Wisconsin's Forests 2009

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Abstract

The second full annual inventory of Wisconsin's forests reports more than 16.7 million acres of forest land with an average volume of more than 1,400 cubic feet per acre. Forest land is dominated by the oak/hickory forest-type group, which occupies slightly more than one quarter of the total forest land area; the maple/beech/birch forest-type group occupies an additional 23 percent. Forty-two percent of forest land consists of large diameter stands, 23 percent contains medium diameter stands, and 8 percent contains small diameter stands. The volume of growing stock on timberland has been rising since the 1980s and currently totals more than 21.1 billion cubic feet. The average annual net growth of growing stock on forest land from 2005 to 2009 is approximately 572 million cubic feet per year. This report includes additional information on forest attributes, land use change, carbon, timber products, forest health, and statistics and quality assurance of data collection.

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Foreword

Our forests are one of our most precious assets. Today, Wisconsin's forests cover 46 percent of our State, totaling more than 16.7 million acres. Since the mid-1960s the extent of forest land in Wisconsin has been expanding, while both the average age and volume of trees has been increasing.

We know our forests are expanding and diversifying because of the information collected by the Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service. The annual inventory of Wisconsin's forests is administered through the FIA Program in partnership with the Wisconsin Department of Natural Resources, Division of Forestry. The latest 5-year inventory of Wisconsin covers the period 2005-2009, with analysis having been completed in 2011 by the U.S. Forest Service.

FIA collects, analyzes, and reports information on the status and trends of America's forests: how much forest exists, where it exists, who owns it, and how it is changing, as well as how the trees and other forest vegetation are growing and how much has died or has been removed in recent years. Since 1968, Wisconsin has provided funding to intensify the inventory by doubling the number of permanent plots from which data are collected. The reason for intensifying the inventory is to provide more reliable data on areas smaller than on a statewide basis and stratified components of the data such as forest type, condition class, species volume, etc.

The information provided by FIA can be used in many ways, such as in evaluating wildlife habitat conditions, assessing the sustainability of forest management practices, and supporting planning and decisionmaking activities undertaken by public and private enterprises. FIA combines its information with related data on insects, diseases, and other types of forest damages and stressors to assess the health condition and potential future risks to forests. FIA also projects what the forests are likely to be in 10 to 50 years under various scenarios. This information is essential for evaluating whether current forest management practices are sustainable and will allow future generations to enjoy America's forests.

Wisconsin proudly supports the nation's largest forest products industry. We employ more people and produce more value from forest products than any other state. The forest industry often uses FIA information in making business decisions regarding the timber resource quantity, quality, and availability in their area. Information can be provided to industry on a county level basis or radius from a mill location. This information, whether for a traditional wood processing plant or a biomass facility, is invaluable in determining whether there will be an adequate supply of the desired species and size in the area to sustain both the current or proposed operation, and the forest itself.

In this report, we briefly describe and highlight the current status and trends observed within Wisconsin's forests. We hope this information will stimulate discussion about the State's forest resources and motivate additional research and analysis, as well as increase our shared commitment to protect and sustainably manage one of Wisconsin's most precious assets.

Paul DeLong
Chief State Forester

Contents

Highlights

On the Plus Side

- Wisconsin's forest land area has been steadily increasing since 1968 with significant gains in central and southwestern Wisconsin. Counties in northern Wisconsin continue to have the highest proportion of forest cover. Seventy-six percent of Wisconsin counties gained forest land area over the last 5 years.

- Ninety-eight percent of the area that was forest land in 2004 remained forest land in 2009. Only 1.5 percent of the area that was forested in 2004 diverted to nonforest land uses, but reversions to forest land that were equivalent to approximately 5 percent of the 2004 forest land area.

- Carbon stocks in Wisconsin's forests have increased substantially over the last several decades. The majority of forest carbon in the State is found in relatively young stands dominated by relatively long-lived species.

- Species that are more shade tolerant are increasing in number and volume. These include hard and soft maples, both red and white oaks, balsam fir, eastern white pine, and American basswood.

- Levels of tree mortality across Wisconsin continue to increase, but this increase may be slowing.

- When annual growth is viewed relative to the total growing-stock volume on timberland, all 10 major species by volume are adding positive growth in excess of 2 percent each year. These commercially important species (with the possible exception of aspen) should continue to provide wood products and other environmental services for society well into the future.

- In 2009, there were more than 260 million standing dead trees present on Wisconsin forest land with similar densities on public and private land.

Yellow birch. Photo by Steven Katovich, U.S. Forest Service.

- Crown indicators show there are no major health problems related to crown conditions in Wisconsin.

- Coarse woody debris constitutes a small but important carbon stock across Wisconsin's forests. The quantity of down woody materials in Wisconsin's forests is consistent with nearby states.

- The level of soil acidification in Wisconsin is low, particularly compared to many eastern states.

- Growing-stock volume on Wisconsin's timberland has been increasing steadily over the past 50 years and the number and volume of several valuable commercial species such as aspen, hard maple, northern red oak, red pine, and eastern white pine, has increased substantially since 1983.

- The supply of sawtimber on Wisconsin timberland has increased steadily since the 1980s. The percentage of high quality sawtimber has also increased.

- Individual tree volume, which adds to its economic value, has been increasing in the last 5 years.

- Wisconsin is ranked as the number one paper-making state in the nation.

- Despite recent declines in the forest products industry, attributes that attracted forest industry sectors to the State a century ago still exist representing significant opportunities to regain and expand the forest industry.

- Rather than being shipped back after manufacturing, an increasing amount of our domestic wood is staying in China for the growing middle class population there and is increasing some of Wisconsin's market share and export opportunities abroad.

- Innovative technology and novel research in the forest products industry is expanding opportunities to offset fossil fuels use through increased biomass utilization.

- Wisconsin's wood resource is well positioned to meet growing demand for "green" projects that favor the use of independently verified environmental certification systems.

- This is a stable mill count of 280 active primary wood processing mills since the last inventory.

Areas of Concern

- While the extent of oak forests in Wisconsin appears to be slowly increasing, age class disparities continue, especially on medium to high quality sites. Older oak forests on sites of medium-to-high productivity are being lost and young oak forests are regenerating poorly.

- Tree species that depend on disturbance to regenerate are decreasing in number and/or volume. These include quaking aspen, bigtooth aspen, jack pine, and paper birch.

- Removals declined between 2004 and 2009, very likely the result of two primary factors: 1) the decline in the number of housing starts, which affects lumber demand, and 2) the accompanying economic downturn, which has negatively impacted all sectors of the economy, including the forest products industry—especially paper.

- The abundance of small diameter stand-size class continues to decline. Concurrently, the distribution of large-diameter stand-size class has increased dramatically.

- Emerald ash borer (EAB) and beech bark disease have become established in Wisconsin. EAB has the potential to kill millions of black, white and green ash trees throughout Wisconsin. The impact of EAB is expected to rival that of chestnut blight and Dutch elm disease.

- The frequency of two or more invasive species per plot is greater in the 2009 inventory than the 2004 inventory (21 and 13 percent, respectively). Reed canarygrass was one of 15 species which increased in occurrence between 2004 and 2009. Only two species (multiflora rose and black locust) declined in occurrence between 2004 and 2009. The sampling of invasive species is still relatively new, so this data does not define a solid trend.

- Jack pine showed significant declines in sawtimber volume.

- Aspen is a major species group used by the economically important paper industry in Wisconsin. The annual growth to removal ratios for quaking aspen (0.9) and bigtooth aspen (0.9) were less than 1.0, which is not sustainable in the long run. However, aspen is a pioneer, short-lived species that is expected to decline in volume over time due to natural succession.

- Downturns in our domestic economy have resulted in a significant loss of forest products companies and the jobs they supported; six of Wisconsin's pulp and composite panel mills closed since 2000.

Issues to Watch

- Growing-stock volume of economically important red and white oak species on medium-to-high quality sites remained the same or increased slightly in the last 5 years possibly as a result of increased knowledge about problems with oak forests in Wisconsin and better management techniques.

- It is important to remember that land-use change results in this report are aggregated at the State scale; there will be local variation where more forest land is being lost than gained.

- Family forest owners are diverse and timber production is not the primary ownership objective for most of them. Policies and programs should be designed to meet the owners' diverse situations and needs.

- Comparing the field and satellite urban forest inventory methods reveals that both are needed to provide community leaders the urban forest information to make management decisions.

- Maturing forests are reflected in decreasing forest density and increasing tree volume. If species that depend on disturbance to regenerate are to remain economically important, measures should be undertaken to encourage regeneration and prevent conversion to other forest types.

- Seedling regeneration may be compromised in closed canopy, late-successional forests. Managers need to ensure that regeneration of light-demanding species, such as quaking aspen, paper birch, and jack pine, is maintained.

- Aspen harvest levels are only marginally sustainable over the long term. Aspen harvest levels have been declining, however, and will probably continue to decline as a result of global competition in the paper and pulp industries and the economic downturn.

- Though economically important species groups have shown growth in total volume and average volume per acre, the rate of increase has not been equally apportioned across all species groups.

- Average annual removals of growing-stock volume on Wisconsin's timberland increased steadily from 1956 to 2004. Since 2004 removals have decreased. The decline in removals between the last two inventories was due primarily to the economic downturn and global competition.

- Average annual mortality of growing-stock volume on Wisconsin's timberland has been increasing since the mid-1960s. However, the rate of increase has diminished since 1996 indicating a decade of more stable forest mortality.

- Sawtimber volumes in some economically important species groups, such as select red oak and hard maple, have remained about the same since 1996 while most others have increased.

- Our forests are aging and species that are late successional, such as the maples, are replacing early successional species, such as quaking aspen and paper birch.

- Changing climate will cause stress to trees, making them more susceptible to opportunistic pests and diseases that may not have been a significant threat in the past.

- As we seek ways to reduce our dependence on traditional fossil fuels, woody biomass is likely to play an increasingly important role in this area.

- To remain competitive, the forest products industry in Wisconsin will need to continue exploring innovative ways of finding new opportunities for growth in niche and global wood products markets.

- Wood products manufacturers are heavily dependent on the health of housing markets and other construction industries that utilizes their products.

- More than 60 percent of the land area in the State's urban forests is available for tree planting. Exploiting this opportunity, as well as maintaining existing large-canopy trees, would significantly increase the environmental, social, and economic services these forests provide to the State and at the same time reduce the impending impact of emerald ash borer on the urban forest canopy.

Background

Yellow lady's slipper. Photo by Linda Haugen, U.S. Forest Service.

A Beginner's Guide to Forest Inventory

What is a tree?

We know a tree when we see one and we can agree on some common tree attributes. A tree is a perennial woody plant with a central stem and distinct crown. 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. In Wisconsin, the problem is in deciding which species should be classified as shrubs and which should be classified as trees. A complete list of the tree species measured in this inventory can be found in Appendix A of "Wisconsin's Forests 2009: Statistics, Methods, and Quality Assurance," on the DVD in the inside back cover pocket of this bulletin.

What is a forest?

We all know what a forest is, but where does the forest stop and the prairie begin? It's an important question. The gross area of forest land or rangeland often determines the allocation of funding for certain State and Federal programs. Forest managers want more land classified as forest land, and range managers want more land classified as prairie. Somewhere you have to draw the line.

FIA defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for nonforest use. The area with trees must be at least 1 acre in size, and roadside, streamside, and shelterbelt strips must be at least 120 feet wide to qualify as forest land.

The urban forest is another type of forest that FIA is trying to quantify. The urban forest meets the definition of forest land above but is found within the boundaries of cities, villages, and other dense developments.

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 Wisconsin, 98.4 percent of the forest land is timberland, 0.6 percent is reserved forest land, and 1.0 percent is other forest land.

- Timberland is unreserved forest land that meets the minimum productivity requirement of 20 cubic feet per acre per year at its peak.

- Reserved forest land is land withdrawn from timber utilization through legislation or administrative regulation. In Wisconsin, the National Park Service owns 40 percent of the reserved land; the State of Wisconsin and National Forests own 30 and 27 percent, respectively.

- Other forest land is commonly found on low-lying sites with poor soils where the forest is incapable of producing 20 cubic feet per acre per year at its peak.

Before 2000 only trees on timberland plots were measured in Wisconsin. Therefore, while we can report volume on timberland for those inventories, we can't report volume on forest land. Under the new annual inventory system, trees were measured on all forest land so forest volume estimates can be produced. Because these annual plots have been remeasured upon completion of the second annual inventory in 2009, we are now able to report growth, removals, and mortality on all forest land, not just on timberland.

Where are Wisconsin's forests, and how many trees are in Wisconsin?

Wisconsin's forests are generally located in the northern and western parts of the State (Fig. 1). There are approximately 2.5 billion trees on Wisconsin's forest land (give or take a few million) that are at least 5 inches in diameter as measured at 4.5 feet above the ground. We don't know the exact number because we

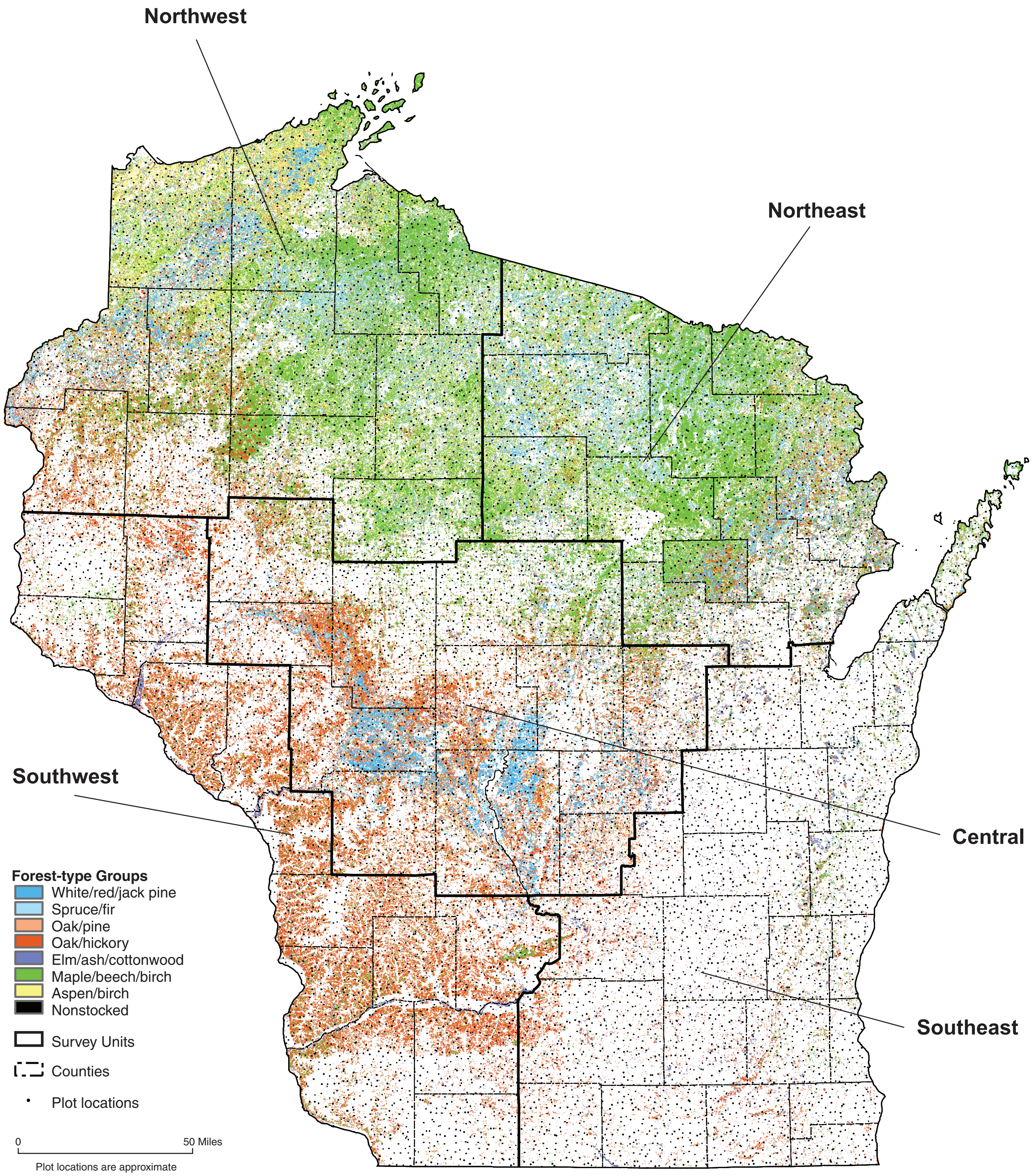


Figure 1.—FIA Survey Units and distribution of forest land by forest-type group, Wisconsin, 2009.

measured only about 1 out of every 16,600 trees. In all, 133,449 trees 5 inches and larger were sampled on 6,189 forested plots.[1]

How do we estimate a tree's volume?

FIA has typically expressed volumes in cubic feet. But, in Wisconsin, wood is more commonly measured in cords (a stack of logs 8 feet long 4 feet wide and 4 feet high). A cord has approximately 79 cubic feet of solid wood and 49 cubic feet of bark and air.

Volume can be precisely determined by immersing a tree in a pool of water and measuring the amount of water displaced. Less precise, but much cheaper, was the method used by the North Central Research Station (which later merged with the Northeastern Research Station to become the Northern Research Station). Several hundred cut trees were measured by taking detailed diameter measurements along their lengths to accurately determine their volumes (Hahn 1984). Regression lines were then fit to these data by species group. Using these regression equations, we can produce individual tree-volume estimates based on species, diameter, and tree site index.

The same method was used to determine sawtimber volumes. FIA reports sawtimber volumes in ¼-inch International board foot scale. Conversion factors for converting to Scribner board foot scale are also available (Smith 1991).

How much does a tree weigh?

The U.S. Forest Service's Forest Products Laboratory and others developed specific gravity estimates for a number of tree species (Miles and Smith 2009). These specific gravities were then applied to tree volume estimates to derive estimates of merchantable tree biomass (the weight of the bole). To estimate live biomass, we have to add in the stump (Raile 1982) and limbs and bark (Heath et al. 2009). We do not currently report the live biomass estimates of roots or foliage.

Forest inventories report biomass as green or oven-dry weight. Green weight is the weight of a freshly cut tree; oven-dry weight is the weight of a tree with zero percent moisture content. On average, 1 ton of oven-dry biomass is roughly equal to 2 tons of green biomass.

How do we estimate all the forest carbon pools?

FIA does not measure the carbon in standing trees or carbon in belowground pools. FIA assumes that half the biomass in standing live/dead trees consists of carbon. The remaining 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?

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. This is certainly valid when comparing the 2004 inventory to the 2009 inventory. But comparisons with inventories conducted before 2000 are problematic because procedures for assigning stand characteristics, such as forest type and stand size, have changed as a result of FIA's ongoing efforts to improve the efficiency and reliability of the inventory. Several changes in procedures and definitions have occurred since the 1996 Wisconsin inventory. Although these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass, they may have significant impacts on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare the 2009 and 2004 annual inventory tables with periodic inventories published for 1936, 1956, 1968, 1983, and 1996.

The 1996 inventory also used modeled plots, i.e., plots measured in 1983 and projected forward using

[1]During the 2009 inventory of Wisconsin (from 2005 to 2009), we measured one 1/6-acre plot for approximately every 3,084 acres of forest land. See "Wisconsin's Forests 2009: Statistics, Methods, and Quality Assurance" on the DVD in the back of this book.

the STEMS (Belcher et al. 1982) growth model. This was done to save money by reducing the number of undisturbed plots that were sent to the field for remeasurement. Disturbance was determined by comparing aerial photographs of the plots and looking for reductions in canopy cover. The idea was that parameters for the STEMS growth model could be fine tuned using the measured, undisturbed plots and then applied to the remaining unmeasured, undisturbed plots. Unfortunately, the use of modeled plots introduced errors, so the current inventory includes full remeasurements. Thus, only field measured plots are used for comparisons with the 1996 inventory in this publication.

A word of caution on suitability and availability…

FIA does not attempt to identify which lands are suitable or available for timber harvesting, particularly because such suitability and availability are subject to changing laws, economic/market constraints, physical conditions, adjacency to human populations, and ownership objectives. The classification of land as timberland does not necessarily mean it is suitable or available for timber production.

Thus, forest inventory data alone are inadequate for determining the area of forest land available for timber production. Additional factors, such as social trends, need to be considered when estimating the timber base.

FIA endeavors to be precise in definitions and implementation. The program tries to minimize changes to these definitions and to collection procedures, but that is not always possible or desirable in a world of changing values and objectives. While change is inevitable, we hope that through clarity and transparency forest inventory data will be of use to analysts for decades to come.

Forest Features

Black spruce. Photo by Steven Katovich, U.S. Forest Service.

Forest Area

Background

For many decades, Wisconsin has had a mix of agricultural and forest land uses. Trends in forest area are often a predictor of future forest resource trends. Fluctuations in forest area may indicate changing land use or forest health conditions. Monitoring these changes provides essential information for management and decisionmaking.

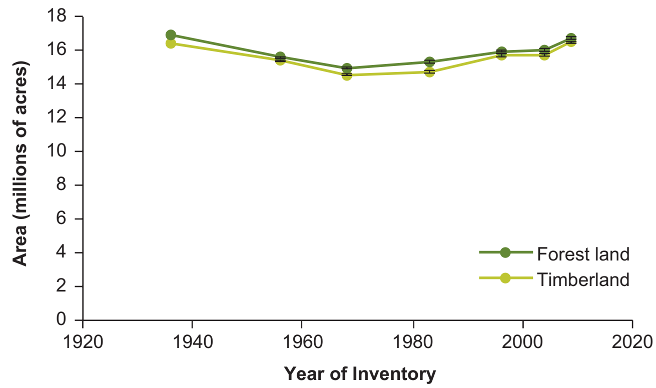


Figure 2.—Area of forest land and timberland, Wisconsin, 1936-2009. Error bars (too small to be seen in this figure) show the 68 percent confidence interval.

What We Found

Forest land area in Wisconsin has increased to 16.7 million acres in 2009 (Fig. 2) up from 16.0 million acres in 2004. This continues an upward trend that began in the 1960s. Approximately 16.5 million acres (98.5 percent) are classified as timberland. Northern Wisconsin counties continue to have the highest proportion of forest cover (Fig. 3). Florence, Iron, Menominee, and Vilas Counties have the greatest forest cover, each exceeding 90 percent forest land. Counties in central and southwestern Wisconsin have generally experienced larger increases in percentage of forest land since the 1960s. However, in the last 5 years the largest gains and losses in forest cover have been primarily in southeastern Wisconsin (Figs. 3 and 4). Of the 39 counties where gains in forest cover exceeded 5 percent since 2004, Dodge and Milwaukee Counties had the greatest gains with 66 and 56 percent, respectively; only three counties lost more than 5 percent forest land: Ozaukee (26 percent), Racine (13 percent), and Ashland (13 percent) (Fig. 4).

