Wisconsin's Forests

2004

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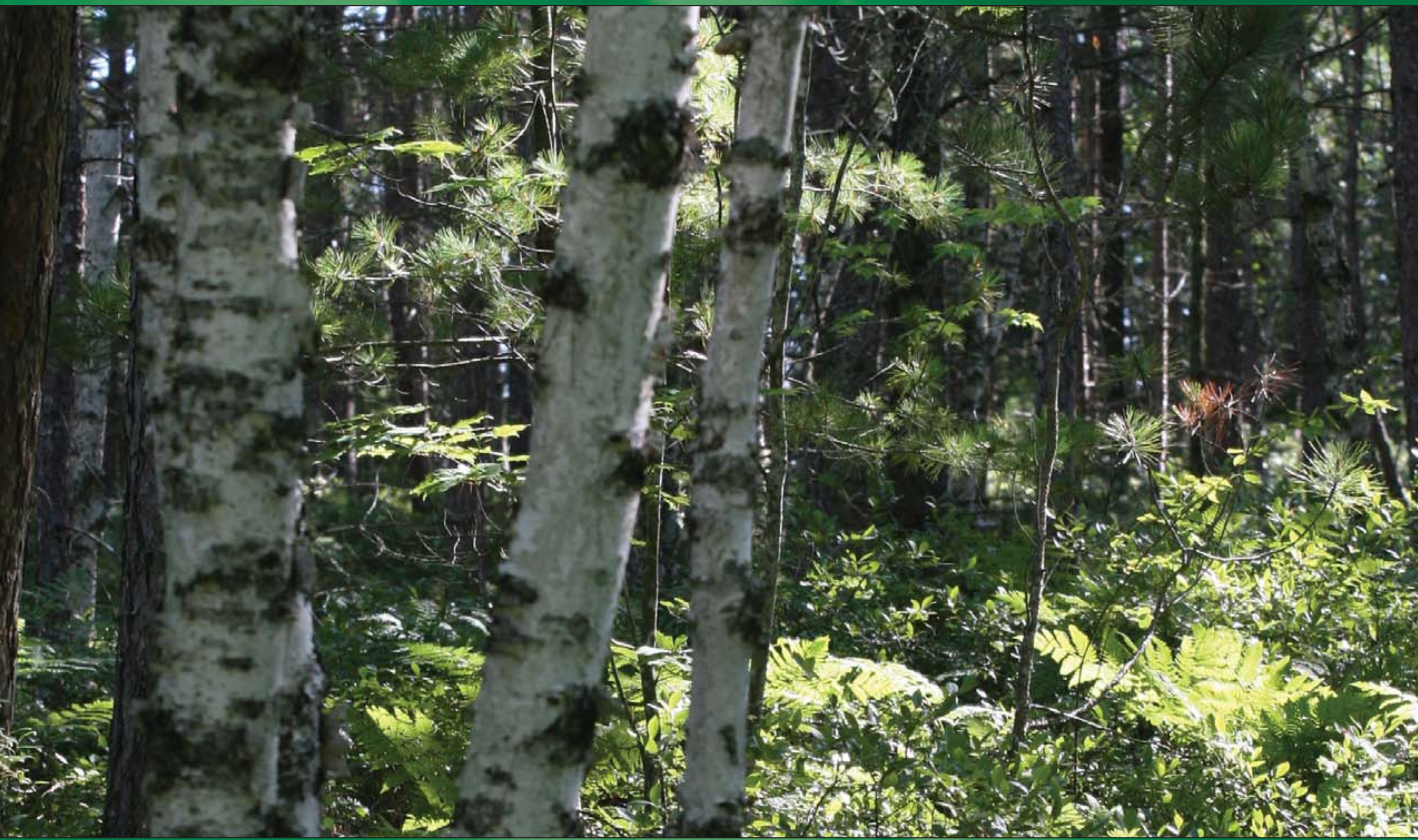
NRS-23



USDA United States Department of Agriculture

Forest Service

Northern Research Station

Acknowledgments

The achievements of an organization are the results of the combined effort of each individual. – Vince Lombardi

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Core tables, a glossary, and sample quality assurance/control methods will be included in a companion document, Wisconsin's Forests, 2004: Statistics and Quality Assurance, Resource Bulletin NRS-24, to be published online only. Data from the Wisconsin forest inventory can be accessed at: http://fiatools.fs.fed.us

Cover: Boreal forest. Photo by Charles H. (Hobie) Perry.

Wisconsin's Forests

2004

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Foreword

Our forests are one of our most precious assets. Today, there are more than 16 million acres of forest land in Wisconsin, or 46 percent of our State's land area. Since the mid-1960s, the extent of forest land in Wisconsin has been expanding and both the average age and volume of trees has been increasing. These increases have been realized during the same period in which Wisconsin's forests have provided a steady flow of wood that fuels a major component of the State's economy, helping meet society's large demand for wood products.

The tremendous diversity in Wisconsin's forests is the result of the State's position along the tension zone between the Laurentian mixed forest and the broadleaf forest. The northern forests are dominated by maples, aspen, northern red oak, basswood, and red and white pine. The southern forest is more fragmented as a result of fire in presettlement times and the removal of forest cover for agriculture during the mid-19th century. The southern forests are dominated by the oaks with a lesser mix of maple and basswood.

Logging of Wisconsin's forests began in earnest in the late 1860s. By 1893, logging had reached its zenith with more than 3.5 billion board feet harvested that year. Unfortunately, the forest was simply cut, not managed carefully with a view to the future. As a result, by the 1930s most of the valuable timber in the State's northern region had been removed or destroyed by fire. The first forest inventory conducted in Wisconsin in 1936 revealed a young forest with aspen-birch as the most prevalent forest type. Since that time, the State's forests have been in a process of recovery, the benefits of which we now enjoy.

Wisconsin now supports a wide array of healthy forest ecosystems that provide an array of wood products and other benefits which expand with our growing forests. However, this valuable resource is threatened by fragmentation and parcelization, invasive species, development in fire-prone areas, and conflicts among recreational users. These are among the many issues that challenge our collective ability to maximize the protection and sustainable management of Wisconsin's forests so that they can provide the full array of ecological, economic, and social benefits for current and future generations.

To know whether Wisconsin's forests are being managed in a sustainable manner, we need to be able to report on the status and trends of forest resources. The U.S. Forest Service, Forest Inventory and Analysis (FIA) Program in partnership with the Wisconsin Department of Natural Resources' Division of Forestry inventoried Wisconsin's forest resources in 1936, 1956, 1968, 1983, and 1996. In 1999, periodic inventories were replaced with annual inventories in which a portion of the field plots was inventoried each year; a full inventory is completed every 5 years. The first full annual inventory of Wisconsin was completed in 2004 and covers the period 2000-04. In addition, a pilot inventory of Wisconsin's urban forests was performed by the Forest Service in 2002 and provides a first-ever look at this part of Wisconsin's forest resource.

In this report we describe and highlight the current status and trends observed within Wisconsin's forests. We hope that this information will stimulate discussion about the State's forest resources and motivate additional research and analysis, as a well as an increased commitment to protecting and managing sustainably one of Wisconsin's most precious assets.

