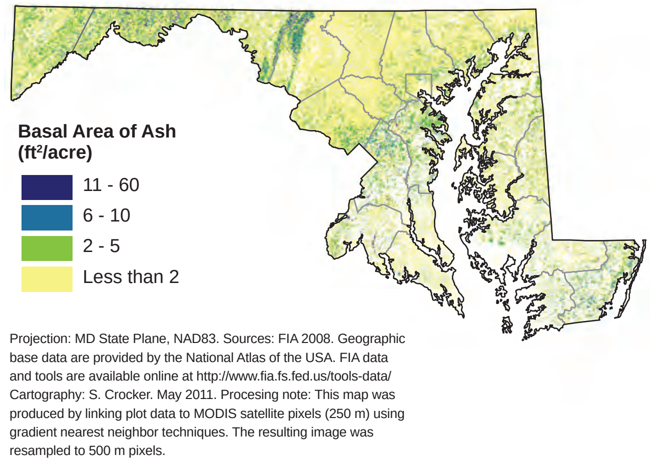


Figure 79.—Distribution of ash on forest land, Maryland, 2008.

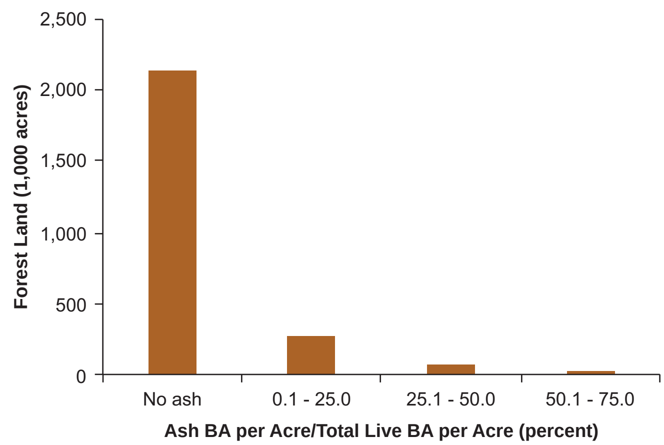


Figure 80.—Presence of ash on forest land as a percentage of stand basal area (BA) (expressed as ash BA per acre/total live BA per acre), Maryland, 2008.

What this means

Ash trees make up a small but important component of Maryland's forested landscape. Found in both upland and riparian sites and planted in urban settings, ash contributes to the structural and ecological diversity of the State. Since the introduction of EAB to North America, millions of ash trees across the eastern U.S. have been killed or removed. Ash mortality and the identification of new EAB infestations will have a large impact on the future makeup of Maryland's forests. Continued monitoring of ash resources will help to identify the long-term impacts of EAB within the State. Additionally, efforts to slow the spread of EAB will be enhanced by discontinuing the transportation of firewood.

Asian Longhorned Beetle

Background

The Asian longhorned beetle (*Anoplophora glabripennis*) (ALB) is an exotic wood-boring insect that attacks a variety of hardwood species found in Maryland. Larval activity girdles the trunk, resulting in tree mortality (USDA Forest Service 2008). ALB was first identified in New York City in 1996, has subsequently been found in Chicago, IL; two cities in northern New Jersey; and in the cities of Boston and Worcester, MA (APHIS 2010). Though not currently found in Maryland, the transportation of infested packing materials and wood products makes ALB a threat to statewide forest resources. ALB will attack a number of hardwood species. However, maple (most favored), birch, willow, and elm are the preferred hosts. Occasional hosts include poplar and ash (APHIS 2010).

What we found

Twenty-two percent of trees on Maryland's forest land, or 327.2 million trees, are susceptible to ALB (Fig. 81). Of this group, maples are the most dominant species (93 percent), followed by ash and elm. Susceptible host species account for 1.0 billion cubic feet of total live-tree volume on forest land. Present throughout the State, these species are most abundant in Garrett, Allegany, Dorchester Counties (Fig. 82).