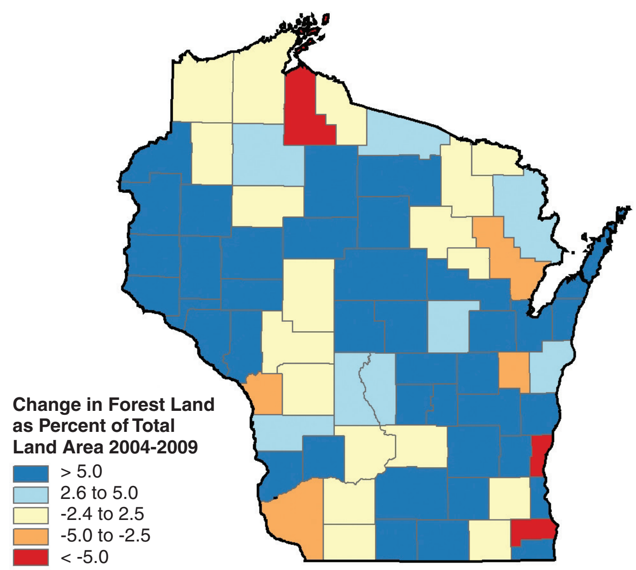


Figure 4.—Change in forest land area as a percentage of total land area by county, Wisconsin, 2004-2009.

What this means

Statewide, Wisconsin's forest land area has been steadily increasing since the 1960s with significant gains in central and southwestern Wisconsin (Figs. 2 and 3). Statewide gains were the result of 39 counties that gained forest land (Fig. 4). The loss of forest land in the lesser populated northern third of Wisconsin especially the significant loss in Ashland County warrant closer study.

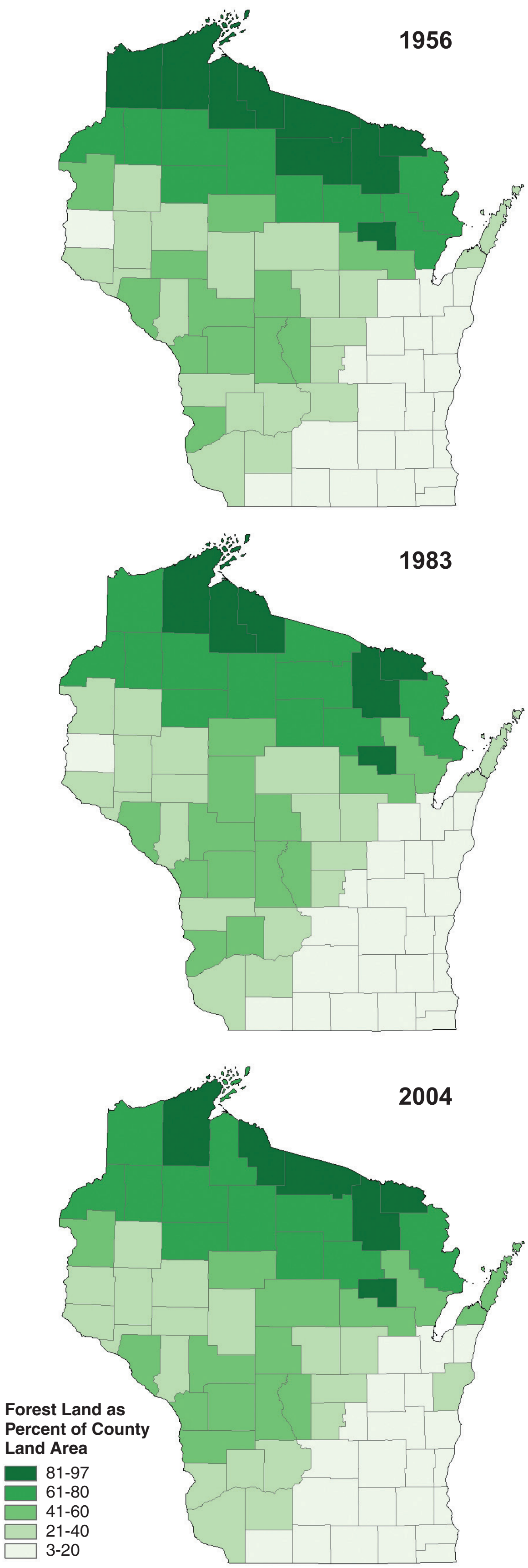


Figure 3.—County forest land area as a percentage of total land area, Wisconsin, 1956-2009.

Changes to Oak Forests

Background

Oak forests are important for their ecological and economic values. Many wildlife species depend on oaks for food and foraging opportunities. In addition, oaks are very important to Wisconsin's economy because of their high value lumber. Throughout the Midwest, oak forests have been decreasing in extent for several decades especially on medium and high-productivity sites (site index > 60). Historically, regeneration in these forests was facilitated by a periodic fire regime which reduced competition from native and non-native plants. The absence of periodic fire along with browsing by white-tailed deer (*Odocoileus virginianus*) has made oak regeneration difficult on nutrient-rich sites. Poor regeneration and selective harvesting have lead to the gradual succession of oak forests to ones dominated by red and sugar maple, basswood, elms, green and white ash, and ironwood.

What We Found

The oak/hickory forest-type group occupied about 3.9 million acres of Wisconsin in 2004 and increased to about 4.1 million acres by 2009. While the extent of this group expanded by 5 percent, a closer look at the data reveals troubling trends. There was an only slight increase in the oldest and youngest age classes of oak between 2004 and 2009. Uneven age-class distribution indicates a continued scarcity of older and younger oak forests, especially on medium and high productivity sites (Figs. 5 and 6). Growing-stock volume on medium to high quality sites increased or remained the same for commercially important select red and white oak species—those that are in most demand for lumber products including northern red, white, swamp white, and bur oaks (Fig. 7).

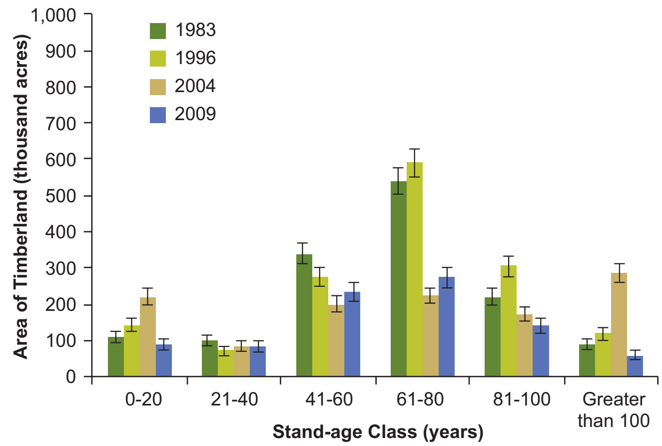


Figure 5.— Age-class distribution of the oak/hickory forest-type group on low quality sites (site index < 60) by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

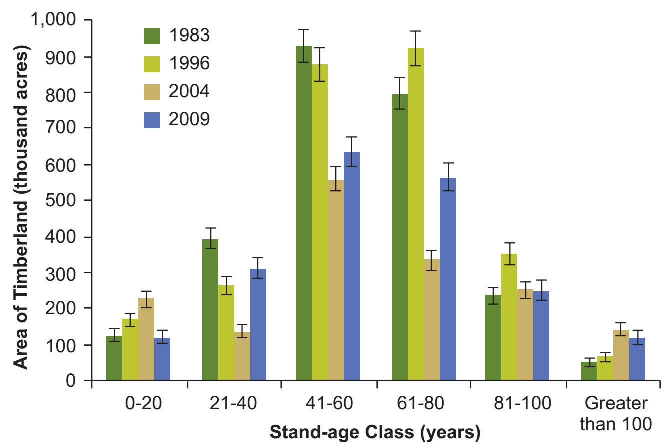


Figure 6.— Age-class distribution of the oak/hickory forest-type group on medium-high quality sites (site index ≥ 60) by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

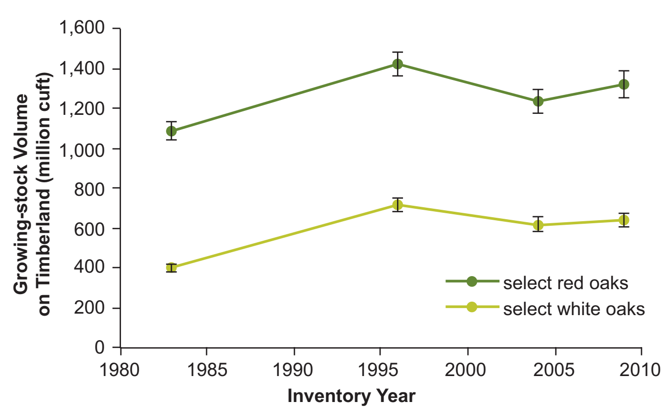


Figure 7.—Growing-stock volume of select red and white oaks on medium-high productivity sites (site index ≥ 60) by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

What This Means

While the extent of oak forests in Wisconsin appears to be slowly increasing, age-class disparities continue, especially on medium-high quality sites. Older oak forests on sites of medium to high productivity are being lost and oak forests are regenerating poorly. Oak regeneration may be declining, though the ratio of seedling density to growing-stock volume appears satisfactory. Growing-stock volume of economically important red and white oak species on medium to high quality sites remained the same or increased slightly in the last 5 years possibly as a result of increased knowledge about problems with oak forests in Wisconsin and better management techniques.

Land-use Change

Background

Information on land-use change is important for understanding the future direction of land use in Wisconsin. In presettlement times, there were approximately 22 million acres of forest land with an additional 9.6 million acres of savanna (Curtis 1959). Most of the change in forest land area occurred before the first forest inventory in the 1930s. In this report, we focus on the change in forest area between 2004 and 2009.

What we found

Approximately 46 percent of Wisconsin was forested in 2009. Ninety-eight percent of the area that was forest land in 2004 remained forest land in 2009 (Fig. 8). Two percent of Wisconsin's area converted to forest land from nonforest land. Lands that convert to forest land are typically referred to as reversion because we assume that in presettlement times the lands had been forested and were now reverting back to their original land use. Fifty-one percent of Wisconsin was classified as nonforest in 2009. One percent of the area of Wisconsin converted from forest land to nonforest land. Lands that convert from forest land to nonforest land are typically referred to as diversion.

Fifty-six percent of reversions come from two sources: agriculture (40 percent) and pasture (16 percent) (Fig. 9). The remaining reversions come from wetlands (18 percent), rights-of-way (6 percent), and urban (20 percent).

Nearly half of the losses of forest land were due to diversion to agriculture (Fig. 10). The other diversions were to pasture (8 percent), wetlands (20 percent), rights-of-way (4 percent), urban (20 percent), and other (4 percent).

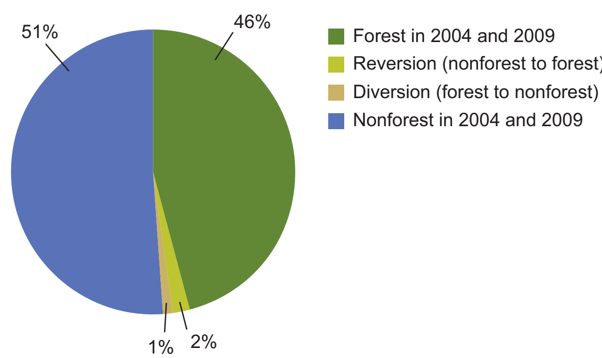


Figure 8.—Land-use change, Wisconsin, 2009.

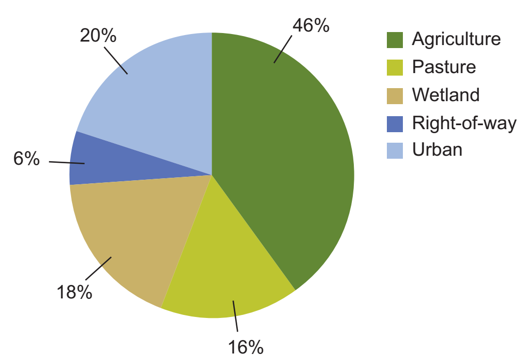


Figure 9.—Forest land reversions by previous land use, Wisconsin, 2009.

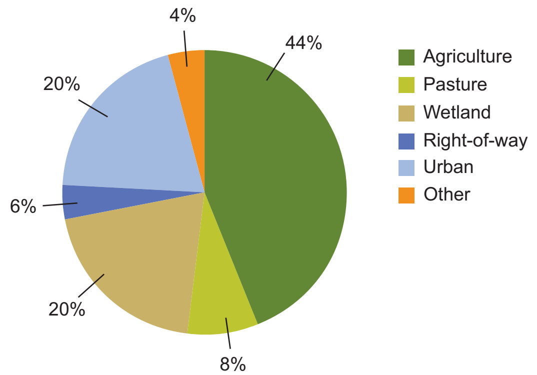


Figure 10.—Forest land use diversions by current land use, Wisconsin, 2009.

What this means

The forest land area of Wisconsin is, for the most part, fairly stable. Approximately 98.5 percent of the land that was forested in 2004 remained forested in 2009. Only 1.5 percent of the area that was forested in 2004 diverted to nonforest land uses, but this was more than offset by reversions to forest land that were equivalent to approximately 5 percent of the 2004 forest land area. The net effect was a 3.3-percent increase in the area of forest land between 2004 and 2009.

Low-lying areas appear to move between forest and nonforest classifications due to weather (drought/flooding) and other natural causes such as beaver dams. These conditions are often not permanent and therefore movement is likely to continue in the future.

Whose Woods Are These?

Background

It is the owners of the forest land who ultimately control its fate and decide if and how it will be managed. By understanding forest owners, the forest conservation community can better help the owners meet their needs, and in so doing, help protect the State's forests for future generations. FIA conducts the National Woodland Owner Survey (NWOS) to better understand who owns the forests, why they own it, how they have used it, and what they plan to do with it (Butler 2008).

What we found

Two-thirds of the forests of Wisconsin are privately owned and of these private acres, 82 percent are owned by families, individuals, and other unincorporated groups, collectively referred to as family forest owners (Fig. 11). Other private owners include forest industry and other companies, Native American tribes, nongovernmental organizations, and clubs and partnerships. The publicly owned forest lands are controlled by Federal, State, county, and municipal agencies that manage the lands for multiple reasons, including water protection, timber production, and recreation.

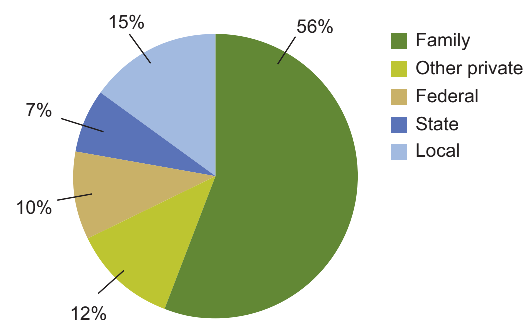


Figure 11.—Forest ownership, Wisconsin, 2006.

Approximately 352,000 family forest owners control 9.1 million forested acres across Wisconsin. Half of these family forest owners have between 1 and 9 acres of forest land, but two-thirds of the family forest land is in holdings of 50 acres or more (Fig. 12). The average holding size is 26 acres. The primary reasons for family forest owners to have land are related to aesthetics and for hunting and/or fishing (Fig. 13).

Although timber production is not a primary ownership objective of most family forest owners, 62 percent of the family forest land is owned by people who have commercially harvested trees. Twenty-nine percent of the family forest land is owned by people who have

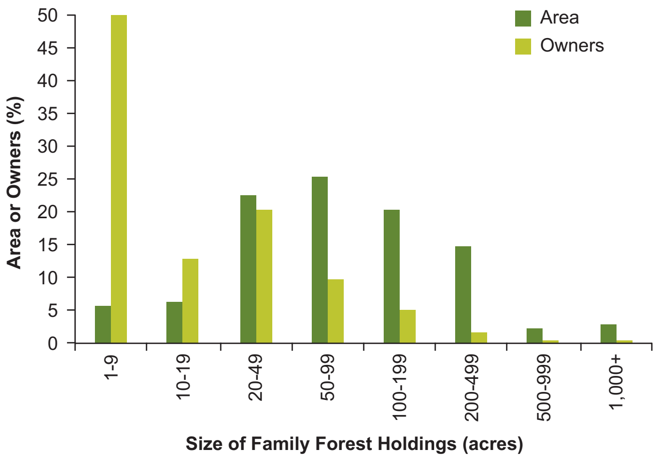


Figure 12.—Size of family forest holdings, Wisconsin, 2006.

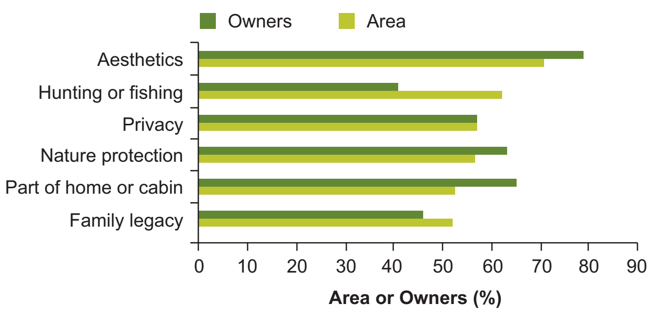


Figure 13.—Primary ownership objectives of family forest owners, Wisconsin, 2006.

a written management plan, and 44 percent of the family forest land is owned by people who have received management advice.

What this means

Private forest owners, and in particular family forest owners, are the dominant type of ownership in Wisconsin, as they are in much of the eastern United States. Although the individual decisions of the thousands of Wisconsin family forest owners will have only a marginal impact on the forest resources, their collective decisions will determine both the current and future state of Wisconsin's forests. Family forest owners are diverse and timber production is not the primary ownership objective for most of them. Policies and programs should be designed to meet the owners' diverse situations and needs.

Forest Biomass

Background

Just as measures of Wisconsin's forest acreage help us understand our resources more clearly, measures of total biomass and its allocation among stand components, such as small diameter trees, down woody debris, and live canopy crowns, helps us refine our understanding of the components in a forest stand and what is available for different uses. Forest biomass beyond a tree's merchantable trunk is playing an increasingly significant role as a biofuel component in efforts to gain U.S. energy independence.

What we found

It is estimated that total live-tree biomass for the forests of Wisconsin exceeds 609 million dry tons. Seventy-one percent of this material is on private property (Fig. 14). The distribution of live-tree biomass (dry tons) among counties is similar to that of forest land (Figs. 3 and 15). The northern 22 counties in Wisconsin contain 58 percent of the biomass while the more populated counties in southeast Wisconsin contain 8 percent.

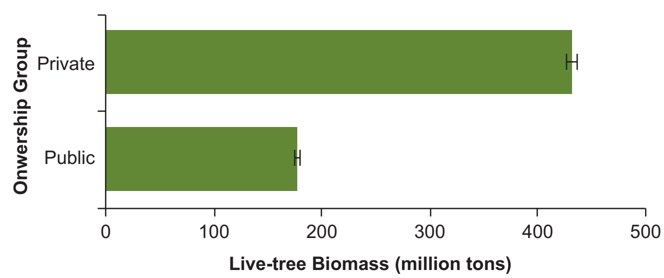


Figure 14.—Distribution of live-tree biomass on forest land by ownership, Wisconsin, 2009. Error bars show the 68 percent confidence interval.

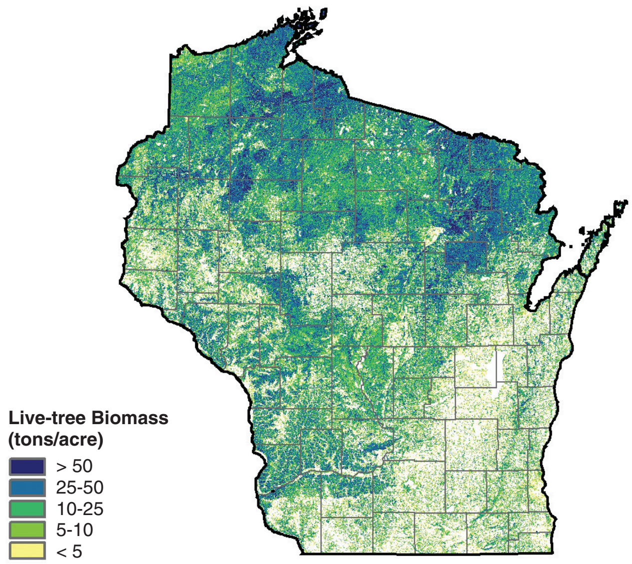


Figure 15.—Spatial distribution of live-tree biomass on forest land, Wisconsin, 2009.

Carbon Stocks

Background

Collectively, forest ecosystems represent the largest terrestrial carbon sink on earth. The accumulation of carbon in forests through sequestration helps to offset emissions of carbon dioxide to the atmosphere from sources such as forest fires and burning of fossil fuels. The FIA program does not directly measure forest carbon stocks in Wisconsin. Instead, a combination of empirically derived carbon estimates (e.g., standing live trees) and models (e.g., carbon in soil organic matter are based on stand age and forest type) are used to estimate Wisconsin's forest carbon. Estimation procedures are detailed by Smith et al. (2006).

What we found

Wisconsin forest currently contains more than 1.6 billion tons of carbon. Soil organic matter (SOM) represents the largest forest ecosystem carbon stock in the State at more than 1.04 billion tons, followed by live trees at more than 304 million tons (Fig. 16). Within the live-tree pool, merchantable boles contain the bulk of the carbon (~207 million tons) followed by roots (~62 million tons) and tops and limbs (~53 million tons). Most of Wisconsin's forest carbon stocks are found in relatively young stands, 41 to 80 years old (Fig. 17). Early in stand development most of the forest ecosystem carbon is in the SOM and belowground tree components. As forest stands mature, the ratio of above- to belowground carbon slowly shifts 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 five of the eight types have between 78 and 98 tons of carbon per acre (Fig. 18). Despite the similarity in per-acre estimates, the distribution of forest carbon stocks by forest type is quite variable. In the oak/hickory group, for example, 35 percent (~27 tons per acre) of the forest carbon is in live biomass, whereas in the spruce/fir group only 10 percent is in live biomass.

What this means

Total forest biomass in Wisconsin is increasing. Over the last 45 years, the management of forest areas across most of Wisconsin has supported the sizable growth of forest biomass.

As new technologies and innovative approaches to utilizing wood residues emerge, the use of woody biomass as an alternative to traditional energy sources is gaining momentum. Most forest biomass resides in the trunks of growing-stock trees on private land. Management of these forests is important because it strongly affects the dynamics of carbon storage and emission. When trees are cut, decomposing slash and exposed soil can emit carbon (a source). As new trees regenerate and grow after a cut, the forest transitions from a source of carbon to a place that stores it (a sink). In addition to the carbon found in growing-stock trees and forest soils, carbon also resides in standing and down dead trees, roots, and non-tree vegetation (live and dead).

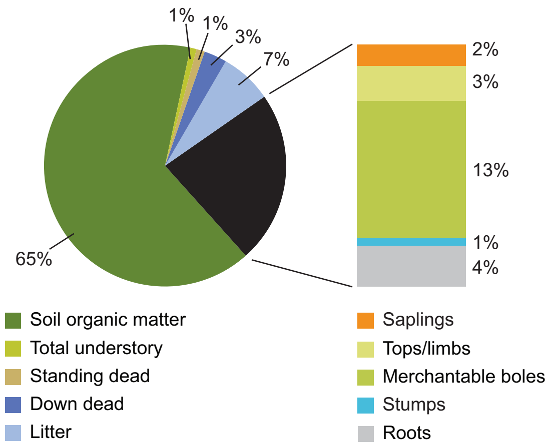


Figure 16.—Estimated total carbon stocks on forest land by forest ecosystem component, Wisconsin, 2009.