Paul DeLong

Paul DeLong, Chief State Forester

Contents

Highlights . . . 6

- On the Plus Side . . . 6
- Areas of Concern . . . 7
- Issues to Watch . . . 8

Background . . . 11

- A Brief Primer on Forest Inventory . . . 12

Where are Wisconsin's Forests? . . . 17

- Ecoprovinces of Wisconsin . . . 18
- Distribution of Forest Land by Forest Type . . . 20
- Distribution of Forest Land by Ownership . . . 23

Forest Features. . . . 27

- Forest Land and Timberland Area . . . 28
- Biomass: A Weighty Issue. . . . 32
- Tree Composition of Wisconsin's Forests . . . 35
- Forest Age and Size Structure . . . 39
- Changes in the Oak Forest . . . 42
- Growing-Stock Volume . . . 47
- Sawtimber Quantity and Quality . . . 52

Forest Health Indicators . . . 55

- Down Woody Materials . . . 56
- Tree Crowns . . . 60
- Forest Soils . . . 62
- Ozone Damage . . . 66
- Forest Invaders: Nonnative Plant Species. . . . 69
- The Urban Forest . . . 72

Forest Change Issues 77
Nonindustrial Private Landowners 78
Forest Insects and Diseases 82
Emerald Ash Borer 86
Forest Products 89
Timber Product Output 90
Certification: Documenting Sustainability 94
Data Sources and Techniques 95
Forest Inventory 96
Sampling Phases 97
Timber Products Ouput Survey 100
National Woodland Landowner Survey 100
Ozone Bioindicator Species and Survey History 101
Literature Cited 101

Highlights

On the Plus Side

- Although Wisconsin ranks 25th among the 50 states in land area, it ranks 23rd in the area of forest land and 14th in timberland area.
- The 16 million acres of forest land in Wisconsin account for 46 percent of the State's land area.
- There are approximately 2.4 billion live trees on Wisconsin's forest land that are at least 5 inches in diameter at breast height (d.b.h., 4.5 feet above the ground).
- The total area of two forest types – elm/ash/cottonwood and white/red/jack pine – have increased significantly since the 1996 inventory. There are 1.35 million acres of elm/ash/cottonwood and about 1.46 million acres of forest land in white/red/jack pine.
- The majority of Wisconsin's forest land (56 percent or 8.9 million acres) is owned by nonindustrial private forest-land owners.
- The public owns 32 percent of Wisconsin's forest land.
- The total area of forest land and timberland continues an upward trend that began in the 1960s, albeit at a slower rate.
- Wisconsin's forests sequester 1.5 billion metric tons of carbon. With the increase in forest volume, there has been an increase in the amount of carbon sequestered. Sixty percent is stored in the soil but the live-tree component accounts for nearly 28 percent.
- Red maple, sugar maple, and red pine continue to increase in both number of trees and total volume.
- The age distribution observed on timberland is shifting slowly toward larger diameter trees between 60 and 99 years old.
- The volume of growing-stock trees greater than 5 inches d.b.h. on Wisconsin's timberland has increased by about 32 percent over the last 20 years.

- Sawtimber growth, removals, and mortality has stabilized since the 1980s, resulting in a steady increase in the supply of sawtimber on timberland.
- Wisconsin's wood-products and processing industry employs more than 93,000 workers with an output of nearly $24 billion.
- The distribution of fuel in the form of down and dead wood generally mimics that found in neighboring states.
- Nearly 30 percent of Wisconsin's forest land is registered under some form of third-party certification.

Areas of Concern

- The total area of forest land in both the maple/beech/birch and aspen/birch forest-type groups has declined by 5 percent since the 1996 inventory.
- Forest land declined in some counties and this trend was not restricted to the State's most populated metropolitan counties.
- Over the past 20 years, quaking aspen, paper birch, and balsam fir have lost significant numbers of trees and declined in total volume. Jack pine and bigtooth aspen also are declining in number.
- The area of timberland with trees more than 100 years old continues to decline.
- The extent of the oak forest is holding steady but older oak forests on sites of medium-to-high productivity are being lost, and young oak forests are regenerating poorly.
- Jack pine showed significant declines in sawtimber volume.
- There are fewer standing dead trees now than in the 1996 inventory. This could affect wildlife habitat.

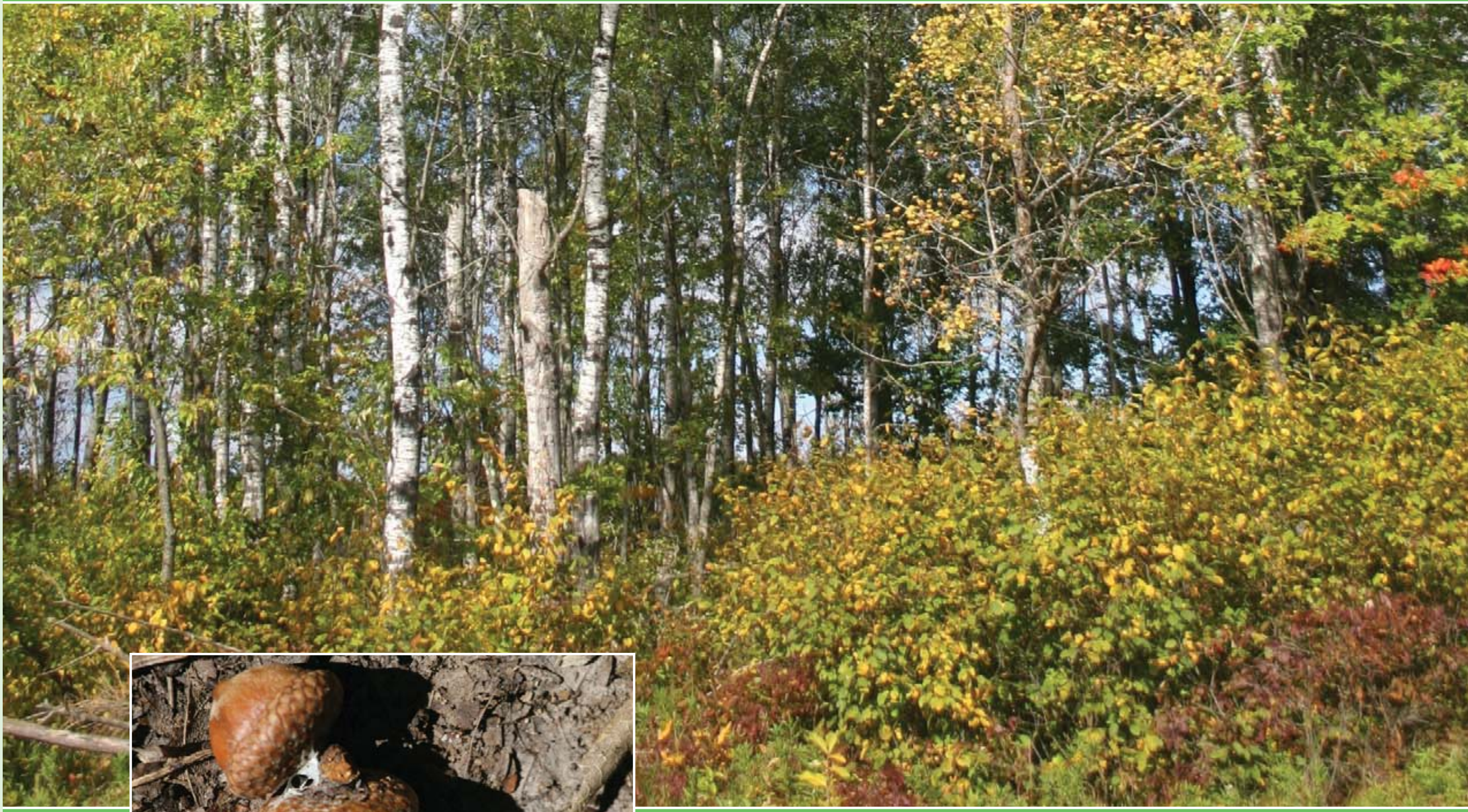
- There were signs of ozone damage on indicator species, particularly along the Lake Michigan shore where ozone exposures are highest. Injury is low to absent in the other regions of the State.
- Sawlog and veneer log production decreased by 12 and 33 percent, respectively, between the 1999 and 2003 timber products inventories.

Issues to Watch

- Much of Wisconsin's forest land is held in private ownership, including an increasing number real estate investment trusts (REITs) and timber management organizations (TIMOs). Changing patterns of ownership can profoundly influence the structure and uses of forest land.
- Between 1993 and 2006, the number of private forest owners increased significantly due primarily to an increase in the number of owners with small parcels (1 to 9 acres). The number of owners with larger parcels did not change significantly during the same period.
- Wisconsin's forests are shifting toward shade-tolerant species, so pioneer species adapted to disturbance (e.g., quaking aspen, paper birch, and jack pine) are in decline.
- The sawtimber resources of Wisconsin's forests have increased since the 1950s, but this increase has not been uniform across all species groups. Since 1996, white and red pines and soft maple have increased in sawtimber volume by more than 30 percent but the sawtimber volume in jack pine has decreased by 18 percent.
- The effective cation-exchange capacity of the soil (a description of mineral nutrition) is lowest under existing aspen forests. This could be important as these forests transition to other later successional forest types that may require greater mineral nutrition.