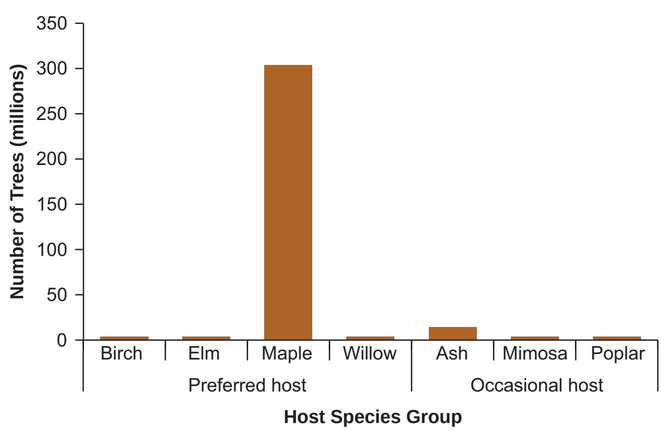
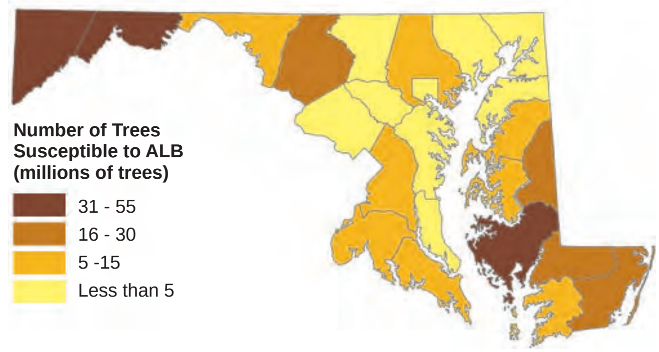


Figure 81.—Number of ALB-susceptible trees by host preference and species group, Maryland, 2008.



Projection: MD State Plane, NAD83. Sources: FIA 2008. 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: S. Crocker. May 2011.

Figure 82.—Distribution of ALB-susceptible trees by county, Maryland, 2008.

What this means

ALB has caused major economic losses in China, where it is a pest of urban trees and trees in windbreaks and plantations (Haack et al. 2010, MacLeod et al. 2002). Since its introduction to the United States, ALB has been a significant source of urban tree mortality. However, with a wide range of susceptible host species, this insect could also have a substantial impact on hardwood forests across Maryland.

Hemlock Woolly Adelgid

Background

White 'wool' on the branches of eastern hemlock (*Tsuga canadensis*) is a telltale sign of a hemlock woolly adelgid (HWA) (*Adelges tsugae*) infestation. A tiny, sap-feeding insect from Asia, HWA was first reported in Virginia in 1951 (USDA Forest Service 2010). By 1986, the adelgid had spread north to Maryland. In many parts of eastern hemlock's range, tree decline and mortality generally occurs within 4 to 10 years of infestation (USDA Forest Service 2010). The rate of tree mortality increases if infested trees also experience drought, attack by secondary insects and diseases, or other environmental stresses.

What we found

Hemlock is found in the Piedmont and Appalachian regions of Maryland (Fig. 83). The highest density of hemlock occurs in western Maryland's Garrett County. There are an estimated 2.8 million hemlock trees (greater than 1-inch diameter) on forest land, which comprise 25.3 million cubic feet of live volume. Hemlock makes up 2 percent of total conifer growing-stock volume. However, with 807,000 cubic feet per year of average annual mortality, it accounts for 9 percent of conifer mortality. When mortality is divided by volume, the rate of hemlock mortality is 4.8 percent. In comparison to other conifers, hemlock has the second highest mortality rate in the State. Overall, hemlock mortality has been increasing since 1986 (Fig. 84).