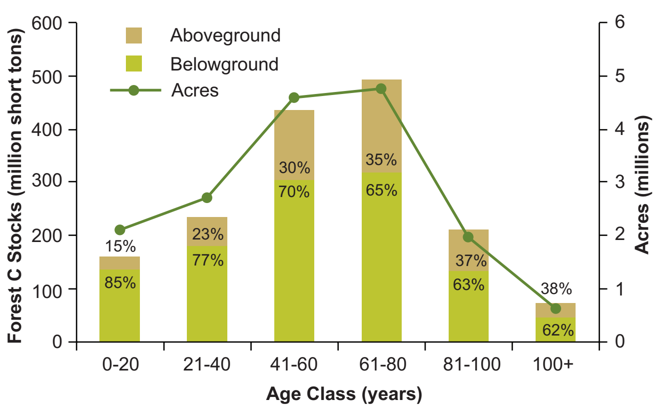


Figure 17.—Estimated above and belowground carbon stocks on forest land by stand-age class, Wisconsin, 2009.

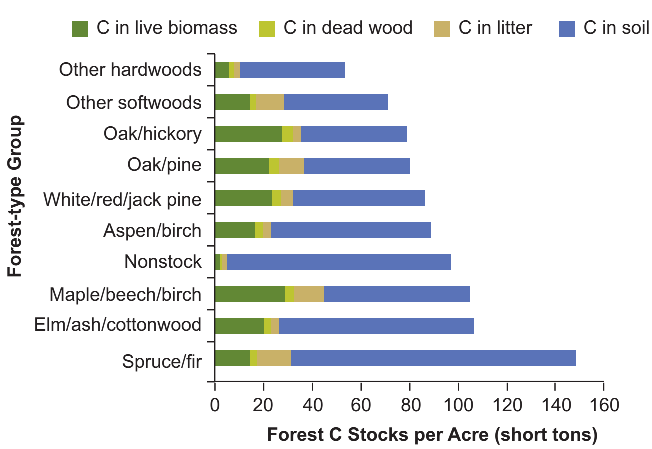


Figure 18.—Estimated carbon stocks on forest land by forest-type group and carbon pool per acre, Wisconsin, 2009. Note that the other softwoods group includes other exotic softwoods the other hardwoods group includes exotic hardwoods.

What this means

The majority of forest carbon in the State is found in relatively young stands dominated by relatively long-lived species. This suggests that Wisconsin's forest carbon will continue to increase as stands mature and accumulate carbon in above- and belowground components. Given the age-class structure and species composition of forests in Wisconsin there are many opportunities to increase forest carbon stocks. That said, managing for carbon in combination with other land management objectives will require careful planning and creative silviculture beyond simply managing to maximize growth and yield.

Tree Species Composition

Background

Forest composition is dynamic, changing over time both within stands of trees and across forested landscapes. Forest change often is slow but sometimes it can be abrupt and drastic. Important factors that influence forest composition include climate and soil; forest disturbances such as fires, storms, insects and diseases, and tree cutting; regenerative ability of nearby tree species; and forest-management decisions. The composition of trees within a forest can influence the composition of other plants and animals or be influenced by them.

What we found

Number of trees: The estimated number of growing-stock trees more than 5 inches d.b.h. has increased by 3 percent over the last 26 years. In 2009, red maple was the most abundant tree species in Wisconsin's forests with 12 percent of all stems (Fig. 19). Red maple growing-stock trees increased in number by 42 percent since 1983. Other abundant species that have increased significantly in number since 1983 include eastern white pine, red pine, and black ash (82, 33, and 31 percent, respectively).

Several common tree species have declined in the number of growing-stock trees since 1983. These include: paper birch, northern red oak, balsam fir, and quaking aspen (-52, -25, -21, and -18 percent, respectively).

Volume of trees: Between 1983 and 2009, the volume of growing-stock trees on timberland increased by 36 percent (Fig. 20). Of the more common species, several increased in volume by more than 10 percent over the last 5 years. These include: northern pin oak (30 percent), green ash (23 percent), eastern white pine (18 percent), tamarack (14 percent), and bur oak (13 percent). Common tree species showing declines in volume over the last 5 years include jack pine (-12 percent) and paper birch (-9 percent).

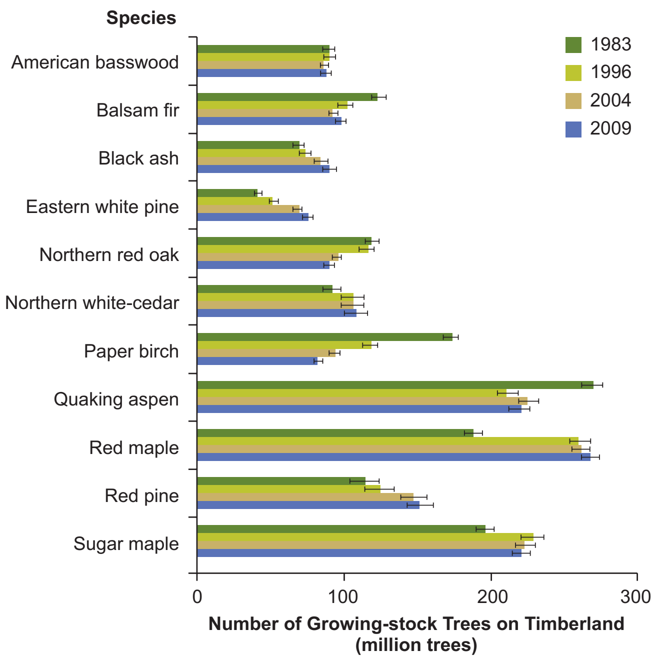


Figure 19.—Number of growing-stock trees on timberland for select species by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

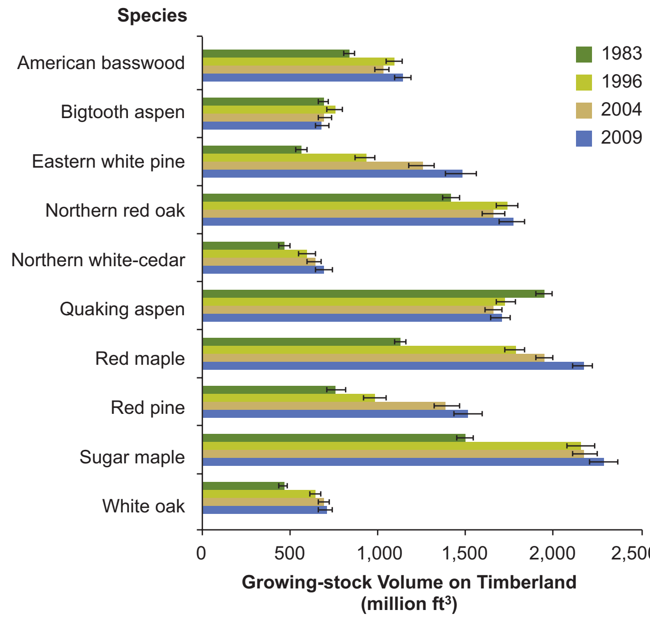


Figure 20.—Volume of growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

What this means

The dominance of certain tree species is constantly evolving but certain trends stand out from the data. For instance, succession to shade tolerant and longer lived species will take place in the absence of major disturbance such as fire, storms, or large-scale logging. In Wisconsin's forests, tree species that depend on disturbance to regenerate are decreasing in number and/or volume. These include quaking aspen, bigtooth aspen, jack pine and paper birch.

Species that are more shade tolerant—and typically follow the early successional species—are increasing in number and volume. These include hard and soft maples, red and white oaks, balsam fir, eastern white pine, and American basswood.

How Thick Are the Woods?

Background

The density of a forest indicates the current phase of stand development and has implications for diameter growth, tree mortality, and yield. Density is typically measured in terms of number of trees or basal area per unit area.

What we found

The density of Wisconsin's forests increased dramatically between 1983 and 2004 as tree numbers increased more quickly than acreage in forests (Fig. 21). More recently, forest density has stabilized as forests age, adding volume per tree instead of new trees. Average annual net growth of growing-stock trees on timberland was higher in 2004 and 2009 when compared with 1983, 32 and 16 percent respectively (Fig. 22). As forests mature, trees become larger and less numerous. Individual tree volume increased by 6 percent on average between 2004 and 2009 (Fig. 23). The number of large trees (over 23 inches d.b.h.) has increased by 115 percent since 1983 while the number of smaller growing-stock trees (5 to 9 inches) has decreased by 9 percent (Fig. 24).

Forest density is highest in the northeast and northwest parts of the State; it increased significantly between 1983 and 2004 and has leveled off since (Fig. 25). In contrast, the density of forests in the southeastern, most urbanized, region of the State has declined since 1996. At the same time, the volume per growing-stock tree is greater in the southern part of the State than in the north (Fig. 26).

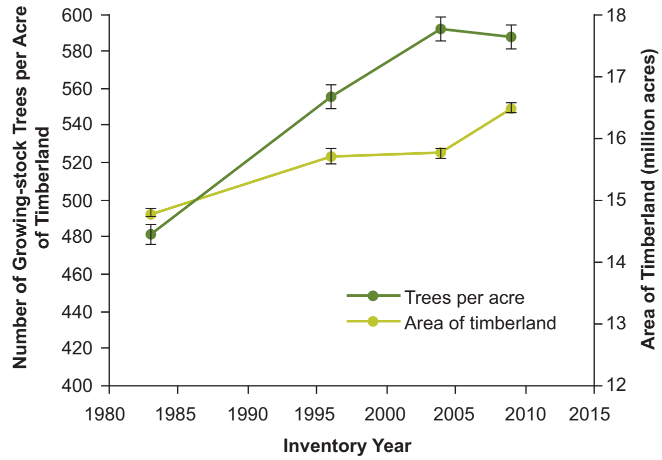


Figure 21.—Number of growing-stock trees on timberland and timberland area by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

Figure 22.—Average annual net growth of growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

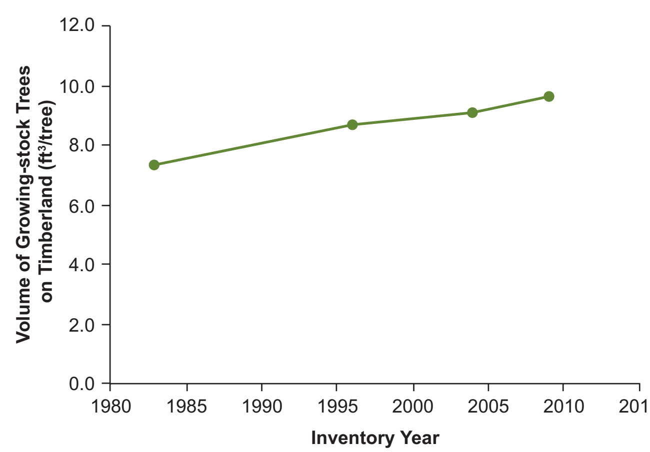


Figure 23.—Estimated mean per-tree volume of growing-stock trees on timberland by inventory year, Wisconsin.

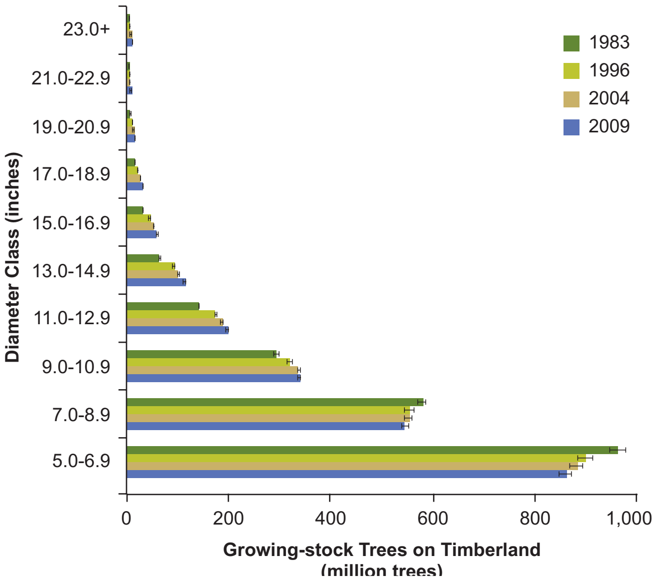


Figure 24.—Number of growing-stock trees on timberland by diameter class and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

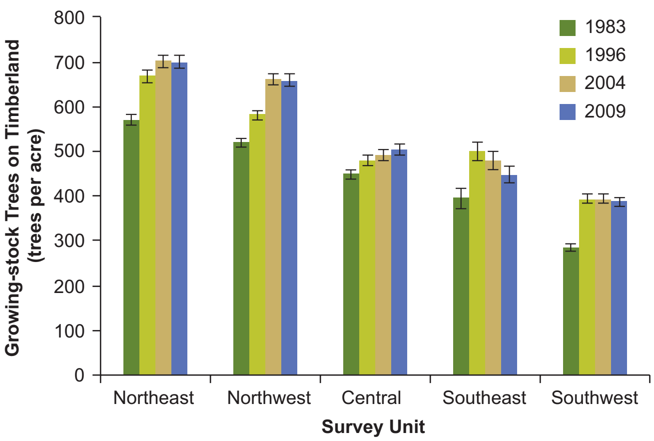


Figure 25.—Number of growing-stock trees on timberland by survey unit and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

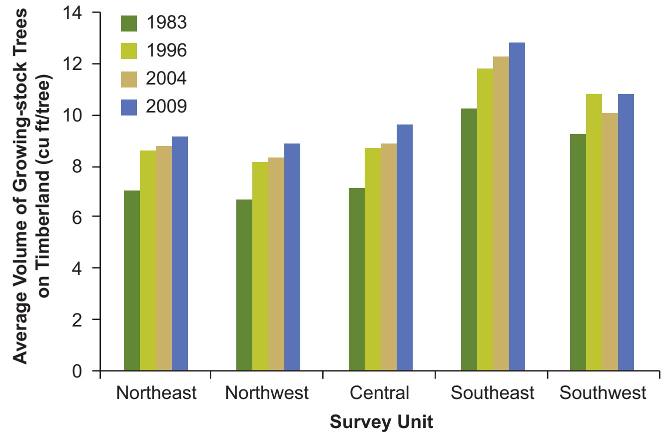


Figure 26.—Average per-tree volume of growing-stock trees on timberland by inventory year and survey unit, Wisconsin.

What this means

The maturing of our forests is reflected in decreasing forest density and increasing tree volume. This is a natural process of succession where many small immature trees are replaced by fewer and larger mature trees. As mature trees dominate, however, less light reaches the forest floor to promote the survival of seedlings and less shade tolerant trees. The future diversity of our forests will depend on maintaining adequate regeneration even as they age.

In the northern region of the State, the stabilization of forest density and the slight increase in individual tree volume in the last 5 years suggests that forests are maturing, adding fewer trees while increasing in volume on established trees. The more pronounced decrease in tree density and increase in individual tree volume in the south may reflect the increased conversion of agricultural land to forest. These marginal lands, which have fewer trees per acre, may eventually qualify as forest, resulting in a decrease in the average density of forest land in the southern part of the State.

Forest Growth

Background

Forest growth is measured as average annual net growth, or, the annual change in volume of sound wood in live trees equal to or greater than 5-inch diameter, plus the total volume of trees entering this class through in-growth, minus the volume losses from natural causes (mortality). Average annual net growth is the average for the years between inventories, most recently between 2000- 2004 and 2005-2009.

What we found

The average annual net growth of growing-stock trees on Wisconsin's timberland almost doubled between 1956 and 2009 (Fig. 27); the growth in 2009 was approximately 593 million cubic feet. Among the top 10 species by volume red maple, red pine, sugar maple, and eastern white pine were the top four species in terms of average annual net volume growth; red maple grew almost 70 million cubic feet per year statewide (Fig. 28). The average annual net growth as a percent of total growing-stock volume averaged 2.7 percent for all species (Fig. 29). Red pine, eastern white pine, red maple, and quaking aspen had the highest growth-to-volume ratios among the top 10 species. Each of these species averaged over 3 percent growth in volume in 2009 (Fig. 29).

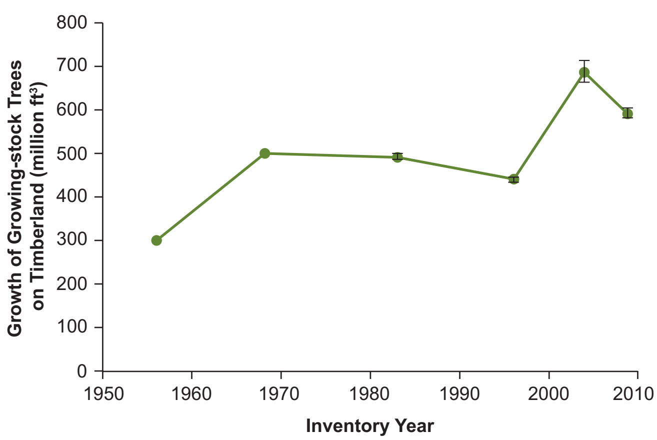


Figure 27.—Average annual growth of growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

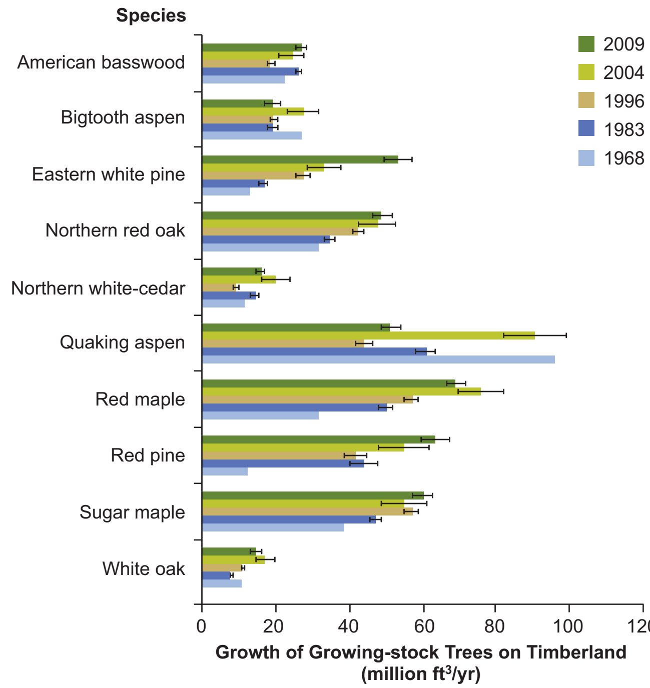


Figure 28.—Average annual growth of the 10 most voluminous growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

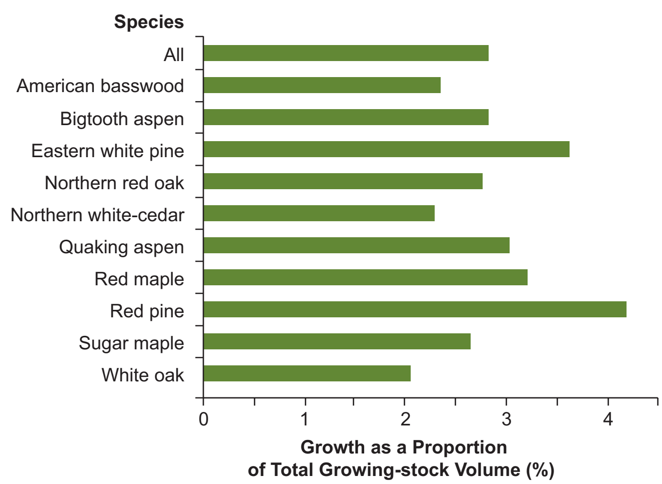


Figure 29.—Average annual growth as a function of total growing-stock volume, Wisconsin, 2009.

The average annual net growth rate of growing-stock trees on timberland as a percent of standing volume varies by landowner class. The rate is highest for Federal lands other than National Forest (3.9 percent), followed by State (3.6 percent), county and other local governments (2.9 percent), private landowners (2.8 percent) and finally National Forests (2.2 percent).

What this means

The average annual net growth of Wisconsin's forests has an increasing trend from 1956 to 2009 indicating an overall sustainable resource. When annual growth is viewed relative to the total growing-stock volume on timberland, all of the 10 major species by volume are adding positive growth in excess of 2 percent each year. As a result, these commercially important species (with the possible exception of the aspen species for reasons discussed below) should continue to provide wood products and other environmental services for society well into the future.

Growth provides only one piece of the sustainability question, however. Information on mortality and removals is also needed to monitor the changing composition of the forest.

Tree Removals

Background

Trees are removed from timberland to meet a variety of management objectives or land-use changes. Changes in the quantity of growing stock removed help to identify trends in land-use change and forest management. Because removals are generally observed on a limited number of plots, the estimates for removals show greater variance than those for growth, mortality, or area. Like forest growth, the rate at which trees were removed represents the average annual growing-stock removals that occurred between inventories, most recently between 2000-2004 and 2005-2009.

What we found

Average annual removals of growing-stock trees on Wisconsin's timberland increased from 1956 to 1996; however, since 1996 removals have leveled off (Fig. 30). Average annual removals for all species in 2009 were approximately 322 million cubic feet. Among the top 10 species by growing-stock volume, quaking aspen, northern red oak, sugar maple, and red pine had the greatest removals (by volume) in 2009. Quaking aspen removals were almost 54 million cubic feet per year statewide (Fig. 31). Average annual removals as a percent of total growing-stock volume was 1.5 percent for all species in 2009 (Fig. 32). Bigtooth aspen (3.2 percent), quaking aspen (3.2 percent), and red pine (1.9 percent) had the highest removals-to-volume ratios among the top 10 species, while northern-white cedar (0.3 percent), eastern white pine (1.0 percent), and American basswood (1.0 percent) had the lowest removals-to-volume ratios (Fig. 32).

The average annual removals rate of growing-stock trees on timberland as a percent of standing volume varies by landowner class. The rate is highest for Federal other than National Forest (2.8 percent), followed by county and other local governments (1.9 percent), private landowners (1.6 percent), State (1.3 percent), and National Forests with the lowest removals rate (0.5 percent).