- Wisconsin's urban forest is generally healthy but there are significant threats to this valuable resource. The emerald ash borer poses a risk to 20 percent of the State's urban forest. There are 5.4 million ash trees in urban areas with an associated structural/replacement value of $1.5 billion.
- Less than 7 percent of family forest owners reported having a written forest management plan, yet 27 percent sought management advice from a natural resource professional, most commonly those working for the Wisconsin Department of Natural Resources or a federal resource agency.
- About 24 percent of the private family-owned forest land is held by owners with intentions to sell their land, subdivide or convert their land from forest to other uses, or pass it on to their heirs in the next 5 years.
- Populations of the gypsy moth are expected to increase and cause widespread defoliation over the next decade. Overmature oak or oak growing on nutrient-poor, droughty soils are particularly at risk.
- Aspen remains the most commonly harvested species in the State, but production has dropped slightly since 1999.
- Third-party certification has created market opportunities for Wisconsin's forest industries but it has not yet led to consistent increases in revenue.

Background



First learn the meaning of what you say, and then speak.
– Epictetus

Above: Aspen stand. Photo by Steven Katovich, USDA Forest Service, bugwood.org. Inset: Acorns. Photo by Charles H. (Hobie) Perry.

A Brief Primer on Forest Inventory

What is a tree?

We know a tree when we see one and we can agree on some common attributes of a tree. Trees are perennial woody plants with central stems and distinct crowns. In general, we define a tree as any perennial woody plant species that can attain a height of 15 feet at maturity. In Wisconsin, the problem is deciding which species should be classified as shrubs and which should be classified as trees. A list of the tree species measured in this inventory is found in “Wisconsin’s Forests, 2004: Statistics and Quality Assurance” Resource Bulletin NRS-24, the companion to this publication.

What is a forest?

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

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

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 percent of the forested acreage is timberland, 1 percent is reserved forest land, and 1 percent is other forest land.

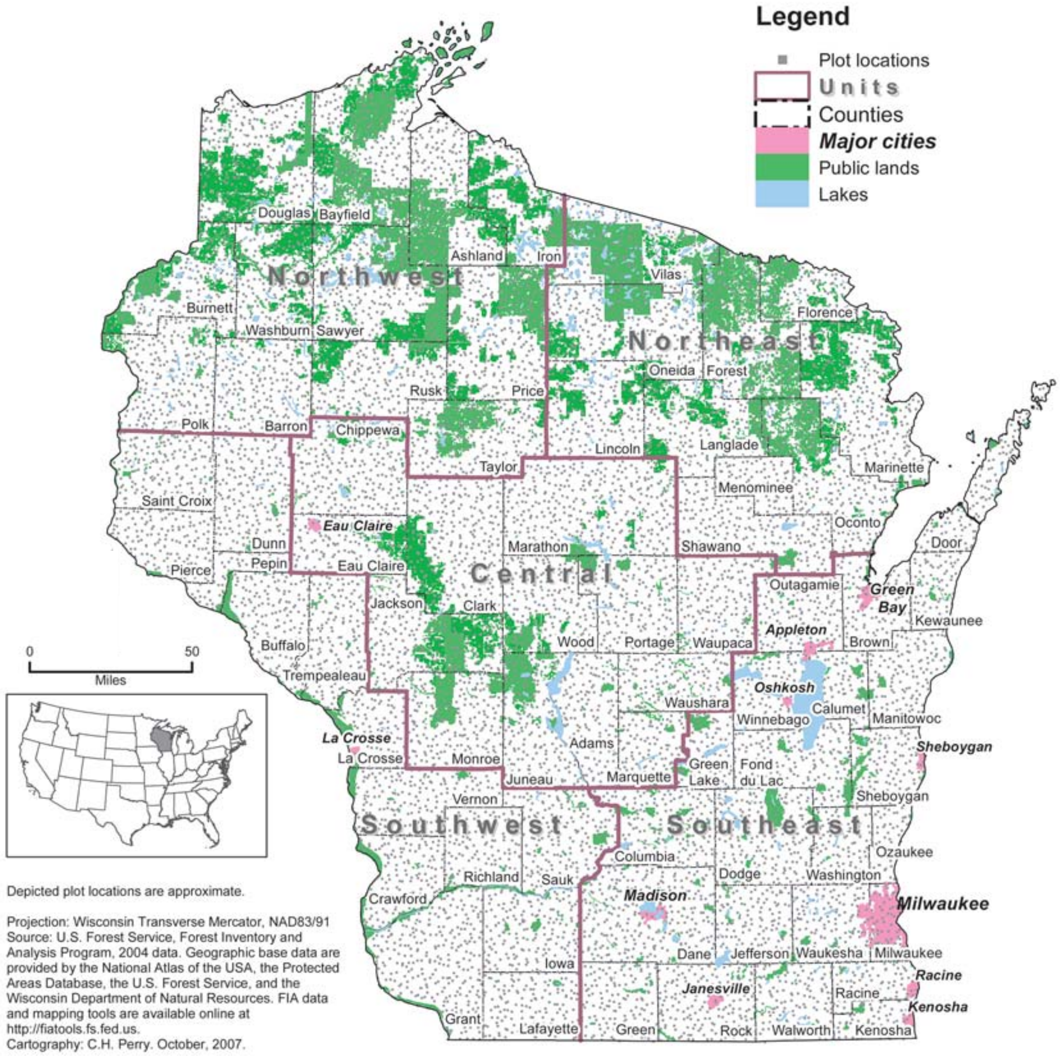
- Reserved forest land cannot be used for timber production due to legislation or administrative regulation.
- Other forest land in Wisconsin is commonly found on low-lying sites with poor soils where the forest at its peak is incapable of producing 20 cubic feet per acre per year.
- Timberland is forest land that is not reserved and meets minimum requirements for productivity.

In prior inventories we measured trees only on timberland plots, so we could not report volume on all forest land. The new annual inventory system facilitates the estimation and reporting of volume on all forest land, including timberland. As these annual plots are remeasured in the coming years, we will also be able to report growth, removals, and mortality on all forest land. Trend reporting in this publication is necessarily limited to timberland except for the area of forest land on which measurements of individual trees are not required.

How many trees are in Wisconsin?

There are 2.4 billion live trees on Wisconsin's forest land (give or take several million) that are at least 5 inches in diameter at breast height (d.b.h., 4.5 feet above the ground). We do not know the exact number because we measured only 221,580 trees or roughly 1 of every 11,000 trees. These trees were measured on 6,478 forest plots (Fig. 1). For information on sampling errors, see the companion document.

Figure 1.—Plot locations and units associated with the current forest inventory, Wisconsin, 2004.



How do we estimate a tree's volume? Eureka!

Forest inventories typically express volumes in cubic feet, but the reader probably is more familiar with cords (a stack of wood 8 feet long, 4 feet wide, and 4 feet high). A cord of wood contains about 79 cubic feet of carefully stacked solid wood and 49 cubic feet of bark and air.

Volume can be determined precisely by immersing the tree in a pool of water and measuring the amount of water displaced. Less precise but much cheaper and easier to do with living trees is a method adopted by the Northern Research Station. Several hundred trees were cut and detailed diameter measurements were taken along their lengths to determine their volumes (Hahn 1984). Statistical tools were used to model this data by species group. With these models we can produce volume estimates for individual trees based on species, diameter, and site index.

This method also was used to calculate sawtimber volumes according to the International 1/4-Inch (board foot) Scale. To convert to the Scribner (board foot) Scale see Smith (1991).

How much does a tree weigh?