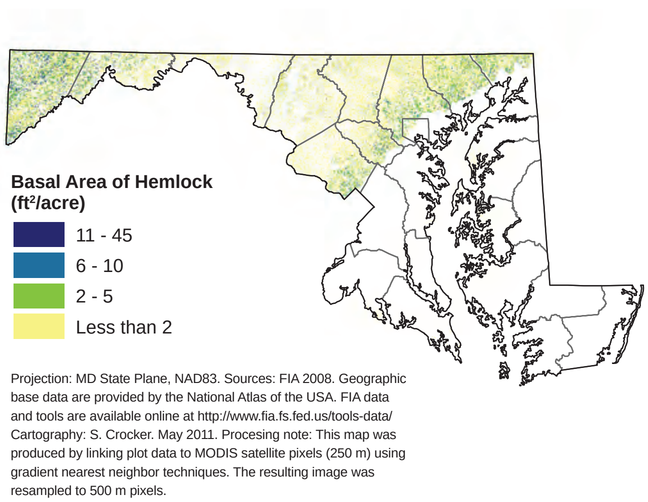


Figure 83.—Distribution of hemlock on forest land, Maryland, 2008.

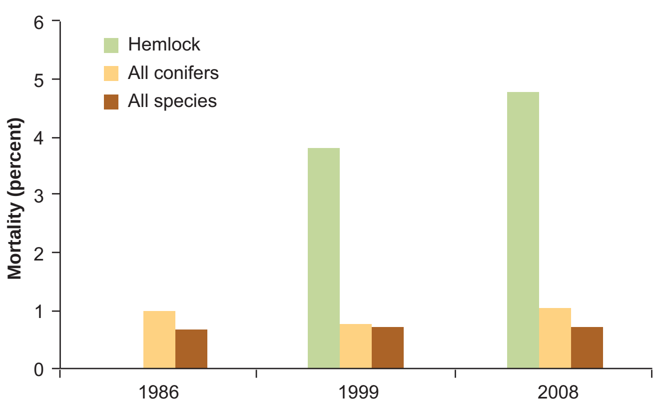


Figure 84.—Average annual mortality of hemlock growing stock as a percent of the total volume of growing stock on timberland, by species and inventory year, Maryland, 2008.

What this means

Hemlock represents a unique and important part of Maryland's forest resource. The species is found in cool, moist ravines with well drained soils; on low ridges; and along lakeshores (Harlow et al. 1996); its disappearance could affect soil stability and quality. Hemlock occurs in both pure and mixed stands (Harlow et al. 1996) and its mortality can impact a variety of species. Continued monitoring of the hemlock resource will help to quantify the effects of HWA in Maryland.

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DVD Contents

Maryland’s Forests 2008 (PDF)

Maryland’s Forests: Statistics, Methods and Quality Assurance (PDF)

Maryland Inventory Database (CSV file folder)

Maryland Inventory Database (Access file)

Field guides that describe inventory procedures (PDF)

Database User Guides (PDF)

Lister, T.W.; Perdue, J.L.; Barnett, C.J.; Butler, B.J.; Crocker, S.J.; Domke, G.M.; Griffith, D.; Hatfield, M.A.; Kurtz, C.M.; Lister, A.J.; Morin, R.S.; Moser, W.K.; Nelson, M.D.; Perry, C.H.; Piva, R.J.; Riemann, R.; Widmann, R.; Woodall, C.W. 2011. **Maryland's Forests 2008.** Resour. Bull. NRS-58. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 60 p. [DVD included].

The first full annual inventory of Maryland's forests reports approximately 2.5 million acres of forest land, which covers 40 percent of the State's land area and with a total volume of more than 2,100 cubic feet per acre. Nineteen percent of the growing-stock volume is yellow-poplar, followed by red maple (13 percent) and loblolly pine (10 percent). All species of oaks combined account for 26 percent of the total growing-stock volume. Red maple is the most abundant species in terms of number of trees. There were about 5.9 billion cubic feet of growing-stock volume in 2008, and the average annual growth rate of volume has been about 2 percent. Additional information on forest attributes, land-use change, carbon, timber products, and forest health is presented in this report. A DVD included in the report provides information on sampling techniques, estimation procedures, tables of population estimates, raw data, a data summarization tool, and a glossary.

KEY WORDS: Forest resources, forest health, forest inventory, Maryland

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