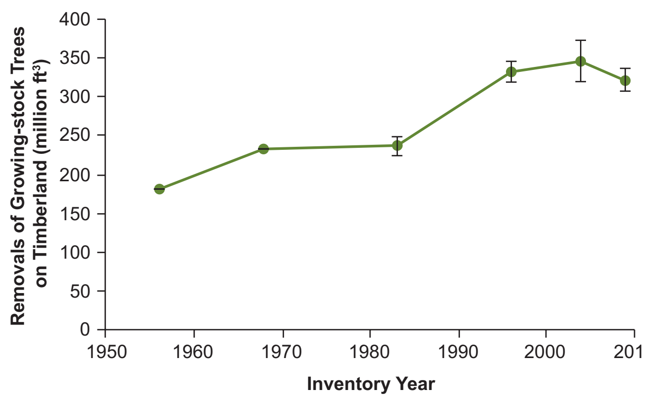


Figure 30.—Average annual growing-stock removals on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

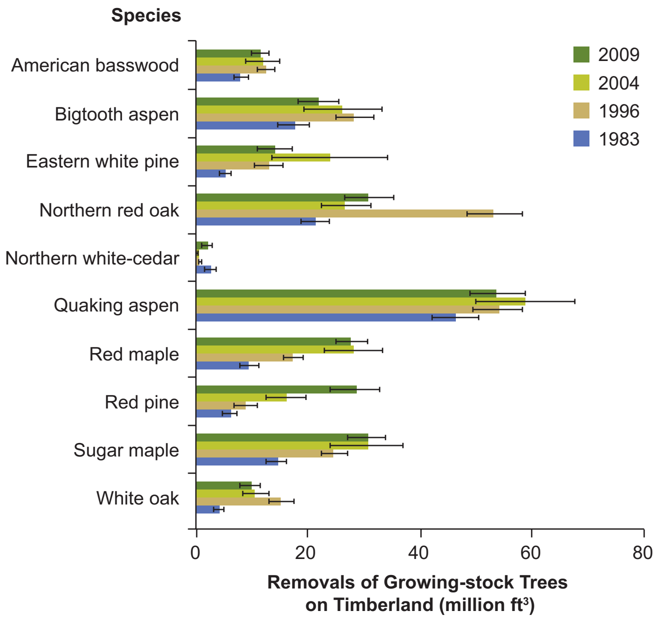


Figure 31.—Average annual removals of the top 10 most voluminous growing-stock trees by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

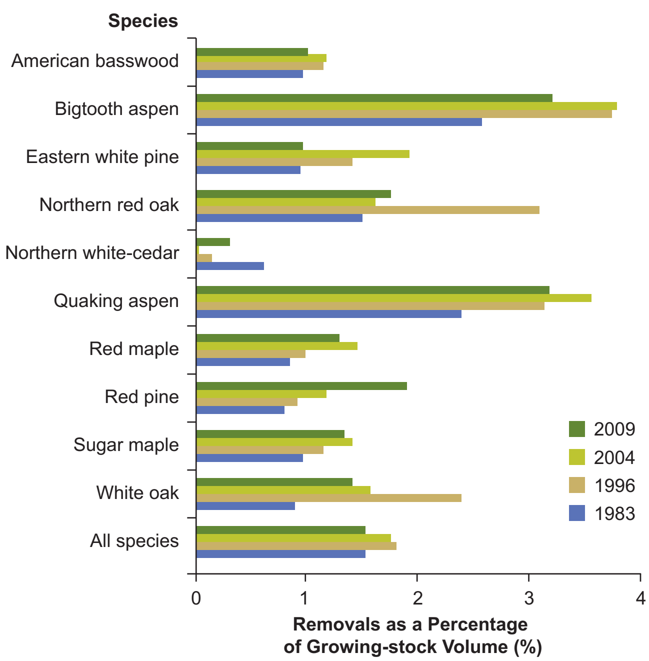


Figure 32.—Growing-stock tree removals as a percentage of growing-stock volume by inventory year, Wisconsin.

What this means

Growing-stock tree removals across Wisconsin have stabilized, to a large extent, over the last decade. The most recent decline in removals between 2004 and 2009 is very likely the result of two factors: 1) the decline in the number of housing starts (which affects lumber demand); and 2) the accompanying economic downturn which has negatively impacted all sectors of the economy, including the forest products industry—especially paper. Tree removals through harvesting for products or land-use change are important components of overall forest sustainability and should be monitored into the future.

Tree Mortality

Background

Mortality can be caused by insects, disease, adverse weather, succession, competition, fire, old age, or human or animal activity; mortality is often the result of a combination of these factors. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates. Growing-stock tree mortality estimates represent the average volume of sound wood in growing-stock trees that died each year as an average for the years between inventories, most recently between 2000-2004 and 2005-2009.

What we found

The average annual mortality of growing-stock trees on Wisconsin's timberland has generally been increasing along with total growing-stock volume since the mid-1960s. However, the rate of increase has diminished slightly since 1996 (Fig. 33). The annual mortality for all species in 2009 was approximately 211 million cubic feet. Among the top 10 species by volume, quaking aspen, bigtooth aspen, northern red oak, and white oak had the highest annual mortality volume in 2009. Quaking aspen mortality was over 44 million cubic feet per year statewide (Fig. 34). The average annual mortality as a percent of total volume averaged 1.0 percent for all species (Fig. 35). Quaking aspen (2.6 percent) and bigtooth aspen (1.7 percent) had the highest mortality-to-volume ratios among the top 10 species, while red pine, sugar maple, and northern-white cedar had the lowest mortality to volume ratios, about 0.2 percent each (Fig. 35).

The average annual mortality rate of growing-stock trees on timberland as a percent of standing volume varies by landowner class. The rate is highest for Federal land other than National Forest (1.2 percent), followed by State (1.0 percent), private landowners (1.0 percent), county and other local governments (0.9 percent) and National Forests (0.9 percent).

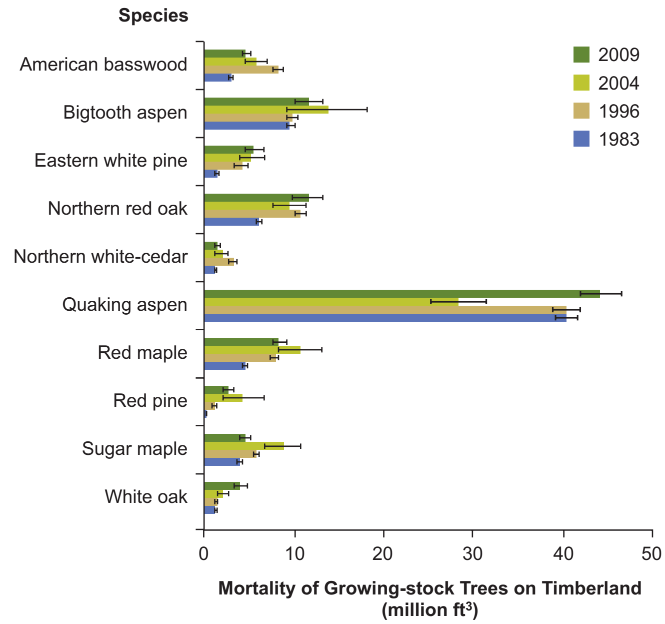


Figure 34.—Average annual mortality of the top 10 most voluminous growing-stock trees by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

Figure 33.—Average annual morality of growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

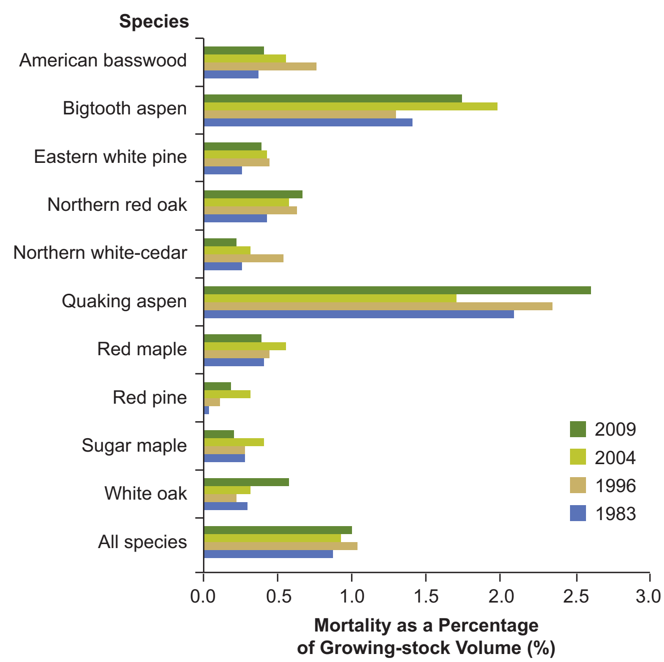


Figure 35.—Average annual mortality as a function of total growing-stock tree volume by inventory year, Wisconsin.

What this means

Tree mortality across Wisconsin continues to increase, but may be slowing over the last decade. Mortality is a natural process in forest stands as they develop and change over time. Quaking aspen and bigtooth aspen are short-lived, pioneer species so it comes as no surprise that they have the highest mortality rates among the top 10 commercial species in Wisconsin. Tree mortality is a crucial component of overall forest health and should continue to be monitored.

Growth-to-Removals Ratio

Background

A primary measure of sustainability is the net annual growth-to-removals (G/R) ratio. The G/R ratio is annual net growth divided by removals where net growth is equal to gross growth minus mortality. A number greater than 1.0 indicates that net annual growth of the species exceeds annual removals and this removal rate is sustainable. A number less than 1.0 indicates that growth is less than removals and this species will not be sustained if removals continue at this level over time.

What we found

The annual G/R ratio of growing-stock trees on Wisconsin's timberland remained relatively stable from 1956 to 2009, varying between 1.5 and 2.0 (Fig. 36). The annual G/R ratio for all species in 2009 was 1.84 (Fig. 37). Among the top 10 species by volume, quaking aspen (0.95) and bigtooth aspen (0.88) were the only species to have G/R ratios less than 1.0. Northern white-cedar (7.52) and eastern white pine (3.73) had the two highest G/R ratios in 2009 (Fig. 37).

The annual G/R ratio of growing-stock trees on timberland varies by landowner class. The rate is highest for National Forests (4.7), followed by State (2.8), private landowners (1.9), and county and other local governments (1.5). Federal other than National Forests had the lowest G/R ratio (1.4).

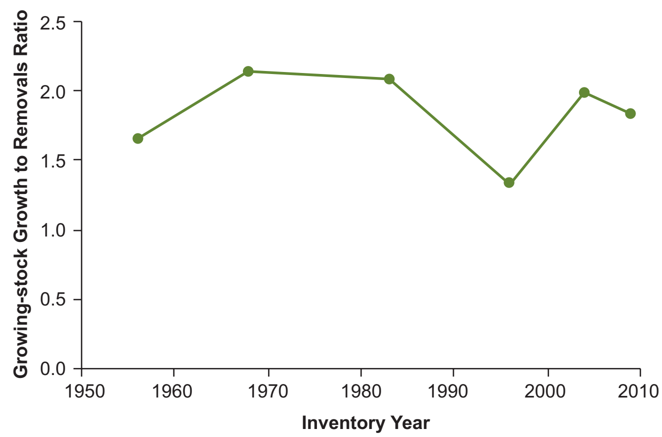


Figure 36.—G/R ratios by inventory year, Wisconsin.

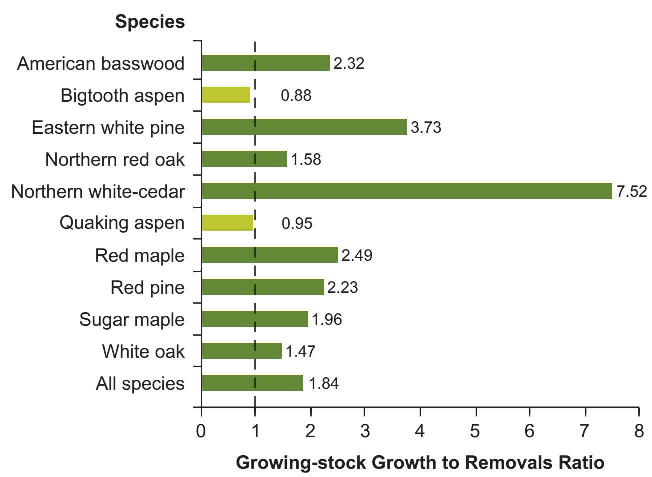


Figure 37.—G/R ratios for top 10 most voluminous species, Wisconsin, 2009.

What this means

The statewide G/R ratio of 1.84 in 2009 confirms that net annual growth exceeded removals and is an indicator that harvest and land-cover change removals are generally sustainable if continued at this rate. Both quaking aspen and bigtooth aspen had high removals-to-volume ratios. Quaking aspen also had a very small (less than 1) G/R ratio because its annual mortality nearly matched net growth. As a result, current aspen harvest levels are only marginally sustainable over the long term. However, aspen harvest levels have been declining and will probably continue to decline as a result of global competition in the paper and pulp industries and the downturn in the economy. As noted previously, aspen are short-lived, early successional species that will be replaced by later successional forest types over time regardless of harvest intensity. Of the three components of change (growth, removals, and mortality), removals are the most directly tied to human activity and as a result are the most responsive to changing economic conditions.

Patterns of Forest Canopy Disturbance

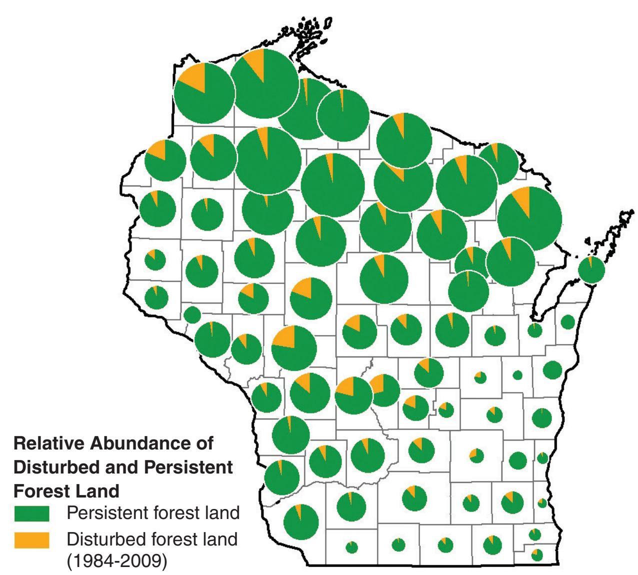
Background

Temporary disturbances to the forest canopy are common in Wisconsin. This loss of existing trees and subsequent regeneration is known as secondary succession. Permanent forest land-use changes, such as reversion of abandoned pasture or agricultural lands to forest or diversion of forest into nonforest uses, are far less common occurrences in Wisconsin in recent years and are discussed elsewhere in this report. Forest canopy disturbances result from a variety of causes, including harvest, wind, ice, fire, insects and disease, etc., all of which impact forest ecosystem composition, structure, and function. Severity of disturbance is affected by the susceptibility of trees (e.g., rooting depth) and the intensity of the disturbance agent (e.g., wind speed). Scales of disturbance also vary widely, affecting the total area and volume impacted, and also the number and size of resulting patches. Abundance of young forest habitat, for example, is directly dependent on the frequency, severity, and scale of canopy disturbances.

We produced satellite image-based maps and statistics to better understand forest canopy disturbances. Using 13 Landsat Time Series Stacks (LTSS) spanning more than 25 years and a 'vegetation change tracker' algorithm (VCTw) (Huang et al. 2010, Stueve et al. 2011a), we mapped the year of the most recent forest canopy disturbances across the entire state of Wisconsin. From these maps we determined the age of the resulting forest patches, their number, and their size.

What we found

Canopy disturbances occurring during the past few decades are reflected by the age of subsequent regeneration (Fig. 38). Older forest, water, and nonforest land also are shown for context. Patterns of young forest vary geographically across the State as does the relative abundance of disturbance (Fig. 39). For example, the predominately forested matrix in northwest Wisconsin contains numerous large patches, while fewer and smaller patches are noted within the predominately forested matrix in the northeast. Small patches are seen within a sparsely forested matrix in the south. Specific disturbance events are clearly evident, like the catastrophic tornado of 2007, resulting in a long, narrow swath of damage in northeastern Wisconsin (Fig. 38, right inset). Figure 40 portrays the spatial distribution of disturbances by the size (area) of regenerating patches. Although very large patches are more noticeable, the vast majority of forest disturbances are small, many under 10 acres. Based on FIA estimates, the predominant source of canopy disturbance is cutting, with weather and disease disturbances comprising the largest component of non-human-caused disturbances in Wisconsin (Fig. 41).



Source: Data derived from LTSS using the VCTw algorithm (Huang et al. 2010, Stueve et al. 2011a).
Note: Pies are sized by the total amount of forest land area in each county.

Figure 39.—Relative abundance of disturbed and persistent forest land by county, Wisconsin.

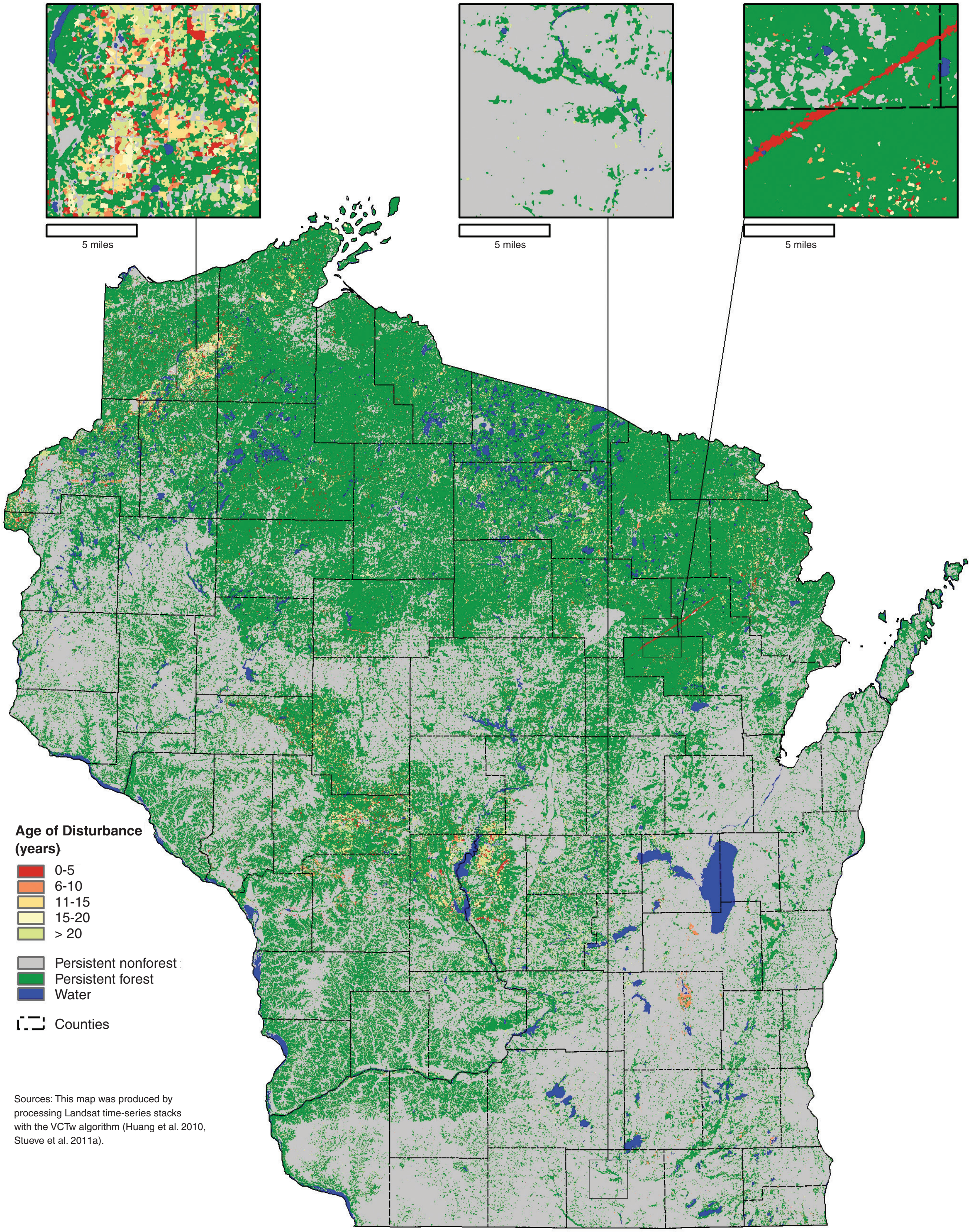


Figure 38.—Forest stand age derived from LTSS and VCTw, Wisconsin, 2009.

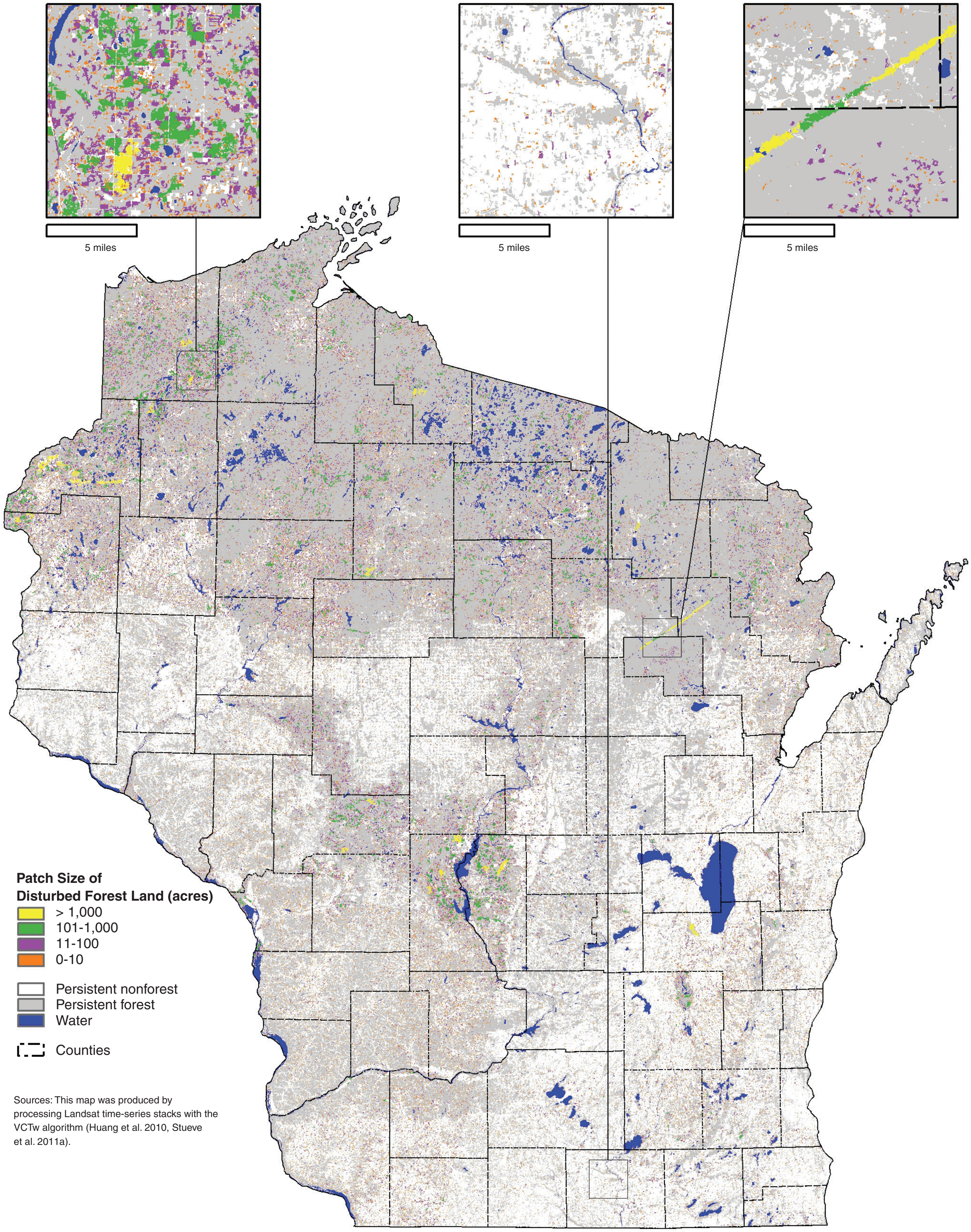


Figure 40.—Size of young forest patches (0-20 years) derived from LTSS and VCTw, Wisconsin, 2009.