Building on previous work, the U.S. Forest Service's Forest Products Laboratory developed estimates of specific gravity for various tree species (USDA For. Serv. 1999). These specific gravities were applied to estimates of tree volume to estimate merchantable tree biomass (that part of the tree that can be used to create products such as lumber or pulp). To determine live biomass, we have to add in the stump (Raile 1982), limbs, and bark (Hahn 1984). We do not currently report the live biomass of roots or foliage.

Forest inventories can report biomass as green weight 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 moisture content. On average, 1 ton of oven-dry biomass equals 1.9 tons of green biomass.

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so. – Mark Twain

How do we compare data from different inventories?

Forest inventories of Wisconsin were completed several times over the past century: 1936 (Cunningham and Moser 1938; Cunningham et al. 1939), 1956 (Stone and Thorne 1961), 1968 (Spencer and Thorne 1972), 1983 (Spencer et al. 1988), 1996 (Schmidt 1998; Kotar et al. 1999), and in 2004. Data from new inventories often are compared with data from earlier inventories to determine trends in forest resources. However, for comparisons to be valid, the procedures used in the two inventories must be similar. As a result of FIA's ongoing efforts to improve the efficiency and reliability of the inventory, there have been several changes in procedures and definitions since the last Wisconsin inventory in 1996. These changes will have little effect on statewide estimates of forest area, timber volume, and tree biomass, but they could have significant effects on plot-classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare 2004 data tables with those published for the 1996 inventory. We have recalculated several important values from the 1996 inventory to facilitate applicable comparisons.

The greatest change between the two inventories was the change in plot design. For consistency's sake, a new, national plot design was implemented by all five regional FIA units in 1999. The old North Central plot design used in the 1996 Wisconsin inventory consisted of a mixture of fixed- and variable-radius subplots. The new, national design used in the 2004 inventory used fixed-radius subplots exclusively. Both designs have their strong points, but they often produce different classifications for individual plot characteristics.

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

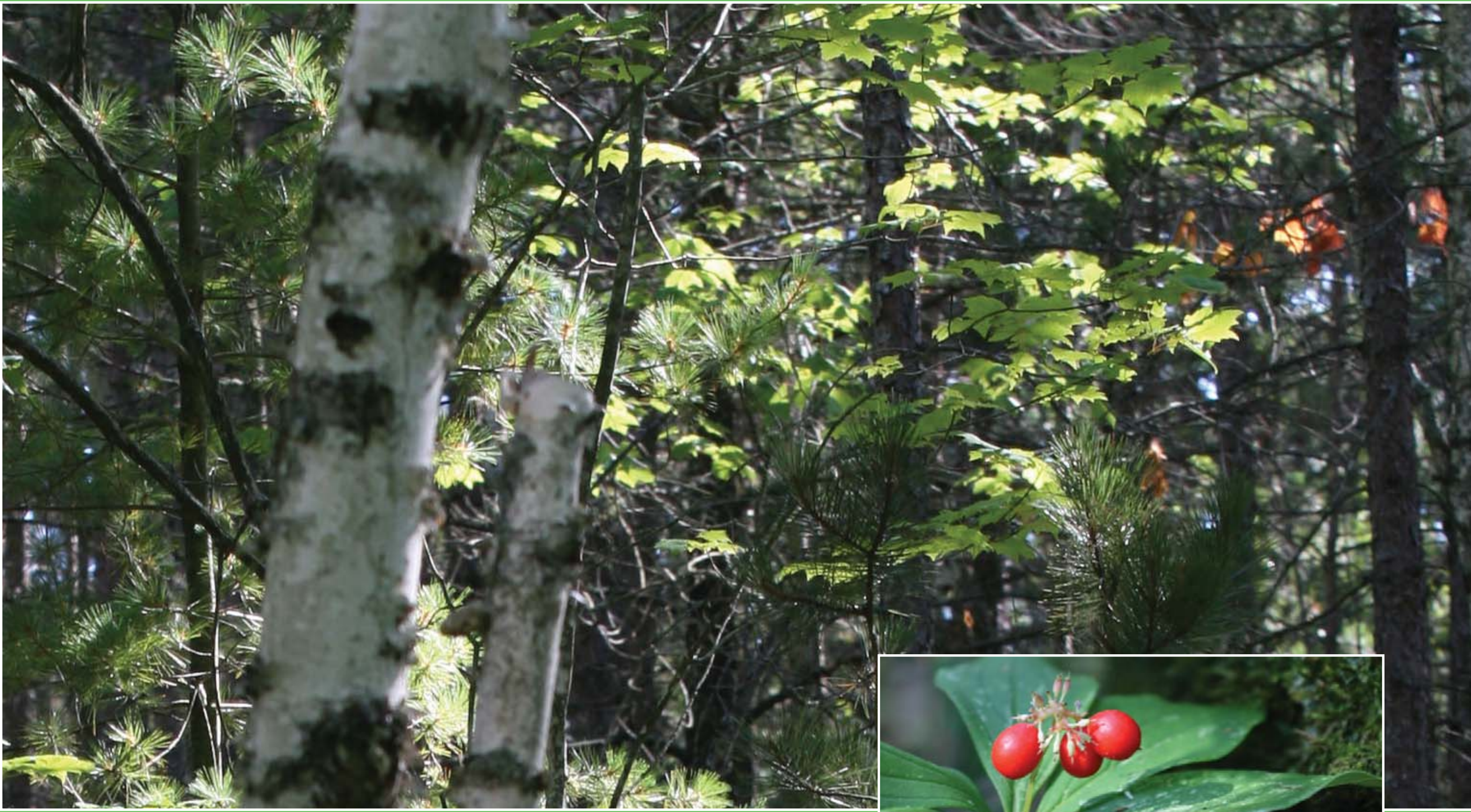
A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting, particularly since such suitability and availability are subject to changing laws and ownership objectives. The classification of land as timberland does not necessarily mean it is suitable or available for timber production.

Nor is it safe to assume that forest owners plan regular harvests or intend to harvest at all. In response to the National Woodland Landowner Survey conducted by FIA, 9 percent of the family forest owners, owning 29 percent of the private forest land in Wisconsin, stated that they intend to harvest sawlogs or pulpwood over the next 5 years. Some of Wisconsin's private landowners choose not to harvest because they believe it would reduce the beauty of their land (Leatherberry 2001). Some owners held their timber because it was too small to sell; 16 percent of owners were opposed to harvesting.

Thus, forest-inventory data alone are inadequate for determining the area of forest land available for timber production. Many factors need to be considered when estimating the timber base, and these factors may change over time.

Where are Wisconsin's Forests?



There is pleasure in the pathless woods.
– Lord Byron

Above: Boreal forest. Photo by Charles H. (Hobie) Perry. Inset: Bunchberry. Photo by Charles H. (Hobie) Perry.

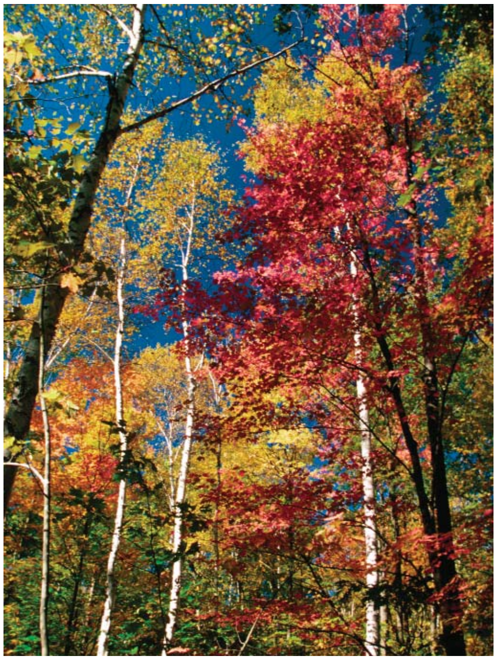
Ecoprovinces of Wisconsin

Wisconsin lies at the transition between the northern mixed forest and the Midwestern broadleaf forest (Fig. 2). These two regions support different forest communities that have evolved in response to differences in climate and soil.