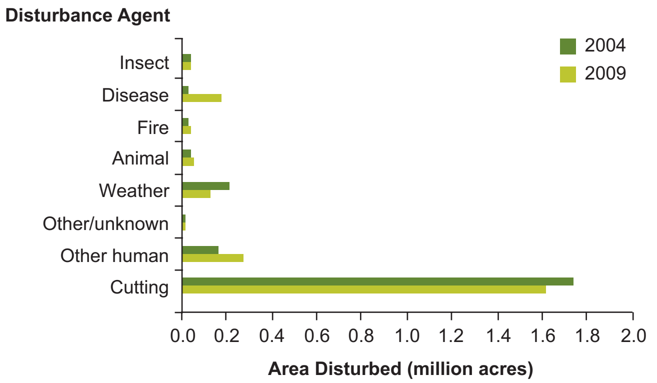


Figure 41.—Forest land area disturbed by agent and inventory year, Wisconsin.

What this means

Forest canopy disturbances are prevalent across Wisconsin, but their number and size vary geographically. The most prevalent natural disturbances are those caused by wind damage. Supporting work by Stueve et al. (2011b) determined that wind-caused disturbances of intermediate magnitude result in similar extent of damage as from catastrophic but rare wind events. Information about the age of forest following disturbance, and the landscape characteristics of those early successional forest patches is being shared with wildlife managers to support habitat work for American woodcock (*Scolopax minor*), golden-winged warbler (*Vermivora chrysoptera*), and other species, as is discussed elsewhere in this report.

Forest Age/Size (Wildlife)

Background

Wisconsin's Wildlife Action Plan (WDNR 2005) identifies wildlife species of greatest conservation need (SGCN) and threats to their habitats. Several of the State's SGCN are associated with forest habitats. Wisconsin forests provide habitat for numerous species of mammals, birds, reptiles, and amphibians, as well as for fish, invertebrates and plants. Forest composition and structure affect the suitability of habitat for each species. Some species, such as American woodcock and golden-winged warbler, depend upon early successional forests comprised of smaller, younger trees, especially aspen, a deciduous species. Both of these SGCN have shown declines in population during the past several decades, believed to be associated with declining abundance of young forest. Another early successional species, Kirtland's warbler (*Setophaga kirtlandii*), is a recent arrival to the State, inhabiting only young jack pine forest. Another SGCN, cerulean warbler (*Setophaga cerulean*), requires older, interior forests containing large trees with complex canopy structure. Other species inhabit the ecotone (edge) between different forest stages, and many require multiple structural stages of forests to meet different phases of their life history needs. Abundance and trends in these structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001). Several indicators of wildlife habitat abundance can be derived from FIA data. Historical trends in Wisconsin's forest habitats are reported for timberland, which comprises more than 98 percent of all forest land in the State. For the current habitat conditions, estimates are reported for all forest land. Habitat characteristics related to patch size are discussed elsewhere in this report.

What we found

Trees in the small diameter stand-size class, which is an indicator of early successional stages, has declined from 1956 and 1968 (38 and 31 percent, respectively) to the most recent decade (21 percent) (Fig. 42). Concurrently, the distribution of trees in the large-diameter stand-size class has increased dramatically from 14 percent in 1956 to 42 percent during the current inventory. Forest with medium diameter trees show a more consistent pattern of abundance during the past six decades (Fig. 42). Most of Wisconsin forest land is in stand-age classes over 40 years, only a tiny fraction of which is over 150 years of age. Small diameter stand-size class predominates young forests (0-20 years), decreasing in relative abundance with increasing stand age (Fig. 43). The opposite trend is seen for large diameter stand-size class, which increases in relative abundance with increasing stand age, becoming predominant at 61-80 years (Fig. 43).

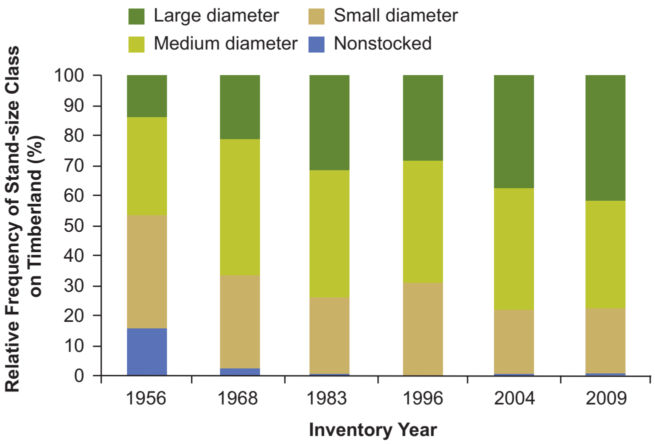


Figure 42.—Relative frequency of stand size-class on timberland by inventory year, Wisconsin.

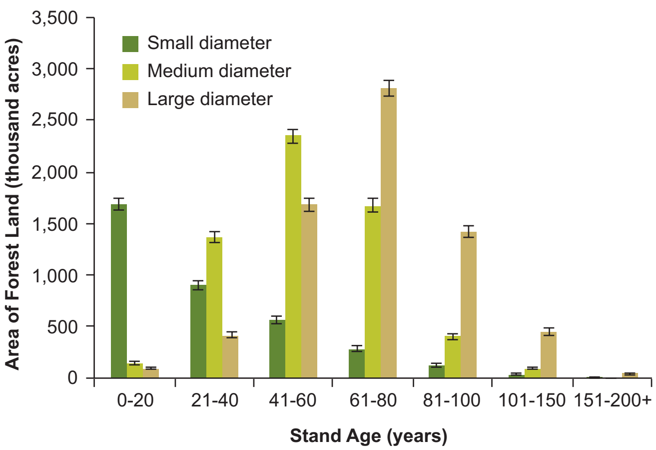


Figure 43.—Area of forest land by stand age and stand-size class, Wisconsin, 2009. Error bars show the 68 percent confidence interval.

What this means

Decreasing abundance of trees in the small-diameter stand-size class is offset by increasing abundance in the large-diameter class. However, almost three-fourths of large-diameter class is less than 80 years of age, with only 7 percent older than 100 years. While both stand-size class and stand-age class provide indicators of forest successional stage, it is interesting to see the persistence of some small-diameter forest in older stand ages and some large-diameter forest in younger stand ages. Thus, these two attributes are not directly interchangeable but are best used in combination. Though seemingly contradictory, there is a need to maintain forest conditions in both smaller and larger structural stages to maintain earlier and later successional habitats for all forest-associated species.

Standing Dead Trees

Background

Specific habitat features such as nesting cavities and standing dead trees (at least 5 inches d.b.h.) provide critical habitat components for many forest-associated wildlife species, including red-headed woodpecker (*Melanerpes erythrocephalus*), a Wisconsin species of greatest conservation need (SGCN) that has declined by more than 50 percent. 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. They also serve as sources of down woody material (discussed elsewhere in this report), which also provides habitat features for wildlife. The number and density of standing dead trees, together with decay classes, species, and sizes, define an important wildlife habitat feature across Wisconsin forests.

What we found

FIA collects data on standing dead trees of numerous species and sizes in varying stages of decay. More than 260 million standing dead trees are present on Wisconsin forest land. This equates to an overall density of 15.6 standing dead trees per acre of forest land, with similar densities on public (16.4) and private (15.2) forest land. Seven species groups each contributed more than 10 million standing dead trees, with the top group, ‘other eastern hard hardwoods’ exceeding 56 million (Fig. 44). Relative to the total number of live trees in each species group, eighteen species groups exceeded one standing dead tree per 100 live trees, with jack pine species group (comprised entirely by jack pine, *Pinus banksiana*) topping the list at 7.7 standing dead trees per 100 live trees (Fig. 45). Eighty-four percent of standing dead trees were smaller than 11 inches d.b.h., with almost 45 percent between 5 and 6.9 inches d.b.h. (Fig. 46). The class of most decay (‘no evidence of branches remain’) contained the fewest standing dead trees (10 percent).

The other four decay classes each contained between 20 and 24 percent of standing dead trees (Fig. 46).

What this means

Snags result from a variety of potential causes, including diseases and insects, weather damage, fire, flooding, drought, competition, and other factors. 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 which 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 Wisconsin.

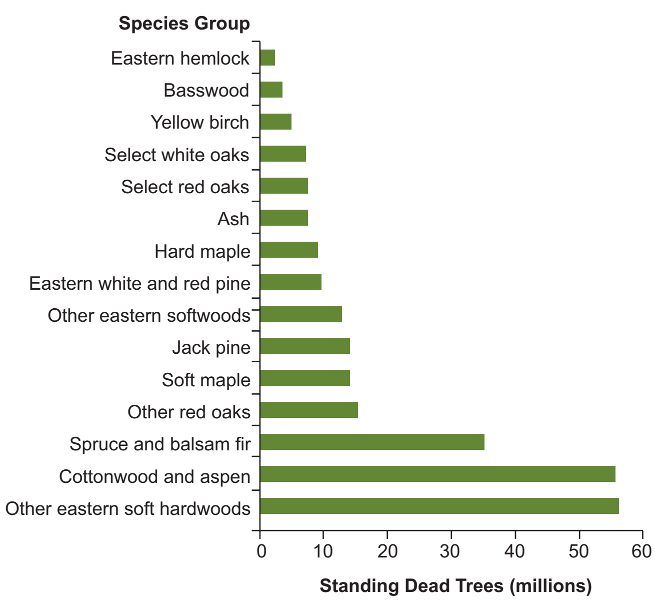


Figure 44.—Number of standing dead trees by species group, Wisconsin, 2009.

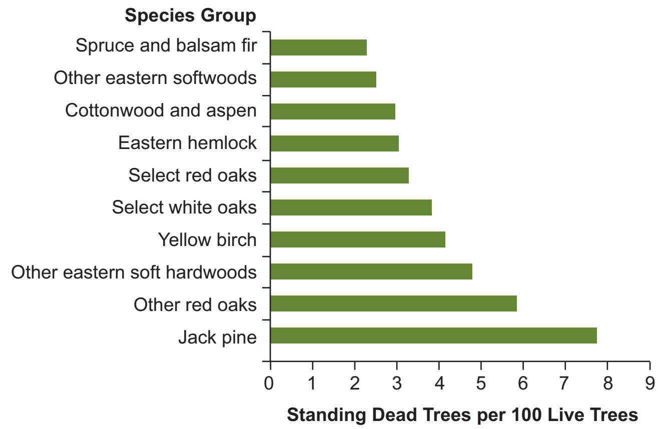


Figure 45.—Number of standing dead trees per 100 live trees by species group, Wisconsin, 2009.

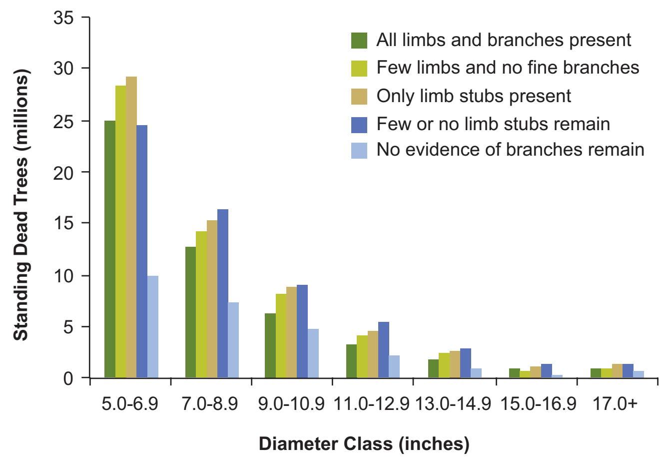


Figure 46.—Distribution of standing dead trees by decay and diameter classes for all dead trees, Wisconsin, 2009.

Urban Forests

Background

Large-scale inventory and assessment of the urban forest is a relatively new and rapidly evolving field. Currently there is no national standard or protocol for continuous urban forest inventory and assessment, but there are several methods and technologies being used and evaluated. The 2004 inventory of Wisconsin (Perry et al. 2007) reported results of a 2002 Forest Service statewide pilot urban forest health monitoring study that used field plot data gathered using traditional FIA protocols modified for urban forest attributes. This study will be repeated in 2012 to collect trend data and assess the ability of this tool to provide urban forest inventory, value, and management information.

In the interim, we used 2001 land cover satellite imagery combined with 1990 and 2000 U.S. census data to complete an urban forest assessment. This study looked at the State's entire urban forest canopy using 30-meter pixels (Nowak and Greenfield 2010). The number of trees and the percentage of tree canopy, green space, and impervious surface cover were estimated using automated classification. This information was overlaid onto community geographic boundaries and census block data to provide additional canopy cover attributes:

- Tree canopy per capita—tree canopy cover divided by number of people
- Total green space—total community area minus impervious surface and water which estimates pervious surface
- Available green space—total green space minus tree canopy, which estimates green space potentially available for tree planting

This study also compared two different boundaries of urban and community forest which overlap. The "urban" classification used population density to delineate the boundary. "Urban" area crosses political boundaries and excludes undeveloped areas outside the population density threshold. The "community" classification used the legal borders of communities, the "city limits" if you will, which includes all area, developed or undeveloped within a political boundary. The "urban" area allows managers to focus on the attributes of developed areas which require more intense management, whereas the "community" area gives a manager the full view of the land cover in their community, both what is currently developed and what could be developed in the future.

What we found

During the 1990s, Wisconsin's population increased by 14.1 percent in urban areas and by 9.3 percent in communities. The land area considered urban increased by 17.7 percent and the land encompassed by communities increased by 13.4 percent over the same time period (Fig. 47). As a result, the population density (people per square mile) actually decreased by 3.1 and 3.6 percent respectively.

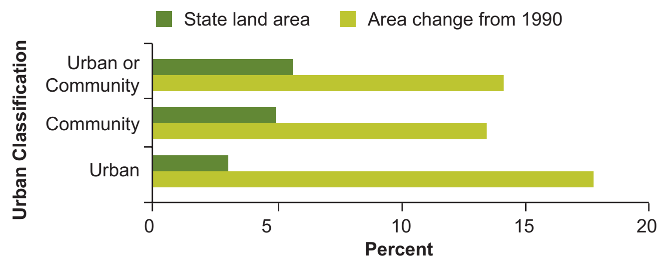


Figure 47.—Area of land by urban classification, Wisconsin, 2000.

There are an estimated 26.2 million trees in urban areas and 66.1 million trees in communities. Because these areas overlap, there are an estimated 74 million trees in urban or community areas combined. Urban areas have an average tree canopy cover of 13.1 percent and communities have 20.2 percent. Tree canopy cover per capita (square feet per person) is 1,615 in urban areas and 3,934 in communities. In urban areas, 75.7 percent of the land is green space and 24.3 percent is impervious, while in communities, 82.8 percent is green space and 17.2 percent is impervious (Fig. 48). In both urban and community areas, 62.6 percent of the existing green space is potentially available for tree planting.

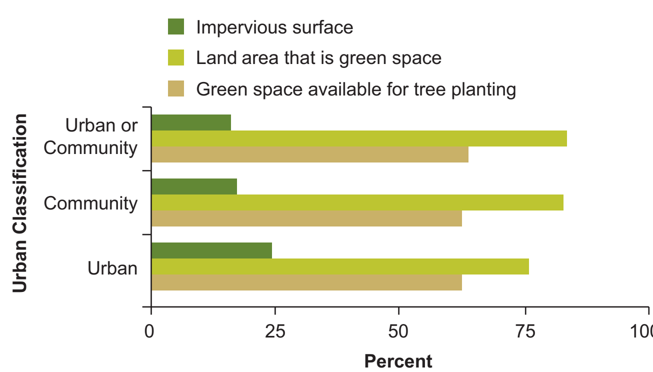


Figure 48.—Urban land cover by use, Wisconsin, 2000.

The trees in the combined areas store 14.1 million metric tons of carbon valued at $321.5 million. They sequester an additional 466,000 metric tons of carbon annually valued at $10.6 million and they remove 9,610 metric tons of air pollutants (ozone, particulate matter, nitrogen oxides, sulfur oxides, and carbon monoxide) annually valued at $82 million (Fig. 49).

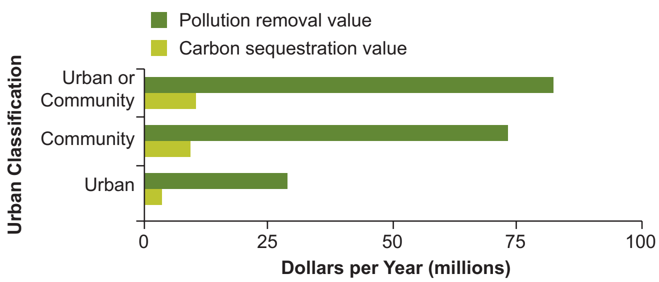


Figure 49.—Selected economic impacts of urban forests, Wisconsin, 2000. Note: pollutants removed by the urban forest include: ozone, particulate matter, nitrogen oxides, sulfur oxides, and carbon monoxide.

What this means

Wisconsin's population is increasing and becoming more urban. In addition, the land area that comprises the urban forest is increasing faster than the population. If these trends continue, urban forests and urban forestry will have an ever greater impact on both the land and the people of the State.

The value of the economic, social, and environmental services the State's urban forests provides to its residents is significant. This value is based on the extent and vitality of the forest as well as the proximity of tree canopy to buildings and infrastructure. The tree canopy cover in the densely populated areas and the overall community areas are both well below the American Forests' recommended goal of 40 percent so there is significant room for improvement. Not only is there plenty of space to plant trees, but because it takes trees so long to reach a size that will provide maximum benefits, preservation of existing canopy will be essential to maintain and increase services over time. In urban areas, the challenge will be preservation of large canopy trees during reconstruction and redevelopment to reach canopy goals. In the overall community where there are more trees and undeveloped land, concentrating on preserving existing large canopy trees and conserving existing forested area, rather than clearing and planting new trees, will be the challenge to minimize lost canopy services during new development.

Similar to the plot-based assessment, the satellite imagery assessment provides a snapshot of current conditions and a baseline for future trend analysis. Comparing the two methods reveals that both are needed to provide community leaders the urban forest information to make management decisions. Sample field plots provide details about the species, structure, and health of the urban forest on a broad scale, while the satellite/census analysis provides more detail on land cover and prioritization of canopy preservation and planting. Satellite/census analysis can also provide resolution down to a smaller scale since all urban and community land area is analyzed.

Forest Health Indicators

American hornbeam. Photo by David Lee, Bugwood.org.

Crown conditions

Background

The condition of tree crowns within a stand reflects the overall health of a forest. Dieback is the percentage of dead branch tips in the crown. The categories for the dieback indicator are none (0 to 5 percent), light (6 to 20), moderate (21 to 50), and severe (51 to 100). Crown transparency is a measure of the proportion of the crown through which the sky is visible. A forest suffering from a disease epidemic will have obvious dieback and high transparency.

What we found

Tree crowns generally are healthy across Wisconsin for most species; the overwhelming majority of trees observed had no or light damage (Fig. 50). The ash, cottonwood and aspen, other red oaks (including northern pin oak), and yellow birch had the biggest changes since 2004 (Fig. 51); however, these amounts of crown dieback still fall within the "light" category.

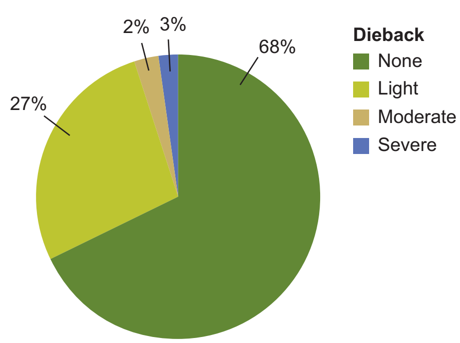


Figure 50.—Dieback classes of all species, Wisconsin, 2009.

The crown transparency of the hickory species group increased by 53 percent between 2004 and 2009, the largest increase of all species groups (Fig. 52). The crown transparency of select red oaks decreased by 19 percent.

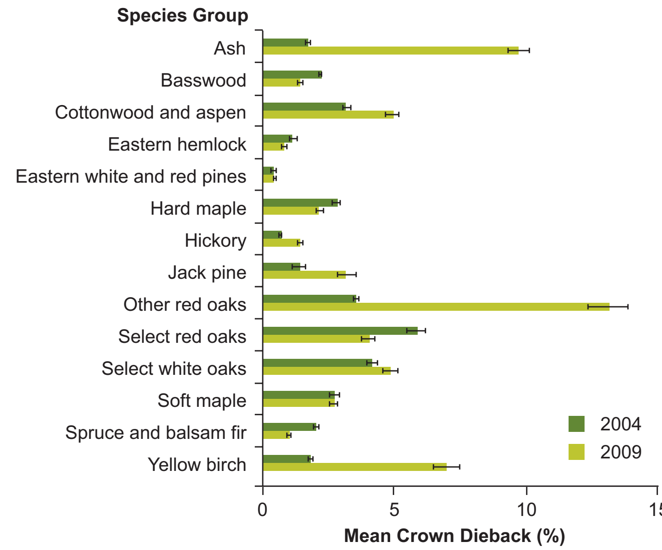


Figure 51.—Mean crown dieback by species group and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

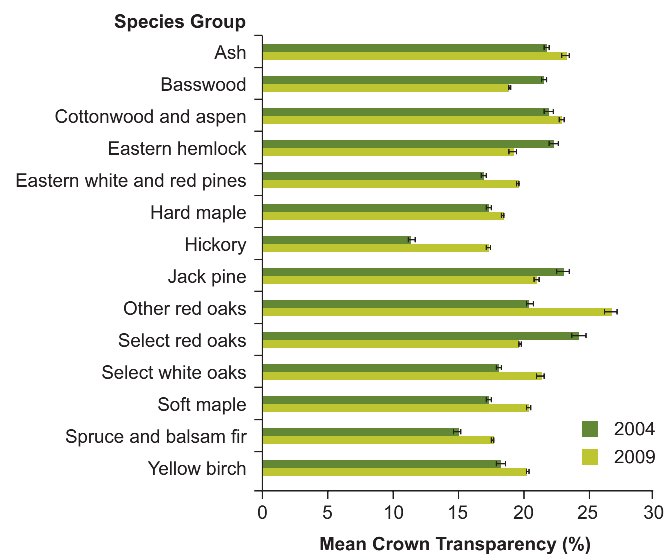


Figure 52.—Mean crown transparency by species group and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

What this means

These measurements of crown indicators appear to indicate there are no major health problems related to crown conditions in Wisconsin. However, these measurements have only been collected twice during the period of record. Additional measurements will provide valuable context for managers in the future. Particular attention should be given to the ash and other red oak species groups.

Down Woody Material

Background

Down woody material, including fallen trees and branches, fills a critical ecological niche in Wisconsin's forests (Tyrrell and Crow 1994). It provides valuable wildlife habitat in the form of coarse woody debris, contributes to forest fire hazards via surface woody fuels, and stores carbon in the form of slowly decaying large logs.

What we found

The fuel loadings and subsequent fire hazards of dead and down woody material in Wisconsin's forests are relatively low, especially when compared with the nearby states of Michigan and Minnesota (Fig. 53). The size distribution of coarse woody debris (diameter larger than 3 inches) is overwhelmingly dominated (83 percent) by pieces less than 8 inches in diameter (Fig. 54). Moderately decayed coarse woody pieces (decay classes 2, 3, and 4) constituted 91 percent of the decay class distribution (Fig. 55). The carbon stocks of coarse woody debris appear to be stable (around 1 ton/acre) across classes of standing live-tree basal area on Wisconsin's forest land (Fig. 56).

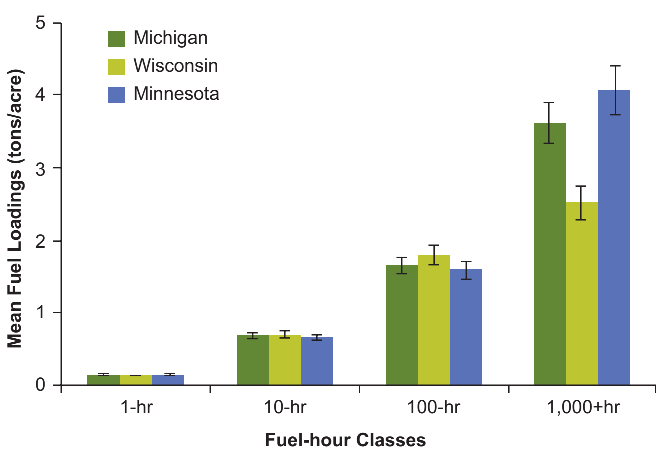


Figure 53.—Down wood fuel loadings in the Lake States, 2009. Error bars show the 68 percent confidence interval.

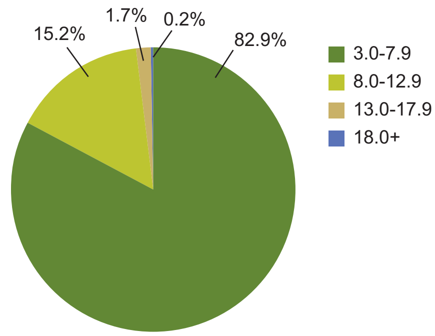


Figure 54.—Diameter distribution of down wood pieces, Wisconsin, 2009.

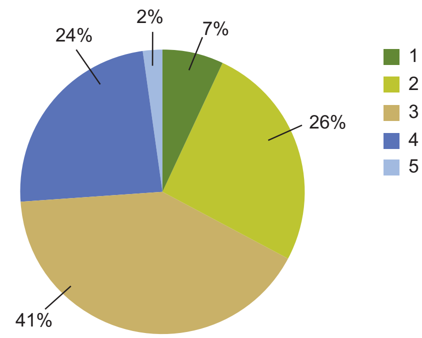


Figure 55.—Distribution of down wood pieces by decay class, Wisconsin, 2009.

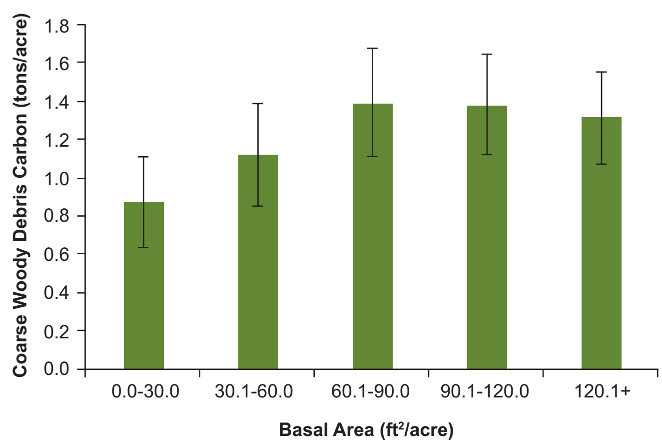


Figure 56.—Distribution of coarse woody debris carbon by forest land basal area, Wisconsin, 2009. Error bars show the 68 percent confidence interval.

What this means

The fuel loadings of downed woody material can be considered a forest health hazard only in times of drought or in isolated stands with excessive tree mortality. The ecosystem services (e.g., habitat for fauna or shade for tree regeneration) provided by down woody material exceeds any negative forest health aspects. The population of coarse woody debris across Wisconsin consists mostly of small pieces that are moderately decayed. Due to this, coarse woody debris constitutes a small, albeit important carbon stock across Wisconsin's forests. The population of down woody material in Wisconsin's forests appears consistent with nearby states.

Ozone

Background

Ozone is a natural constituent of both the lower (ground level) and upper atmosphere. Elevated ozone concentrations in the lower atmosphere are commonly found within and downwind of major urban and industrial areas. Hot summers often produce significant exposures while cool wet summers result in low exposures.

Ozone is an air pollutant that damages trees, reduces their growth, and thus makes them vulnerable to insects and diseases. The growth rates and biomass of bioindicator species have been reduced in controlled exposure studies around southern Lake Michigan (Bennett et al. 2006). Individual species and sensitive populations within species may have lower productivity, thus influencing overall competitiveness and forest composition.

What we found

Biosite index values can vary widely over individual years due to varying ozone concentrations and distribution across forest landscapes. The trend in biosite index values is best calculated as a rolling 5-year average. The mean biosite index value has decreased in Wisconsin's forests since the late 1990s (Fig. 57). When comparing the severity of damage observed in 2004 and 2009 for individual bioindicator plants, the same trend emerges: decreasing ozone damage severity (Fig. 58). Most bioindicator plants had damage half as severe or less in 2009 than in 2004. Common and tall milkweed (*Asclepias syriaca*) was the most severely damaged plant in both inventories. Mean plant injury, a gauge of the relative number of plants that showed any level of ozone damage, decreased substantially from 2004 to 2009 (Fig. 59).

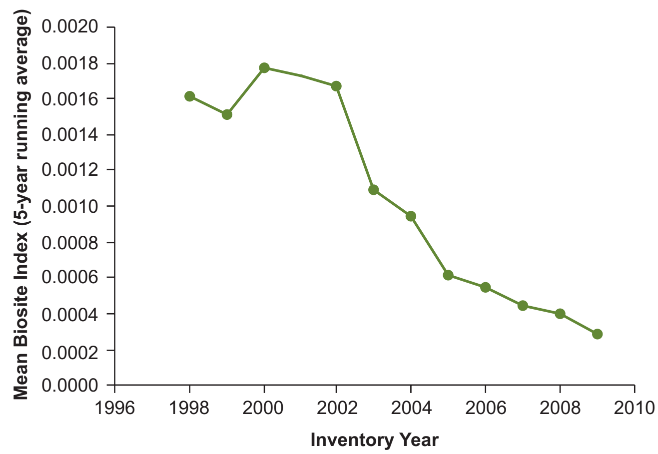


Figure 57.—Five-year moving average of biosite index by inventory year, Wisconsin.

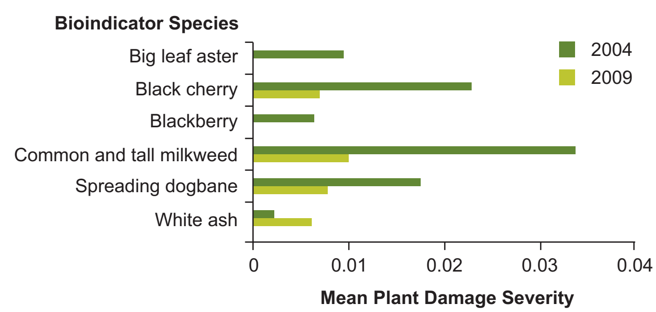


Figure 58.—Mean plant damage severity (unitless ratio of ozone damage, 1 indicates complete damage) by inventory year, Wisconsin.

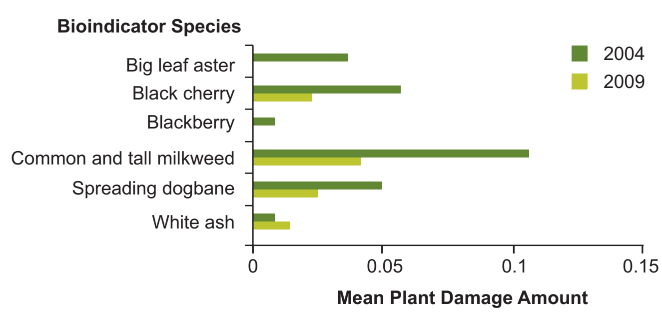


Figure 59.—Mean plant damage amount (unitless ratio of number of plants damaged by total number of plants samples) by inventory year, Wisconsin.

What this means

The exposure of Wisconsin's forest land to ozone continues to decline. The forests are at low risk of foliar injury and growth and productivity losses. The potential effects of ozone stress should be even less severe on the most common tree species (e.g., maples and oaks) as these are relatively tolerant of ozone. However, the monitored ozone exposures, the confirming evidence of foliar injury, and the overall injury scores indicate the potential for reduced growth and negative impact on the health of Wisconsin's forests. Of particular concern will be ozone-sensitive tree species, such as quaking aspen, black cherry, chokecherry, white ash, and green ash, that occur along Lake Michigan.

Forest Insects and Diseases

Background

Insects and diseases have always been a part of Wisconsin's forest ecosystem and have been monitored since the mid-1950s. In the past decade, the threat and impact from exotic insects and diseases has increased as the number of them established in Wisconsin and the United States increases. Combined impacts from multiple stressors, both living and nonliving, also appear to be an increasing problem.

What We Found

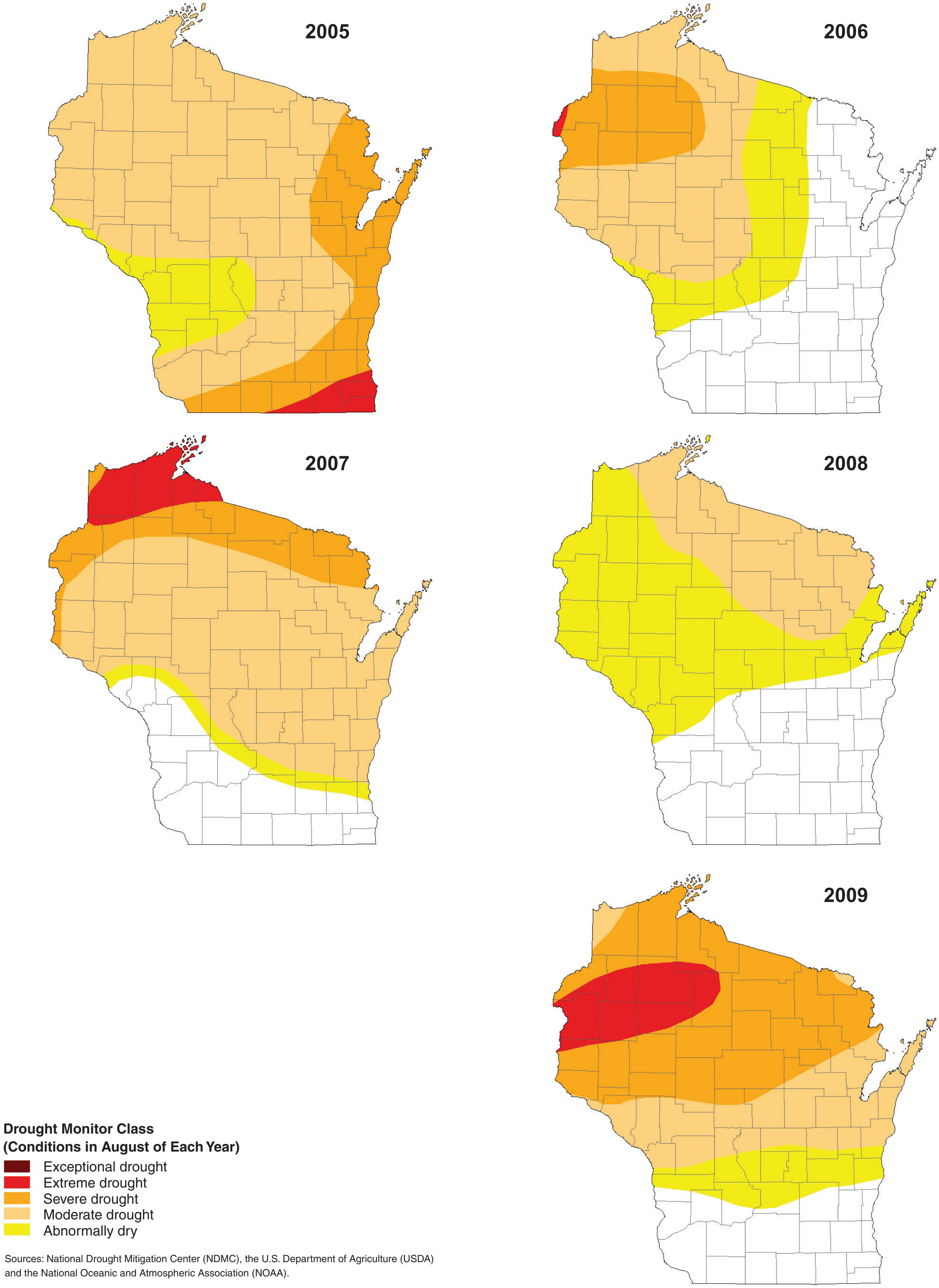
Weather and a variety of insects and diseases impacted Wisconsin's forests during 2005-2009. This period was characterized by diebacks and declines in several tree species due to multiple factors. Northern Wisconsin counties experienced drought during the 2005-2007 growing seasons and in 2009 (Fig. 60). Drought was particularly severe in northwestern counties.

Invasive pests and diseases are an issue of increasing concern in Wisconsin. Emerald ash borer (*Agrilus planipennis*—see the EAB section) and beech bark disease (*Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*) (Fig. 61) were first found in the State during this 5-year period. Ash yellows (Fig. 62), Annosum root rot of pine (*Heterobasidion irregulare*) (Fig. 63) and oak wilt (*Ceratocystis fagacearum*) (Fig. 64) continue to spread across the state. Gypsy moth, (*Lymantria dispar*) which was already established in the eastern half of the state, increased to outbreak levels for the second time in Stevenson Township in northeastern Wisconsin and in the central counties of Adams and Juneau, causing 23,000 acres of defoliation in 2007 (Fig. 65).

Jack pine budworm (*Choristoneura pinus*) at its peak in 2005 caused 222,500 acres of defoliation of jack pine, mostly in northwestern counties and extending south to the west-central counties of Eau Claire, Jackson, Monroe, Juneau, and Adams. The outbreak collapsed over the following 2 years as commonly occurs with the cyclical outbreaks that characterize this native pest. What was not typical of this insect was its shift to feeding on red pine in 2005-2008. Feeding damage, which characteristically occurs on older jack pine, was now occurring on younger red pine (20 to 30 years old) or on individual older trees.

What this means

Decline, dieback, and mortality of trees due to the combined stress of multiple factors, both living and nonliving, is not new to Wisconsin. It has been documented as occurring in previous decades and can be expected in the future. It should be recognized, however, that the initial source of stress that opens trees to attack by opportunistic or weak pests and diseases is often weather events such as drought, storm damage, frost, or flooding. Wisconsin has experienced warming weather in the last two decades and a changing climate will cause an increase in the background level of stress experienced by trees leaving them increasingly susceptible to the accumulation of stress from minor or secondary pests and diseases.



Sources: National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Association (NOAA).

Figure 60.— Drought conditions, Wisconsin, 2005-2009.

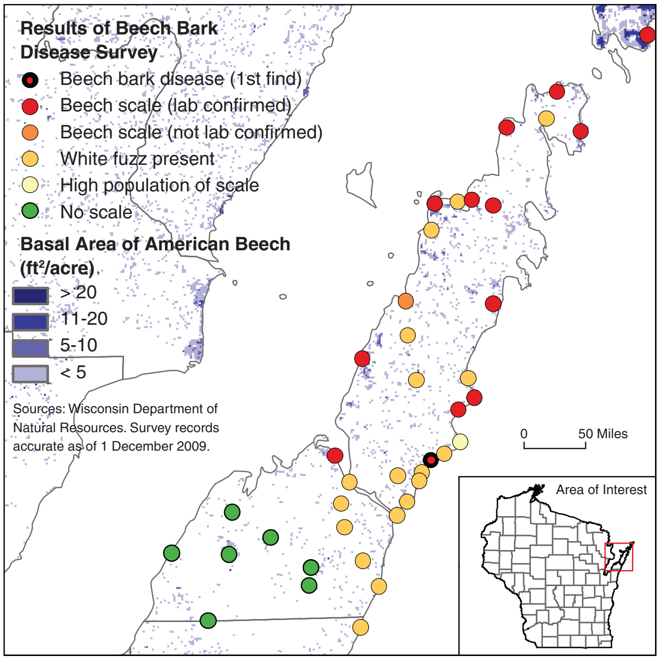


Figure 61.— Beech bark disease distribution in Wisconsin, 2009. Beech bark disease progresses from high populations of scale through white fuzz to identification of beech scale and beech bark disease.

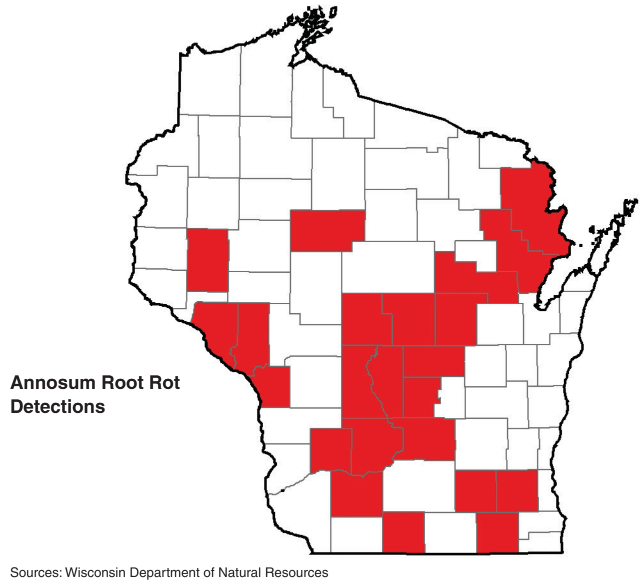


Figure 63.—Wisconsin counties where Annosum root rot of pine has been confirmed as of 2009.

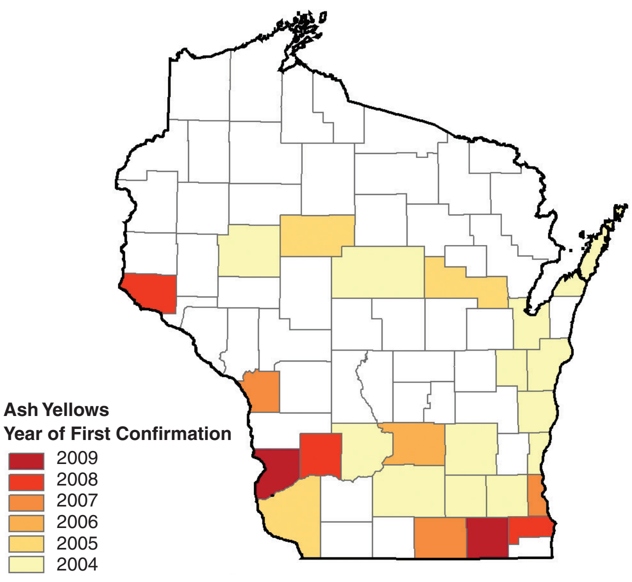


Figure 62.—Wisconsin counties where ash yellows has been confirmed as of 2009.

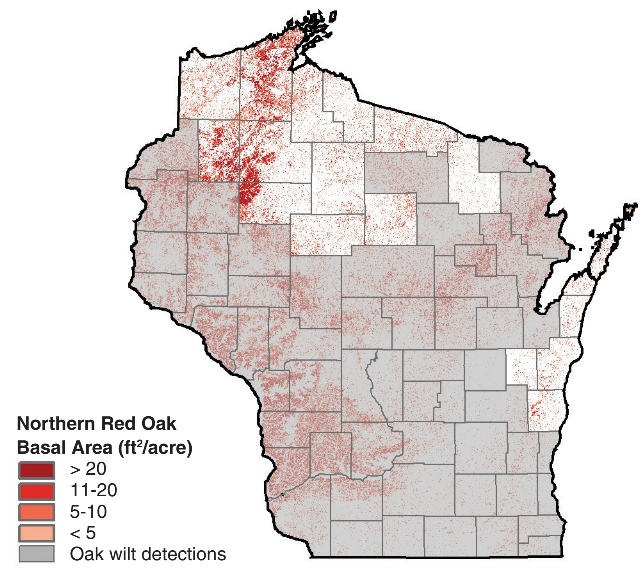


Figure 64.—Wisconsin counties where oak wilt has been confirmed as of 2009.

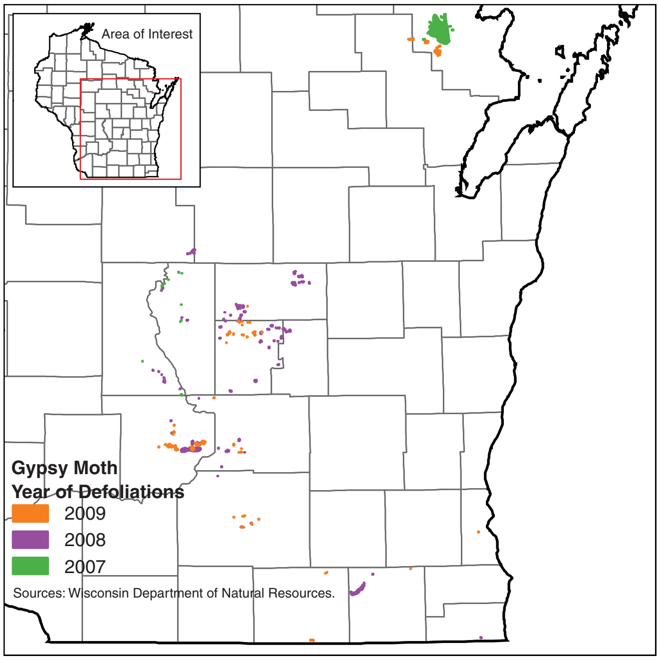


Figure 65.—Distribution of defoliation in Wisconsin by gypsy moth between 2004 and 2009.