The northern mixed forest represents the transition from broadleaf deciduous forest in the south to the Canadian boreal forest. It is referred to as mixed forest because deciduous hardwoods are found in combination with conifers. Hardwoods such as maples, beech, and birch tend to occupy high quality sites, and conifers such as pine, tamarack, and spruce are common in the less productive landscapes.

The Midwestern broadleaf forest is dominated by deciduous hardwoods. Different species of oak mix with hickory on dry sites, and lowland hardwoods are found in valley bottoms. Conifers are found on the dry sites but are much less common.

Wisconsin's forests are primarily in the northern mixed forest (Fig. 3), and several northern counties are more than 80 percent forested. Much of the forest land in the southern part of the State was converted to agricultural uses when European settlers immigrated to the area.



Northern hardwood forest. Photo by Steven Katovich, USDA Forest Service, bugwood.org.

Figure 2.—Ecological provinces of Wisconsin (adapted from USDA Forest Service ECOMAP Team, in press).

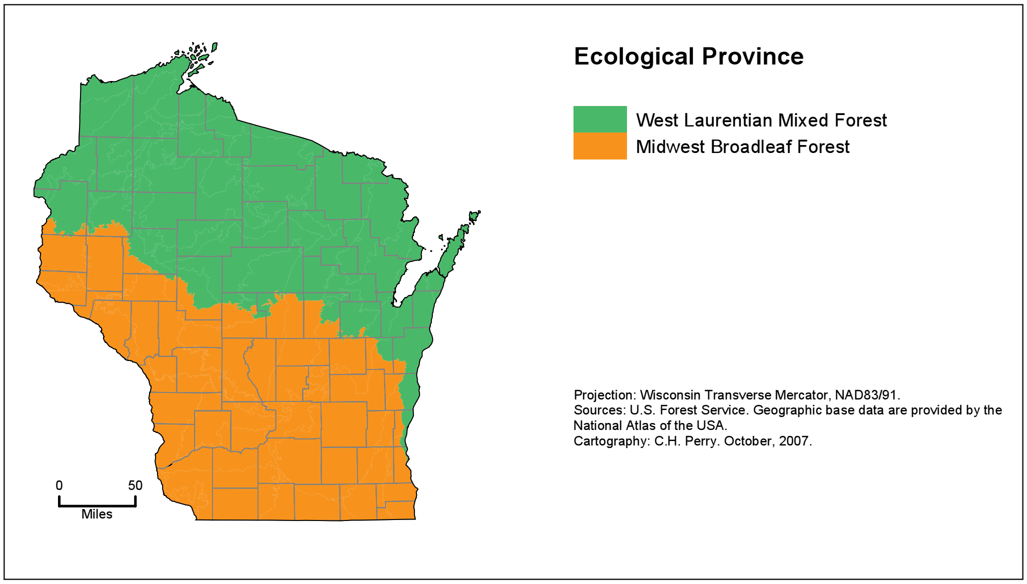
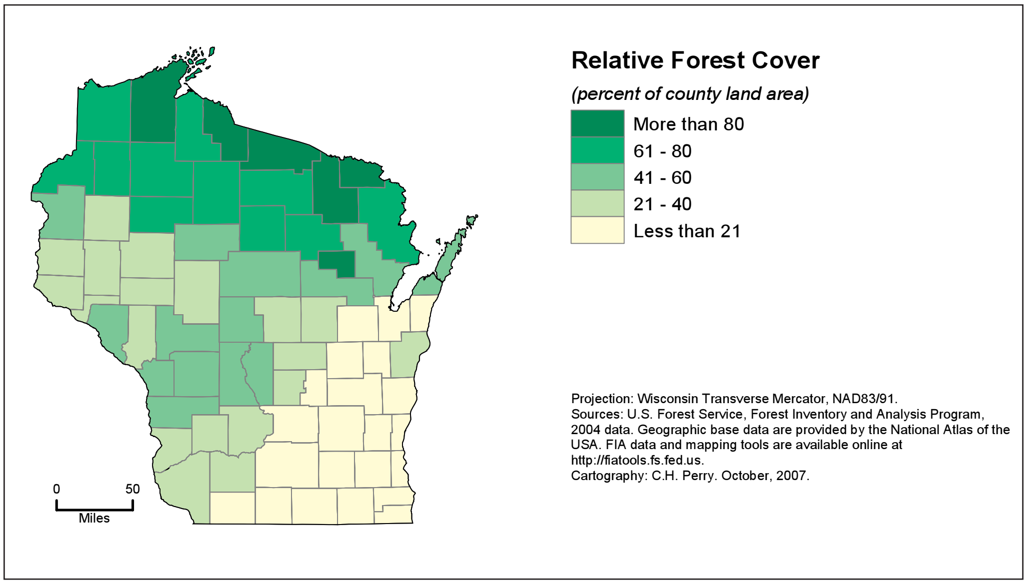


Figure 3.—Area of forest land by county, Wisconsin, 2004.



Distribution of Forest Land by Forest Type

Background

Information from forest-inventory plots can be combined with other types of data, e.g., climate or topography, to create forest-type maps. The distribution of forest land across different forest types reflects the interaction between the original distribution of forest types in the State and the influence of humans and other disturbance agents.

What we found

Eighty percent of the total area of forest land is occupied by 15 forest types (Fig. 4). Aspen is the most common forest type in Wisconsin (18 percent) occupying more than 2.7 million acres of forest land. Sugar maple/beech/birch is the second most common forest type (14 percent, 2.3 million acres). Red pine is the most common coniferous forest type (4 percent, 648,000 acres).

Related forest types can be combined into forest-type groups of related plant communities (Fig. 5), and important changes in forest-land area can be tracked over time. For example, aspen is the most common forest type in Wisconsin, but the area of aspen/birch has declined since the 1996 inventory (Fig. 6). The area of forest land in the maple/beech/birch and oak/hickory forest-type groups also has declined since 1996. By contrast, the area of forest land in the elm/ash/cottonwood and pine forest-type groups has increased.

What this means

Wildlife species and the forest-products industry are influenced by the amount of land in different types. Some species depend on different forest types for habitat, forage, and reproduction. The forest-products industry is highly specialized and uses specific forest products, so changes in the area of land of different forest types can have profound implications.

Figure 4.—Distribution of forest land area by forest type, Wisconsin, 2004.