Invasive pests and disease have the potential to change forest composition, some in dramatic ways and others more subtlety. For pests where the host has little resistance, such as emerald ash borer and beech bark disease, the host species are likely to be eventually removed from the forest community, as has been the case with American elm (*Ulmus americana*) and American chestnut (*Castanea dentata*). Collection and propagation of resistant strains of ash and beech may allow eventual reintroduction of these species into the forest in combination with establishment of natural controls of the pests and other aspects of an integrated pest management approach. Other invasive pests, such as gypsy moth, stress but do not eliminate their hosts. As has been observed elsewhere in North America, we can expect outbreaks about every 5 years in areas with dry, sandy soil, and contiguous oak or aspen similar to the Stevenson Township area or parts of central Wisconsin. In mixed forests on moister soils, outbreaks are expected frequently with 10 or more years between defoliation by high numbers of gypsy moth. In Pennsylvania, periodic defoliation by gypsy moth since the mid-20th century is considered to have led to a 3 percent reduction in the oak component of that State's forests and we may eventually see a similar small change. The long-term effect of some invasive species, such as ash yellows, Annosum root rot, and oak wilt, is not clear at this time.

In addition to new invasive pests, our native pest species have the potential to change behavior and impact. It is not clear if feeding by jack pine budworm on red pine along the southern edge of the pest's range represents a response to a short-term increase in the palatability of red pine in that area or a longer term host shift by the local population. Further observation may clarify the situation.

Emerald Ash Borer

Background

The emerald ash borer (EAB; *Agrilus planipennis*) is native to Asia and is thought to have been introduced accidentally to the Detroit area in the mid-1990s before being first detected there in 2002. In North America, EAB has only been identified as a pest of ash and all native species of ash appear to be susceptible, even when healthy (Cappaert et al. 2005, Poland and McCullough 2006). This insect causes ash tree death when larvae feed under the bark, cutting off the flow of water and nutrients. Spread of EAB has been facilitated by human transportation of infested material, typically firewood. Systemic insecticides injected into trees can provide 1 to 3 years of protection, and three species of parasitoids have been cleared for introduction into the United States.

What We Found

In August 2008, EAB was observed for the first time in Wisconsin; a well established population of EAB was found in Newburg, Ozaukee County (Fig. 66). The area is rural residential with ash dominated woodland along the upper reaches of the Milwaukee River. Dendrochronology, or tree ring dating, indicates the insect had been there at least since 2004. In April 2009, a population that covered a larger area was found on the opposite side of the state along the Mississippi River in Victory, Vernon County, and dated back to 2006.

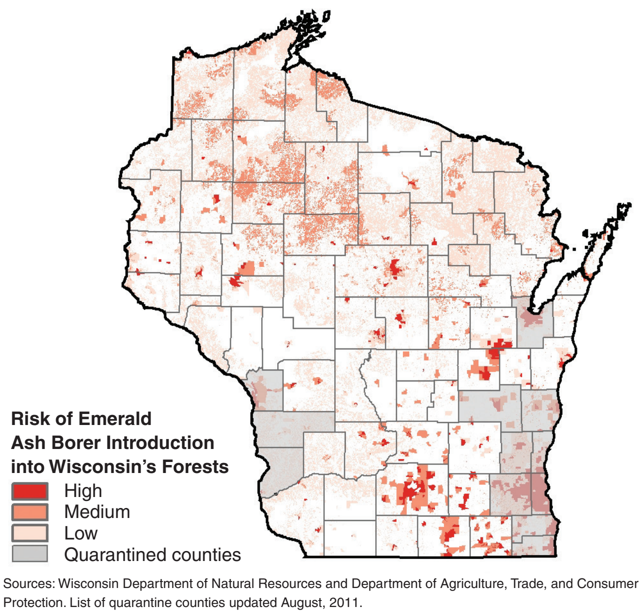


Figure 66.—Risk model of emerald ash borer introduction into Wisconsin's forests with counties under quarantine as of August, 2011.

As the year progressed, many infested trees were found in the Milwaukee-area communities of Oak Creek, Franklin, and Kenosha and an adult EAB was trapped in Green Bay.

The risk of spread of EAB throughout the rest of Wisconsin is thought to be highly dependent on the amount of ash, on human population density, and to a lesser extent on the number of campsites and seasonal homes (Fig. 66). The risk model developed by the Wisconsin DNR has helped guide State and Federal officials on where to conduct detection surveys.

A great deal of the forest resource is threatened. Wisconsin's forest land contains an estimated 807.5 million ash trees (greater than 1-inch diameter) and 1.4 billion cubic feet of live ash volume (greater than 5-inch diameter). Black ash, which grows on mesic and wet sites, is the most common species of ash. Green ash is found growing most commonly with other hardwoods on bottomland sites. White ash may be a component of several forest types and is more common on upland sites. Ash is found throughout Wisconsin but is most common in the northern half of the State (Fig. 67). Ash is present on 5.8 million acres, or 35 percent of forest land, but is rarely the most abundant species in a stand (Fig. 68). Instead, ash generally makes up less than 25 percent of total live-tree basal area. Green and white ash together are the second most common tree in Wisconsin communities, making up an average of 20 percent of urban trees and potentially serving as a conduit for establishment of EAB into Wisconsin forests.

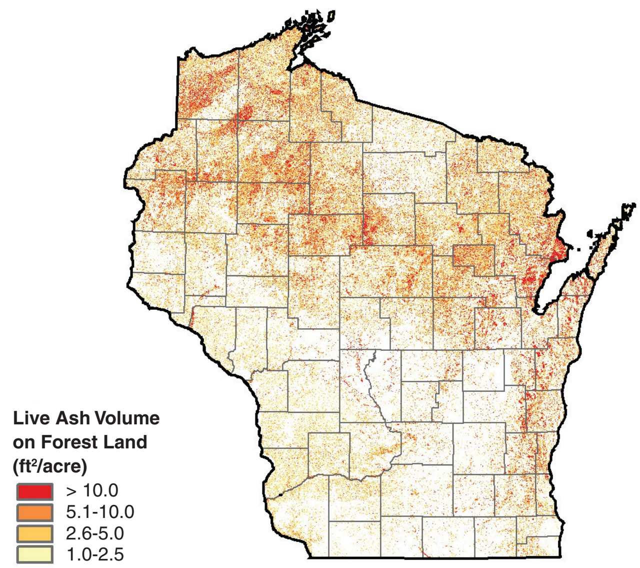


Figure 67.— Ash density on forest land, Wisconsin, 2009.

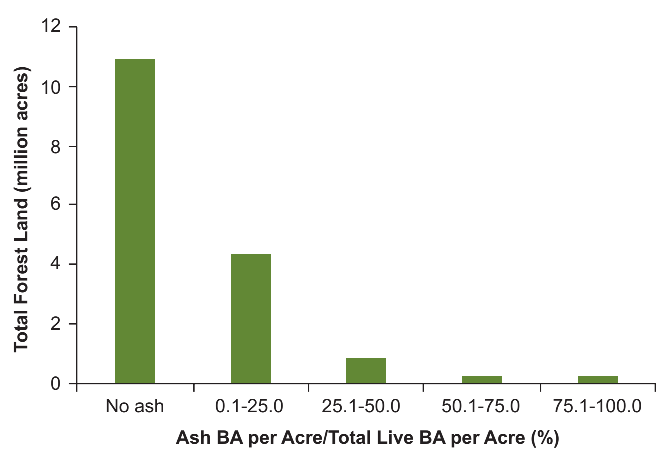


Figure 68.—Presence of ash on forest land, as a percentage of live-tree basal area (BA), Wisconsin, 2009.

What This Means

The emerald ash borer has the potential to kill millions of ash trees on several forest types throughout Wisconsin. The impact of EAB is expected to rival that of chestnut blight and Dutch elm disease. In addition to economic losses, ash mortality in forested ecosystems will affect species composition and alter community dynamics. Of particular concern is the loss of black and green ash on mesic to wet sites. These wet sites may have few to no other species of trees present. Growing other species to replace lost ash on these wet sites is limited by our knowledge of regeneration practices and challenged by invasion of exotic plants such as reed canarygrass (*Phalaris arundinacea*). Natural spread along river corridors appears to be already happening particularly along the Mississippi River where EAB has since been found on the western shore in Minnesota and Iowa and north and south from the original Victory find. Widespread mortality of ash along the river has not yet occurred but is expected in the next few years as populations of the pest build in already infested trees.

Quarantines have been placed on counties where EAB has been found in or near. These quarantines limit movement and destination of ash from quarantined areas to prevent spread of EAB. Mills outside the quarantined area may only receive ash logs from quarantined areas if they agree to comply with shipping and processing requirements. Logs may be moved from quarantined areas to mills outside of the quarantine from October to the end of March when EAB are in the pre-pupal stage within logs. The receiving mills must process the logs and any waste by the end of April to prevent emergence of adult EAB. All hardwood firewood is prohibited from leaving the quarantined area unless treated to kill infesting EAB. No ash nursery stock is allowed to leave the quarantined area as there is no treatment to ensure it is free of EAB.

Nonnative and Invasive Plants Species

Background

Nonnative plants can be detrimental to native forest ecosystems, threatening ecological diversity, increasing forest management costs through their impact on forest tree regeneration and growth, and limiting management options.

What we found

Forest inventory data was collected on 96 vegetation diversity plots from 2007 to 2009. A regional guide to nonnative invasive plants was used to identify species of interest (Olson and Cholewa 2009). Seventeen different species were identified in Wisconsin's forests in 2009 (Fig. 69; Table 1); this is an increase from nine species in 2004. The two most common nonnative invasive species were reed canarygrass (*Phalaris arundinacea*) and common buckthorn (*Rhamnus cathartica*). One or more species were found on 50 plots (Fig. 70), but it was relatively uncommon to find two or more species occurring on the same plot (21 percent). Particular concerns are raised when comparing the 2009 inventory with the 2004 inventory. The frequency of two or more invasive species per plot is greater in the 2009 inventory than the 2004 inventory (21 and 13 percent, respectively). Reed canarygrass was one of 15 species which increased in occurrence between 2004 and 2009; only two species (multiflora rose (*Rosa multiflora*) and black locust (*Robinia pseudoacacia*)) declined in occurrence between 2004 and 2009. The sampling of invasive species is still relatively new, so this data does not define a solid trend.

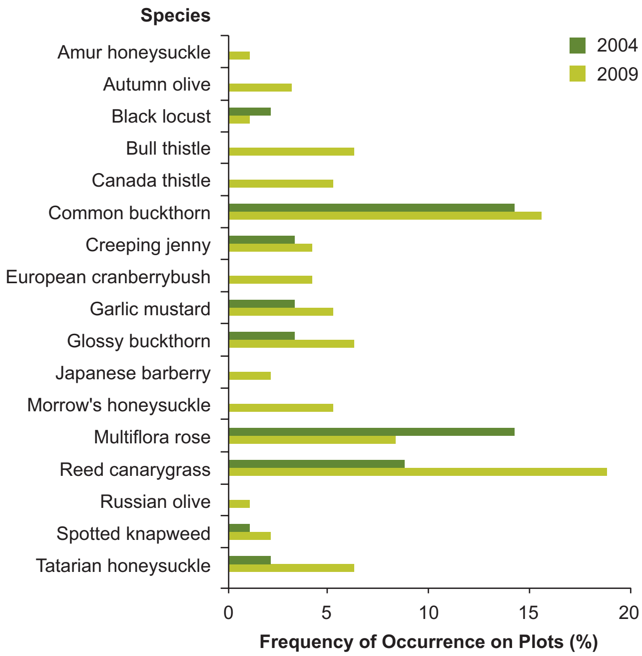


Figure 69.—Frequency of occurrence of nonnative invasive understory plants, Wisconsin, 2004 and 2009.

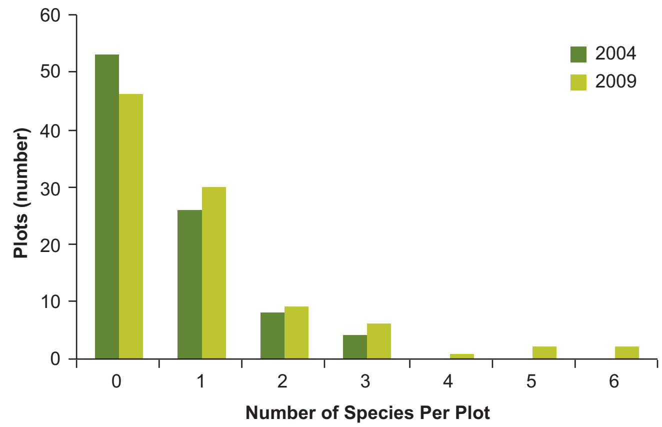


Figure 70.—Distribution of nonnative invasive species observed on vegetation diversity plots, Wisconsin, 2004 and 2009.

Table 1. List of nonnative invasive species observed in Wisconsin, 2007-2009. Additional information is available in the USDA Plants Database (USDA NRCS 2012).

Common name	Scientific name
Amur honeysuckle	*Lonicera maackii*
Autumn olive	*Elaeagnus umbellata*
Black locust	*Robinia pseudoacacia*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Common buckthorn	*Rhamnus cathartica*
Creeping jenny	*Lysimachia nummularia*
European cranberrybush	*Viburnum opulus*
Garlic mustard	*Alliaria petiolata*
Glossy buckthorn	*Frangula alnus*
Japanese barberry	*Berberis thunbergii*
Morrow's honeysuckle	*Lonicera morrowii*
Multiflora rose	*Rosa multiflora*
Reed canarygrass	*Phalaris arundinacea*
Russian olive	*Elaeagnus angustifolia*
Spotted knapweed	*Centaurea biebersteinii*
Tatarian honeysuckle	*Lonicera tatarica*

What this means

Although nonnative plant species represent a minority of species in Wisconsin's forests, they are a forest health concern because they can out-compete native plant species, including trees, and threaten ecological diversity by altering natural plant communities. Some species already are distributed across the State but several are not, and this may present managers with opportunities for limiting range expansion. The vegetation diversity sample is relatively small (96 plots over 3 years); the increasing numbers of several invasive species requires continued attention to determine if this is a long-term trend.

Forest Economics

Red pine stand. Photo by Steven Katovich, U.S. Forest Service, bugwood.org.

Growing-stock Volume

Background

The growing-stock volume distributed across Wisconsin's timberland constitutes an important resource in the State's economy. Wisconsin leads the nation in paper production, as it has for many years. To evaluate the effects of past paper and lumber production as well as estimate future resource production, it is helpful to know the growing-stock volume of certain tree species and how this is changing.

What we found

The total volume of growing stock on Wisconsin timberland has increased since 1956; the current estimate is 21.1 billion cubic feet (Fig. 71). The volumes of several species groups have increased while several others have decreased over the past three inventories (Figs. 72 and 73). The eastern white and red pines group has the largest softwood growing-stock volume across Wisconsin. In the hardwood species groups, cottonwood and aspen, followed by soft maple, hard maple, and select red oaks have the largest growing-stock volumes in the State. The eastern white and red pines (softwoods) and soft maple (hardwoods) groups have had the greatest gains in growing-stock volume since 1983. The total volumes in larger diameter classes have increased since 1983 in both softwoods (Fig. 74) and hardwoods (Figure Fig. 75). Growing-stock volume in most Wisconsin counties increased between 1983 and 2009, with the largest gains in the heavily forested northern counties (Fig. 76).

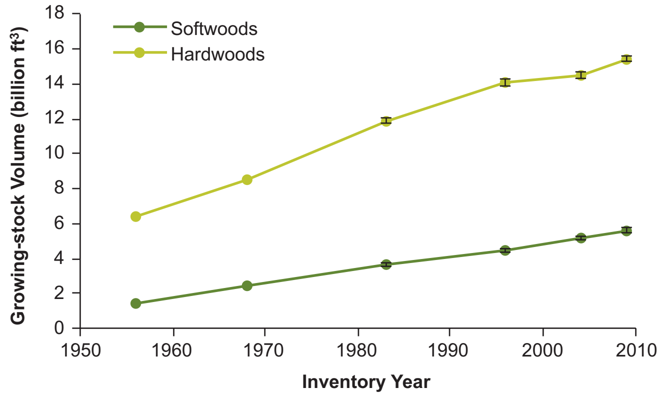


Figure 71.—Growing-stock volume on timberland by major species group and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

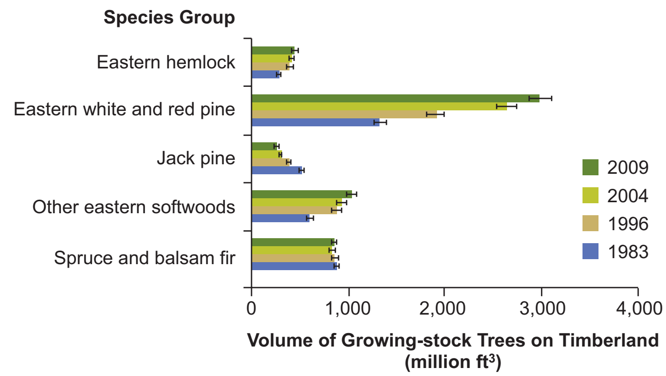


Figure 72.—Volume of softwood growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

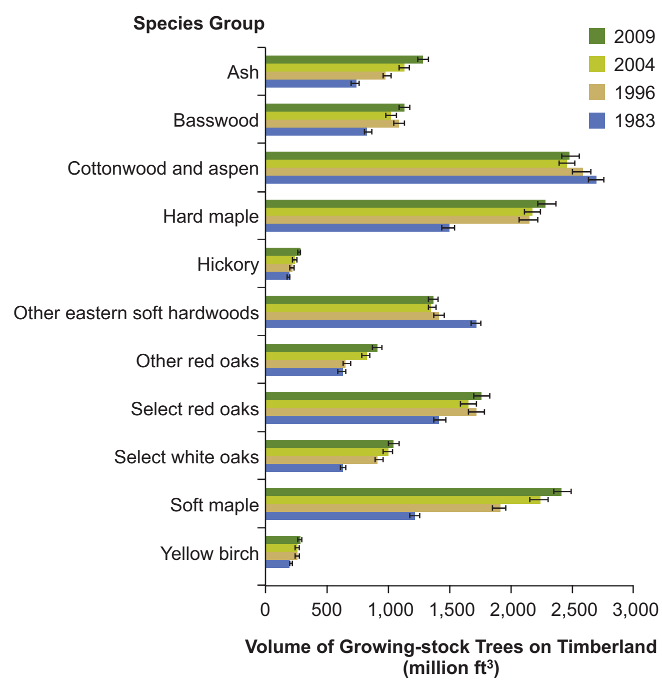


Figure 73.—Volume of hardwood growing-stock trees on timberland by inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

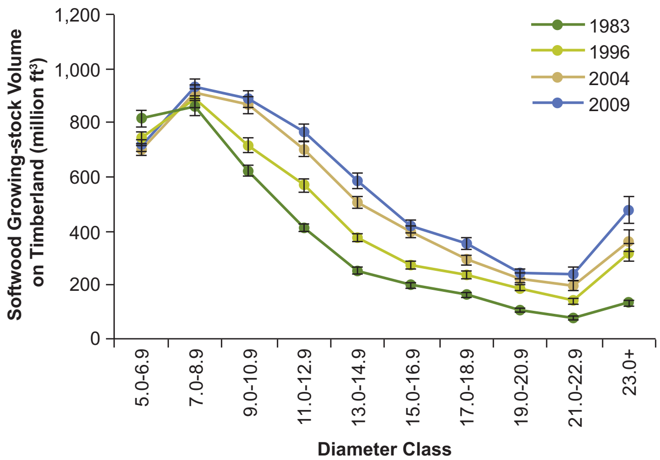


Figure 74.—Volume of softwood growing-stock trees on timberland by diameter class and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

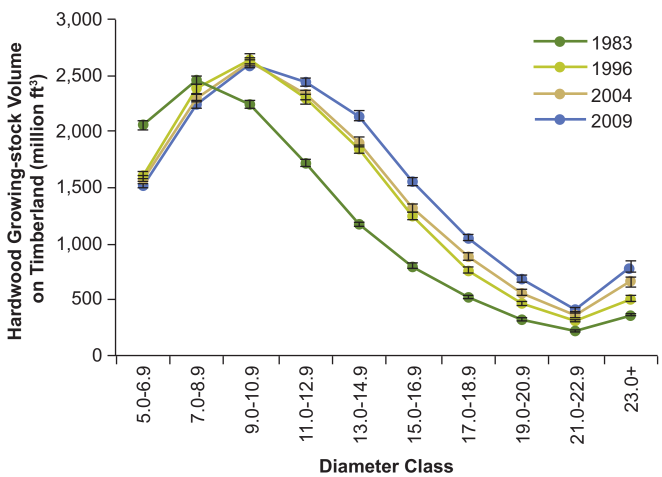


Figure 75.—Volume of hardwood growing-stock trees on timberland by diameter class and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

What this means

The volume of growing stock on Wisconsin's timberland has been increasing steadily over the past 50 years. Although economically important species groups have shown growth in total volume and average volume per acre, the rate of increase has not been equally apportioned across all species groups. Species groups such as eastern white and red pines and soft maple have experienced large increases in growing-stock volumes, but jack pine, aspen, and the oaks have shown smaller increases or decreases. The increase in growing-stock volume can be attributed to the aging of the forest, limited mortality, net growth exceeding removals, and increasing timberland area over the last 50 years. Wisconsin's growing-stock inventory appears stable and growing, but it could be compromised by invasive plant species, insects and diseases, and loss of timberland to development.

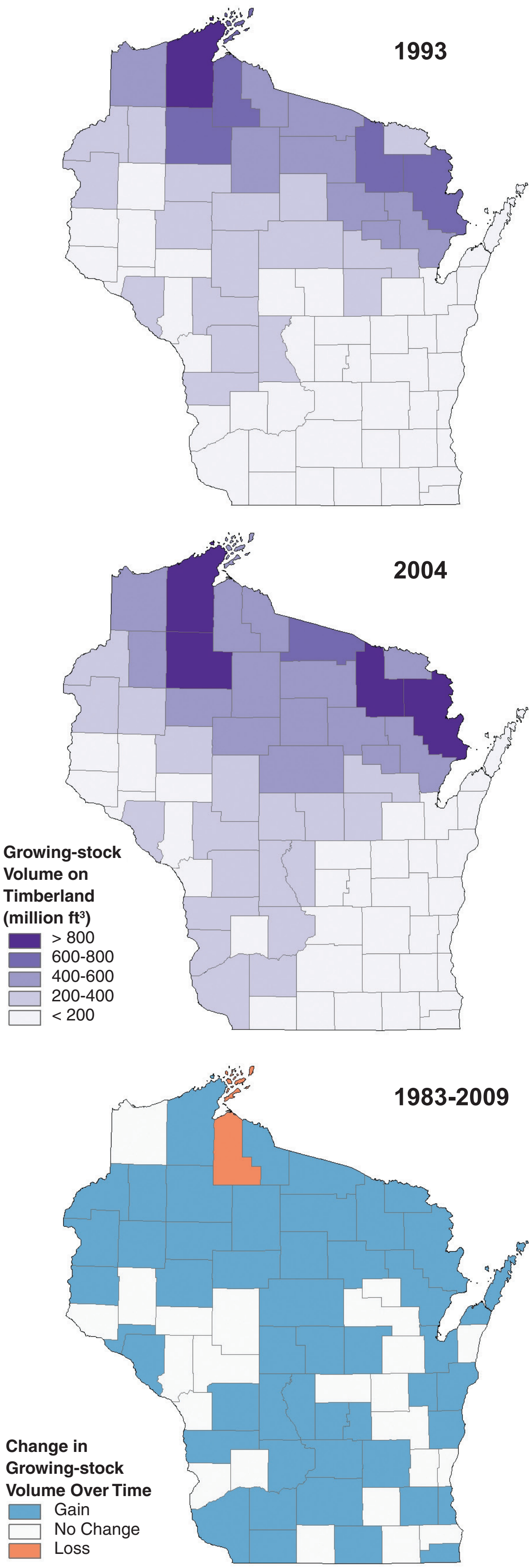


Figure 76.—Distribution of change in growing-stock volume in Wisconsin. Observations of change are significant at the 68 percent confidence interval (1 standard error).

Sawtimber Volume

Background

Sawtimber volume is an important indicator of the economic value of Wisconsin's forests. This resource not only provides direct economic benefit through sawtimber and veneer sales but also supports wood-using secondary industries such as furniture and millwork manufacturing. The quantity of sawtimber needs to be measured to accurately gauge its economic value.

What we found

Sawtimber volume has increased steadily across Wisconsin since 1956 and it is currently estimated to be 62.1 billion board feet (Fig. 77). This increase has not been uniform across all species groups. The sawtimber volume of most economically valuable species groups increased between 1996 and 2009. The eastern white and red pines, soft maple, and other red oaks groups have increased in sawtimber volume by more than 30 percent since 1996 (Fig. 78). There was a major decline in jack pine sawtimber volume (27 percent). The net growth, removals, and mortality of sawtimber have remained relatively constant since 1983 (Fig. 79).

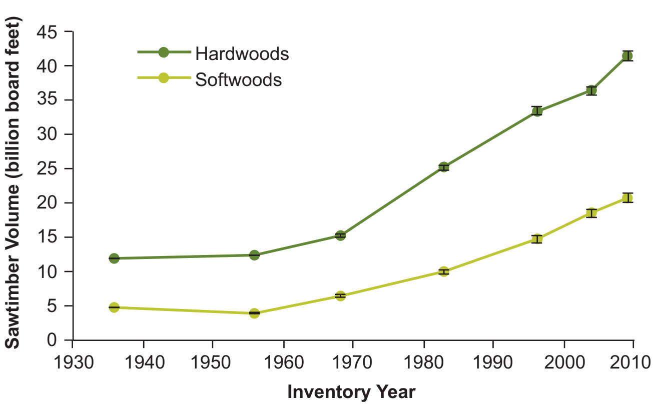


Figure 77.—Volume of sawtimber on timberland by major species group and inventory year, Wisconsin. Error bars show the 68 percent confidence interval.

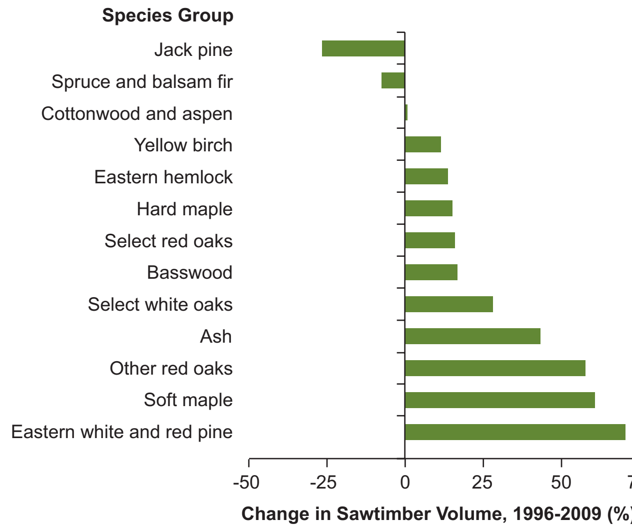


Figure 78.—Change in sawtimber volume on timberland by species group and inventory year, Wisconsin.

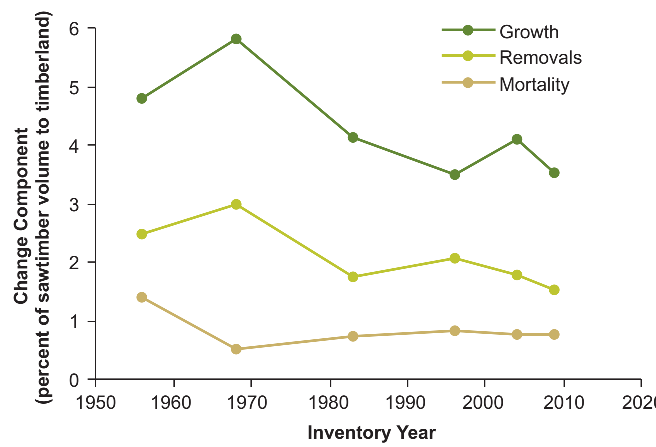


Figure 79.—Components of change for sawtimber on timberland by inventory year, Wisconsin.

What this means

Sawtimber growth, removals, and mortality have stabilized since the 1980s, and this has resulted in a steady increase in the supply of sawtimber on Wisconsin timberland.

Sawtimber Quality

Background

Just as the sawtimber volume is an important indicator of the economic value of Wisconsin's forests, it is also important to understand the quality of that sawtimber. The quality of sawtimber directly impacts the economic benefits of sawtimber and veneer sales and also supports wood-using secondary industries such as furniture and millwork manufacturing. Both the quality and quantity of sawtimber needs to be measured to accurately gauge its economic value.

What we found

Sawtimber quality is classified by grades 1 to 3; 1 represents the highest quality and 3 the lowest. Overall, all grades of sawtimber increased in volume between 1983 and 1996. Grade 1 increased by 7 percent between 2004 and 2009 and grade 2 has remained fairly constant as a percentage of total sawtimber since 1996 (Fig. 80).

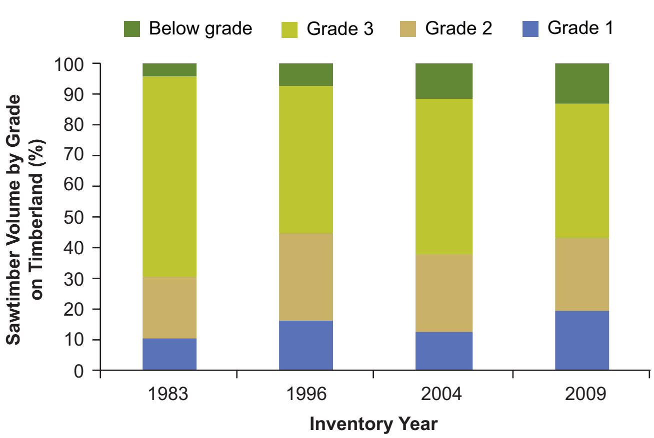


Figure 80.—Distribution of sawtimber volume on timberland by grade and inventory year, Wisconsin.

What this means

There are ever-increasing global demands for wood products, continued development pressures, and threats from invasive pests. Developing well informed policy and management decisions that sustain high quality forest resources in Wisconsin require continued monitoring of sawtimber quantity and quality.

Timber Products

Background

Wisconsin's wood products and processing industry is significant to the State's economy and is a key component of sustainable forest management. The harvesting and processing of timber products produces a stream of income shared by timber owner, managers, marketers, loggers, truckers, and processors. The primary and secondary wood-using industries encompass sectors including, but not limited to, sawmills, pulpmills, veneer and plywood manufacturers, and flooring, millwork, and furniture producers. The industry provides employment for nearly 61,000 workers in the State and generates a value of shipments worth $17.9 billion (WDNR 2010). To better manage the State's forests, it is important to know the species, amounts, and locations of timber being harvested.

What We Found

Surveys of Wisconsin's wood-processing mills are conducted periodically to estimate the amount of wood volume that is processed into products (Haugen and Everson in preparation[2]). This is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from Wisconsin. In 2008, there were 226 active primary wood processing mills surveyed to determine the species that were processed and the source of wood material; this represents a stable mill count since the last inventory (Fig. 81). These mills processed 230.9 million board feet of saw logs, veneer logs, pulpwood, and other wood products.

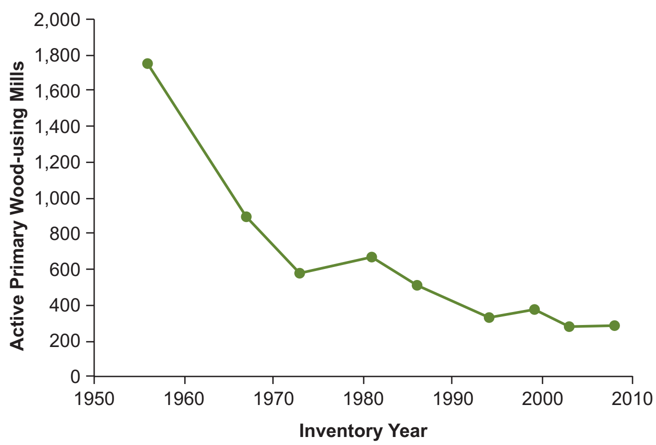


Figure 81.—Number of active primary wood-using mills by inventory year, Wisconsin.

In 2008, 261.3 million cubic feet of industrial roundwood was harvested from Wisconsin's forest land. Pulpwood accounted for 65 percent of the total industrial roundwood harvested, and saw logs accounted for 30 percent (Fig. 82). Other products harvested were veneer logs, excelsior/shavings, post, poles, cooperage, cabin logs, and industrial fuelwood. Maple, aspen, and pine accounted for almost 70 percent of the total industrial roundwood harvest in 2008 (Fig. 83). Other important species groups harvested were the oak, basswood, birch, and spruce.

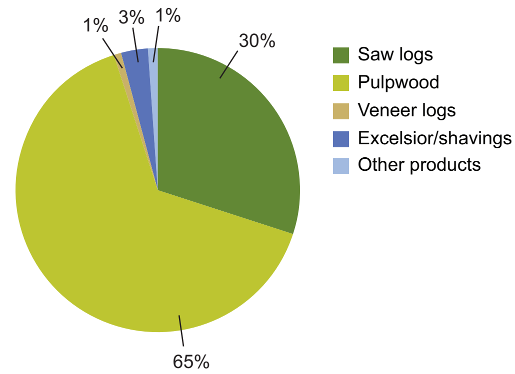


Figure 82.—Allocation of industrial roundwood harvest by product type, Wisconsin, 2008.

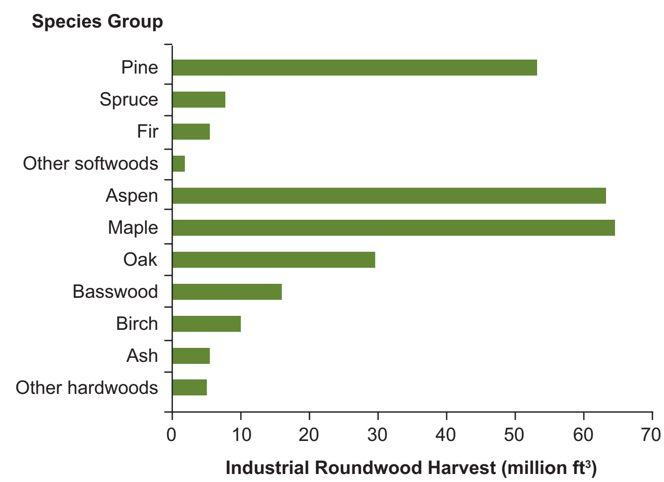


Figure 83.—Allocation of industrial roundwood harvest by species group, Wisconsin, 2008.

In the process of harvesting industrial roundwood, 106.3 million cubic feet of harvest residues were left on the ground (Fig. 84). Eight-five percent of the harvest residues came from nongrowing-stock sources such as crooked or rotten trees, tops and limbs, and dead trees. The processing of industrial roundwood in the State's primary wood-using mills generated 1.9 million green tons of wood and bark residues. Just over half of the mill residues generated were used for industrial fuelwood and a quarter was used for fiber for the pulp and particleboard industry. Other secondary products from Wisconsin's primary mill residues include residential fuelwood, wood pellets, mulch, and animal bedding. Only 3 percent of the mill residues were unused (Fig. 85).

[2]Manuscript in preparation, Daugen, D.E.; Everson V.A. Wisconsin timber industry—an assessment of timber product output and use, 2008. To be published by the Northern Research Station, U.S. Forest Service.

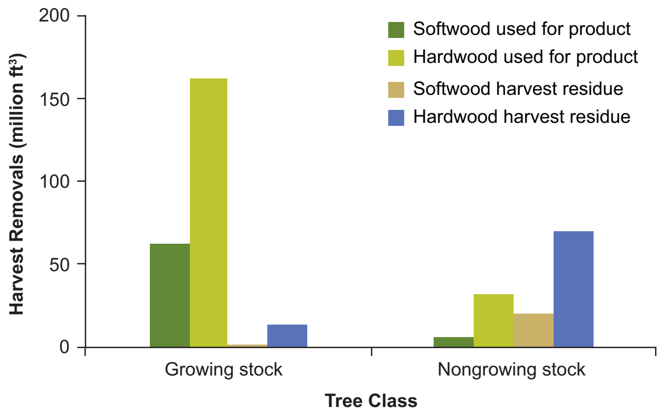


Figure 84.—Allocation of industrial harvest removals by tree class and use, Wisconsin, 2008.

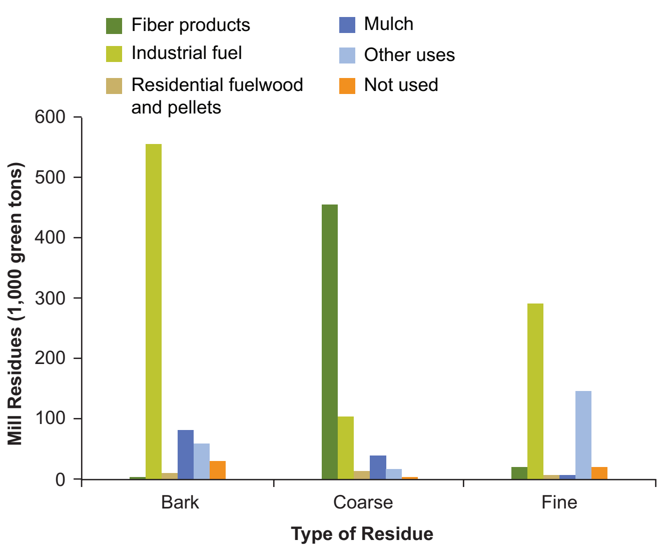


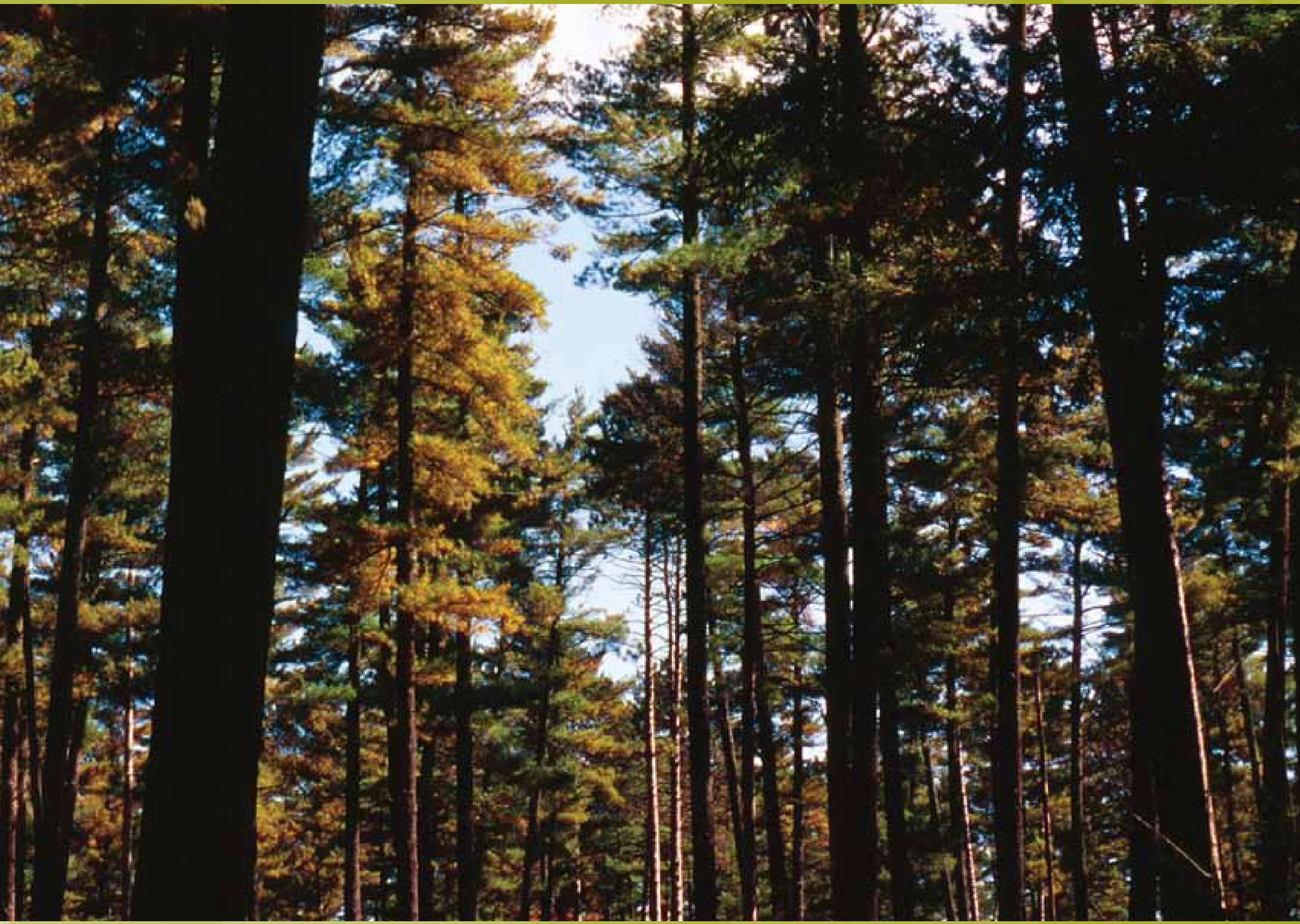
Figure 85.—Disposition of mill residue generated by primary wood-using mills, Wisconsin, 2008.

What This Means

Well designed forest harvests are an essential part of maintaining forest health, ecological services, and our State's economy. The poor economy has led to the idling and closure of an increased number of primary wood-processing facilities. An important consideration for the future of the primary wood-products industry is its ability to retain industrial roundwood processing facilities. The loss of processing facilities is not only important for the number of jobs that are lost, but it makes it harder for landowners to find markets for the timber harvested from management activities on their forest land.

The closure of six of Wisconsin's pulp and composite panel mills since 2000 means that there are fewer options for utilization of the smaller-diameter sections of the harvested trees. Nearly 15 percent of the harvest residue generated during the harvest is from growing stock sources (wood material that could be used to produce products). Industrial fuelwood or wood pellets could be possible markets for the smaller diameter material, and thus, could lead to better utilization of the forest resource.

Data Sources and Techniques



Eastern white pine. Photo by Linda Haugen, U.S. Forest Service.

Forest Inventory

Information on the condition and status of forests in Wisconsin was obtained from the Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of the State's forest resources were completed in 1936, 1956, 1968, 1983, 1996, and 2004 (Cunningham and Moser 1938; Cunningham et al. 1939; Kotar et al. 1999; Perry et al. 2007; Schmidt 1998; Spencer and Thorne 1972; Spencer et al. 1988; Stone and Thorne 1961).

Tabular data can be generated at the Forest Inventory and Analysis Data Center Web page at http://www.fiatools.fs.fed.us/. Additional details can be found in "Wisconsin's Forests 2009: Statistics, Methods, and Quality Assurance," on the DVD in the inside back cover pocket of this bulletin.

For additional information about FIA, contact: Program Manager, Forest Inventory and Analysis, Northern Research Station, 1992 Folwell Avenue, St. Paul, MN 55108 or State Forester, Wisconsin Department of Natural Resources, Division of Forestry, P.O. Box 7921, Madison, WI 53707-7921.

National Woodland Owner Survey

Information about family forest owners is collected through the U.S. Forest Service's National Woodland Owner Survey (NWOS). The NWOS is designed to increase our understanding of owners' attitudes, behaviors, and related characteristics (Butler et al. 2005). Individuals and private groups identified as forest owners by FIA are invited to participate in the NWOS. Data presented here are based on survey responses collected between 2002 and 2006 from 1,525 randomly selected families and individuals who own forest land in Wisconsin. For additional information about the NWOS, visit: http://www.fia.fs.fed.us/nwos.

Timber Products Output Inventory

Information on the harvest and use of forest products is collected under a cooperative effort of the Division of Forestry of the Wisconsin Department of Natural Resources (WIDNR) and the Northern Research Station (NRS). Using a questionnaire designed to determine the size and composition of Wisconsin's forest products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, Wisconsin Division of Forestry personnel visited all "known" primary wood-using mills within the State. Completed questionnaires were sent to NRS for processing and analysis. The last complete survey was collected in 2008 (Haugen and Everson in preparation[2]). As part of this inventory, 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.

Mapping Procedures

Maps in this report were constructed using (1) categorical coloring of Wisconsin's counties according to forest attributes (such as forest land area); (2) a variation of the k-nearest-neighbor (kNN) technique to apply information from forest inventory plots to remotely sensed MODIS imagery (250-m pixel size) based on the spectral characterization of pixels and additional geospatial information (Wilson et al. 2012); or (3) colored dots to represent plot attributes at approximate plot locations. Geographic base data was provided by the National Atlas of the United States (U.S. Geological Survey 2012). Any additional data sources are reported with the relevant maps.

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The second full annual inventory of Wisconsin's forests reports more than 16.7 million acres of forest land with an average volume of more than 1,400 cubic feet per acre. Forest land is dominated by the oak/hickory forest-type group, which occupies slightly more than one quarter of the total forest land area; the maple/beech/birch forest-type group occupies an additional 23 percent. Forty-two percent of forest land consists of large diameter stands, 23 percent contains medium diameter stands, and 8 percent contains small diameter stands. The volume of growing stock on timberland has been rising since the 1980s and currently totals more than 21.1 billion cubic feet. The average annual net growth of growing stock on forest land from 2005 to 2009 is approximately 572 million cubic feet per year. This report includes additional information on forest attributes, land use change, carbon, timber products, forest health, and statistics and quality assurance of data collection.

KEY WORDS: inventory, forest statistics, forest land, volume, biomass, carbon, growth, removals, mortality, and forest health

DVD Contents

Wisconsin’s Forests 2009 (PDF)

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

Wisconsin Inventory Database (CSV file folder)

Wisconsin Inventory Database (Access file)

Field guides that describe inventory procedures (PDF)

Database User Guides (PDF)

Wisconsin's Forests 2009
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