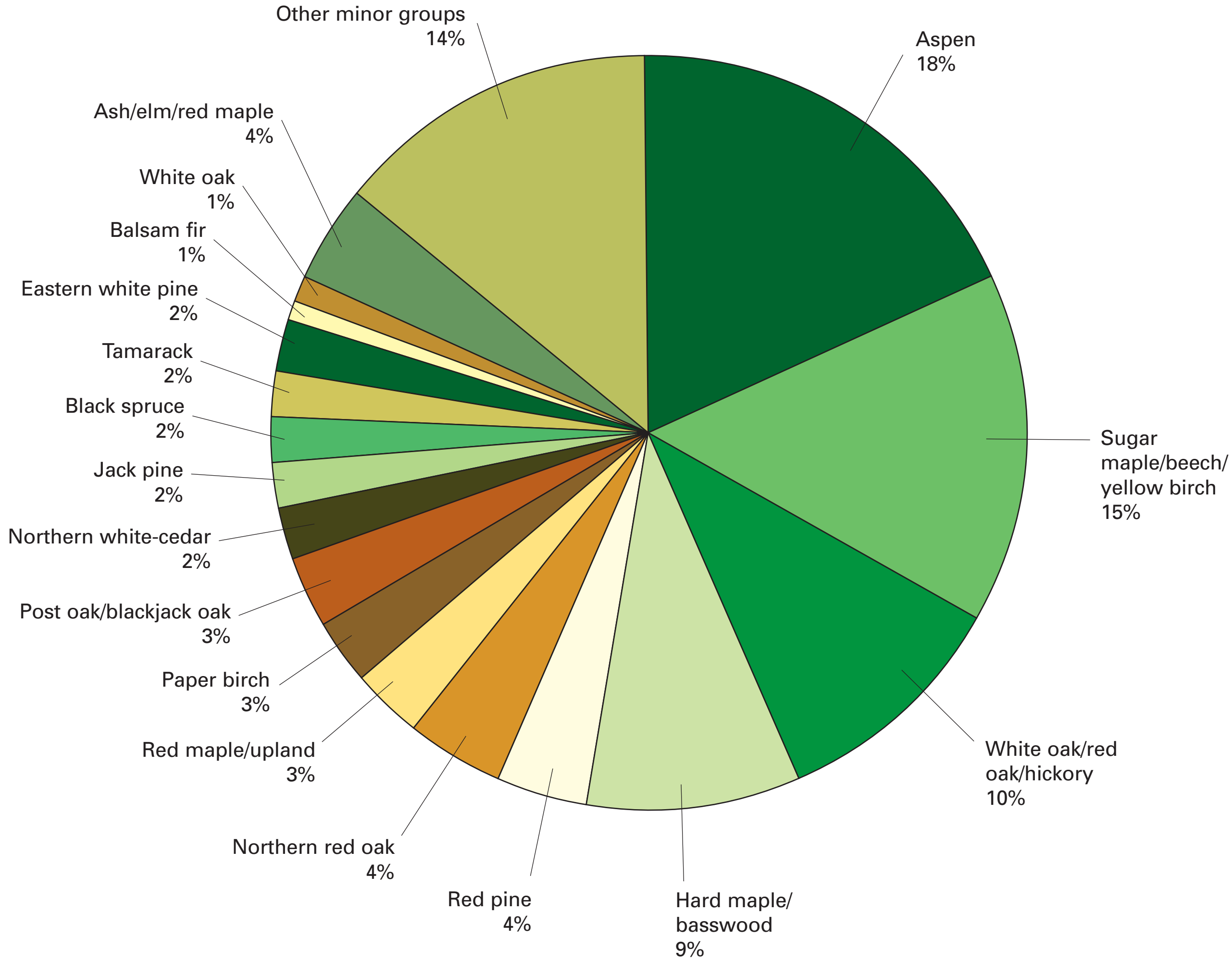


Figure 5.—Forest-type groups of Wisconsin, 2004.

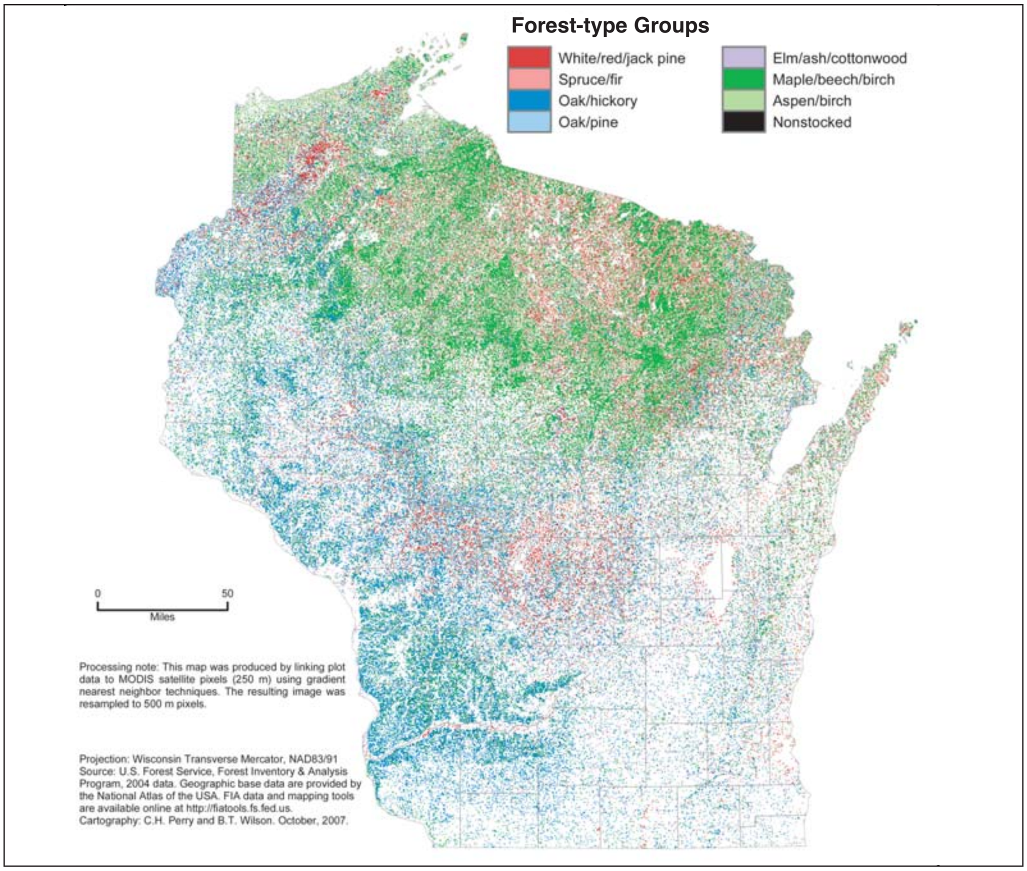
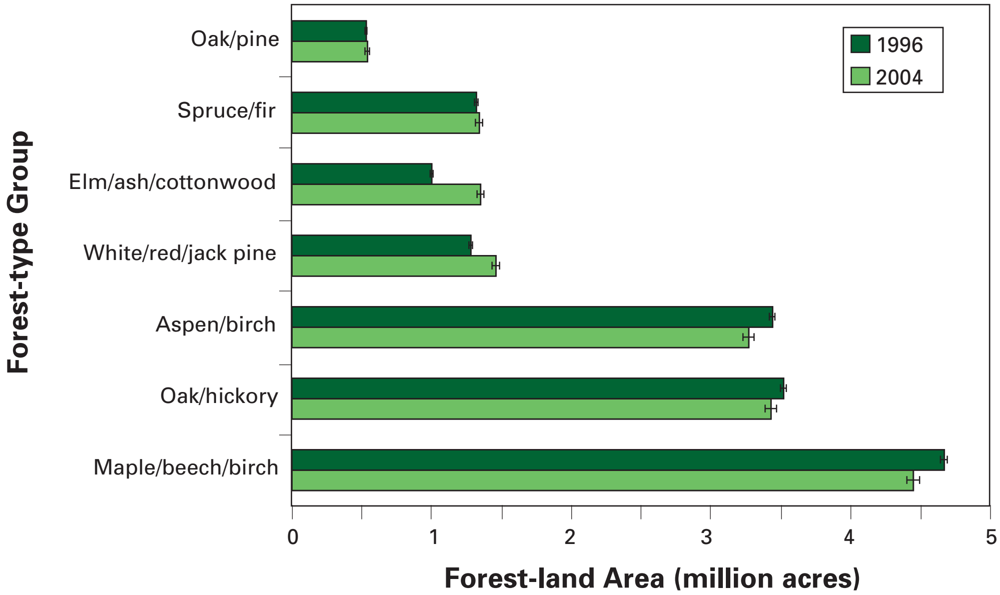


Figure 6.—Area of forest land by forest-type group and inventory year, Wisconsin, 1996 and 2004 (error bars represent 66-percent confidence interval around the estimate).



Distribution of Forest Land by Ownership

Background

Those who own the forest have a great deal of influence over its structure, composition, function, sustainability, and whether land remains as forest. Different landowners (public, private, industrial) have different objectives and planning horizons. As landowners manage for their objectives, they have the opportunity to modify existing forest communities or perpetuate current forest conditions.

What we found

More than two-thirds of Wisconsin's forest land (68 percent) is in private ownership (Fig. 7). Of this fraction, 56 percent is owned by nonindustrial private forest-land owners. Corporate owners hold 9 percent of the forest land while Native American holdings, such as Menominee Tribal Enterprise lands, constitute 2 percent of total forest land.

The public owns 32 percent of Wisconsin's forest land. The largest single public owner category is county/local ownership with 15 percent; there are nearly 2.4 million acres in Wisconsin's county forests. Federal agencies own 10 percent with the majority National Forest land; state agencies own 7 percent. Federal holdings are concentrated in the Chequamegon-Nicolet National Forest; State lands are concentrated in State Forests (Figs. 8 – 9).

What this means

It will be important to track changes in forest-land ownership over time. Private forest industries are selling their lands to relatively new types of ownership entities: real estate investment trusts (REITs) and timber investment management organizations (TIMOs). Changing patterns of ownership can influence the availability of forest land for resource management, recreation, and other uses.

Capital Square in downtown Madison. Photo used with permission from Wisconsin DNR.

Figure 7.—Forest land by ownership or administering governmental unit, Wisconsin, 2004.

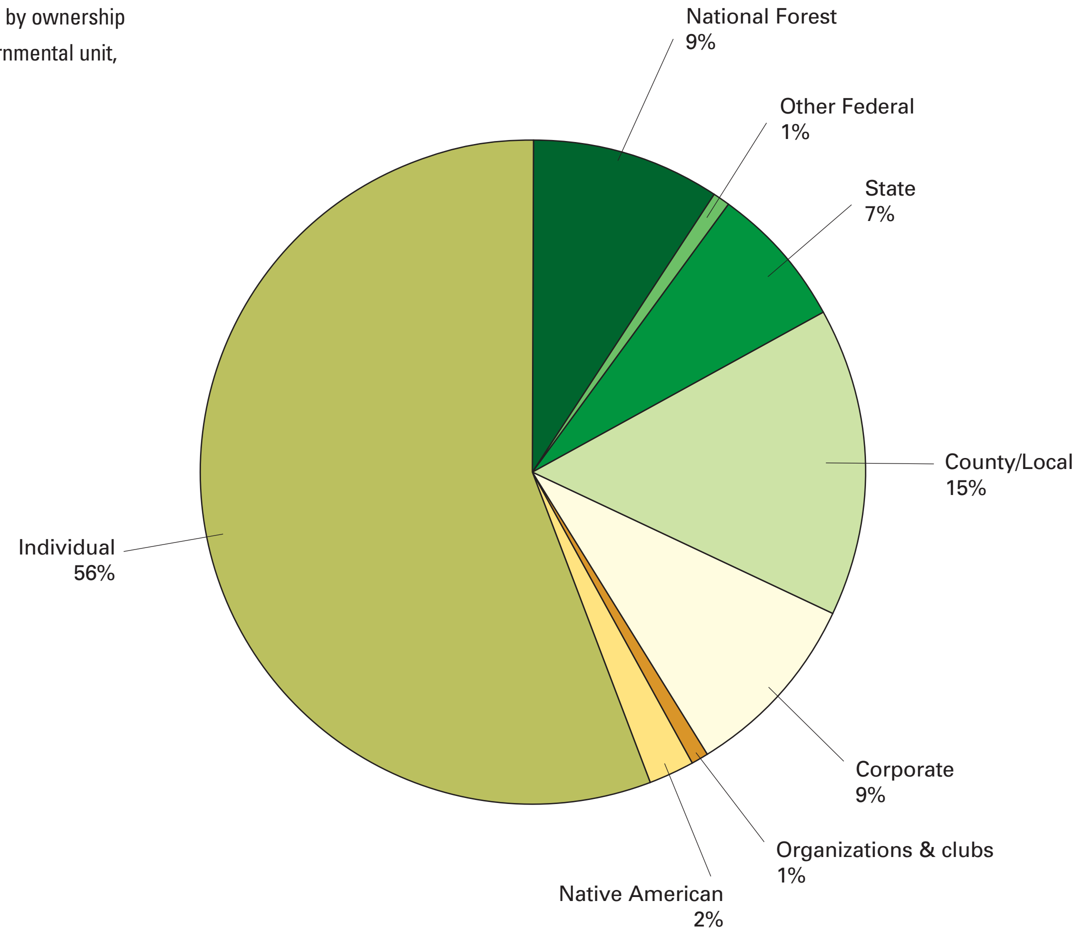


Figure 8.—Distribution of land owned by public agency, Wisconsin.

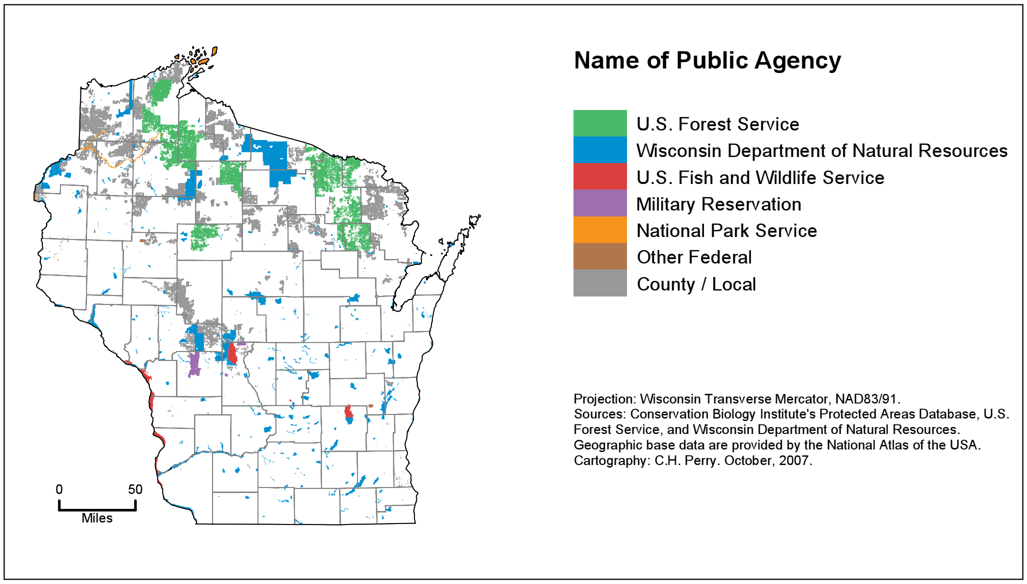
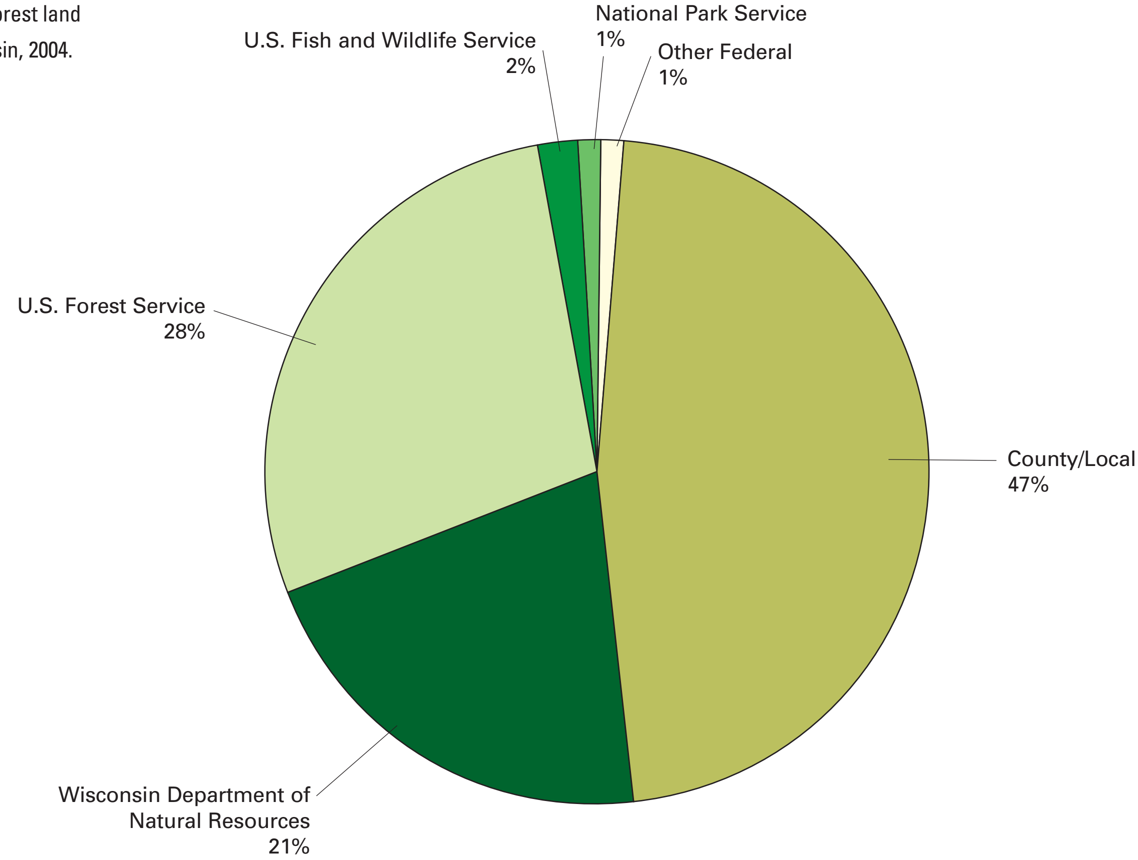


Figure 9.—Distribution of forest land held by the public, Wisconsin, 2004.



Forest Features

Never say there is nothing beautiful in the world anymore. There is always something to make you wonder in the shape of a tree, the trembling of a leaf. – Albert Schweitzer

Above: Eastern white pine stand. Photo by Linda Haugen, USDA Forest Service, bugwood.org. Inset: Northern red oak sun leaves. Photo used with permission from Steven J. Baskauf, bioimages.vanderbilt.edu.

Forest Land and Timberland Area

Background

Wisconsin has long had a blend of agricultural and forest land uses. By tracking the area of forest land and timberland in the State, we document changing land-use patterns.

What we found

Wisconsin is approximately 46 percent forested. It ranks 25th of the 50 states in land area, 23rd in forest-land area, and 14th in timberland area. The total acreage of forest land is an estimated 16.0 million acres. Of that, about 15.8 million acres are classified as timberland. Total forest land and timberland acreage in Wisconsin is less than pre-European settlement acreage. There was extensive conversion of forest land and timberland through the 1960s, but forest cover increased in the 1970s, 80s and 90s. Forest area (as both forest land and timberland) grew by 4 percent between 1983 and 1996 but has not changed since then (Fig. 10). Per-capita forest land continues to decrease (Fig.11).

The relative amount of forest cover may change but the counties in northern Wisconsin continue to maintain the highest proportion of forest cover (Fig. 12). Iron, Florence, and Menominee Counties have the most relative forest cover; each is more than 90 percent forested. Counties with low relative forest-land area are in the southeastern part of the State. Milwaukee and Dodge Counties have the least relative forest cover with 3 and 4 percent, respectively.

What this means

Forest land has increased since a low point during the late 1960s (Fig. 10), and the most significant gains frequently occurred in southwestern Wisconsin (Fig. 13). The stability of forest-land area between the 1996 and 2004 inventory is supported by the relative balance of counties gaining and losing forest land. The loss of forest land in the heavily populated counties of the southeast and around Green Bay was not unexpected. The loss of forest land in the lesser populated northern third of Wisconsin, e.g., Ashland, Forest and Sawyer County, should be investigated to determine the cause.

Red pine. Photo by Joseph O'Brien, USDA Forest Service, bugwood.org.

Figure 10.—Forest land and timberland by inventory year, Wisconsin (error bars – too small to be seen – represent 66-percent confidence interval around the estimate).

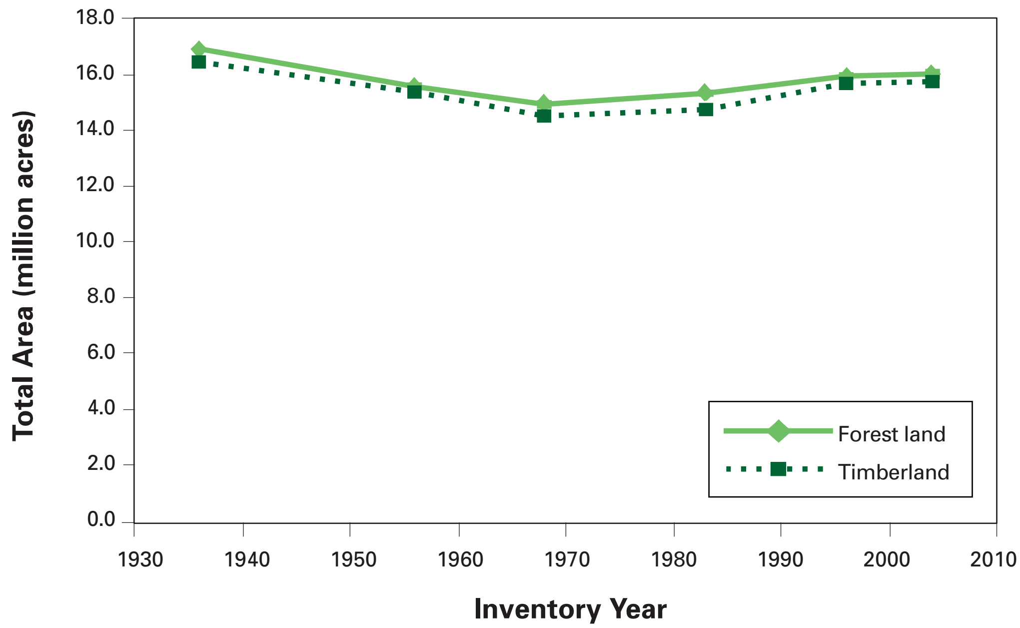


Figure 11.—Per capita forest land by inventory year, Wisconsin (error bars – too small to be seen – represent 66-percent confidence interval around the estimate).

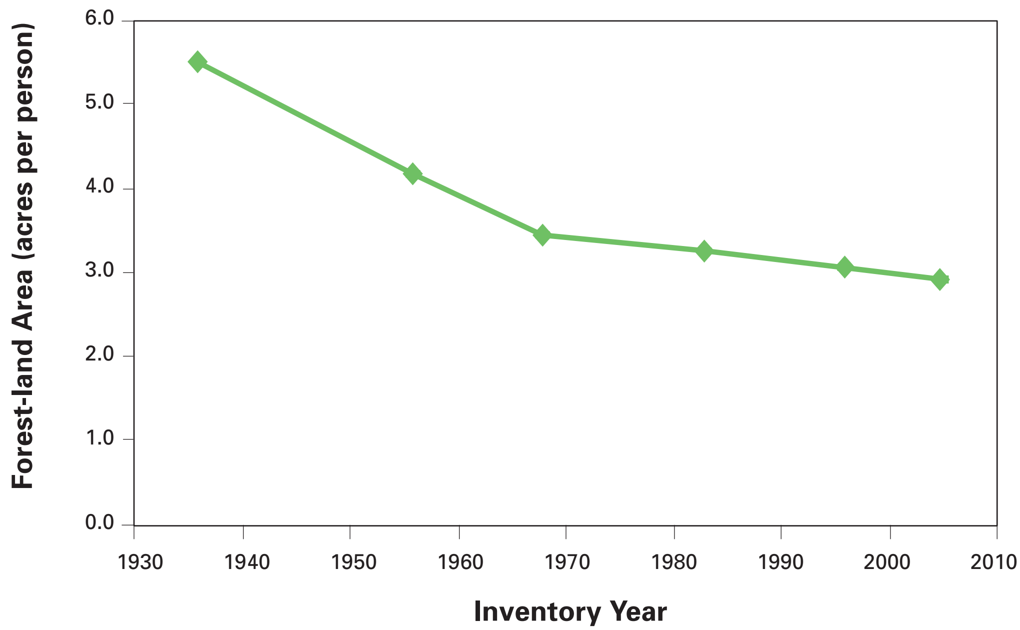


Figure 12.—Distribution of relative area of forest land by county and inventory year, Wisconsin (county-level data unavailable for 1936 inventory).

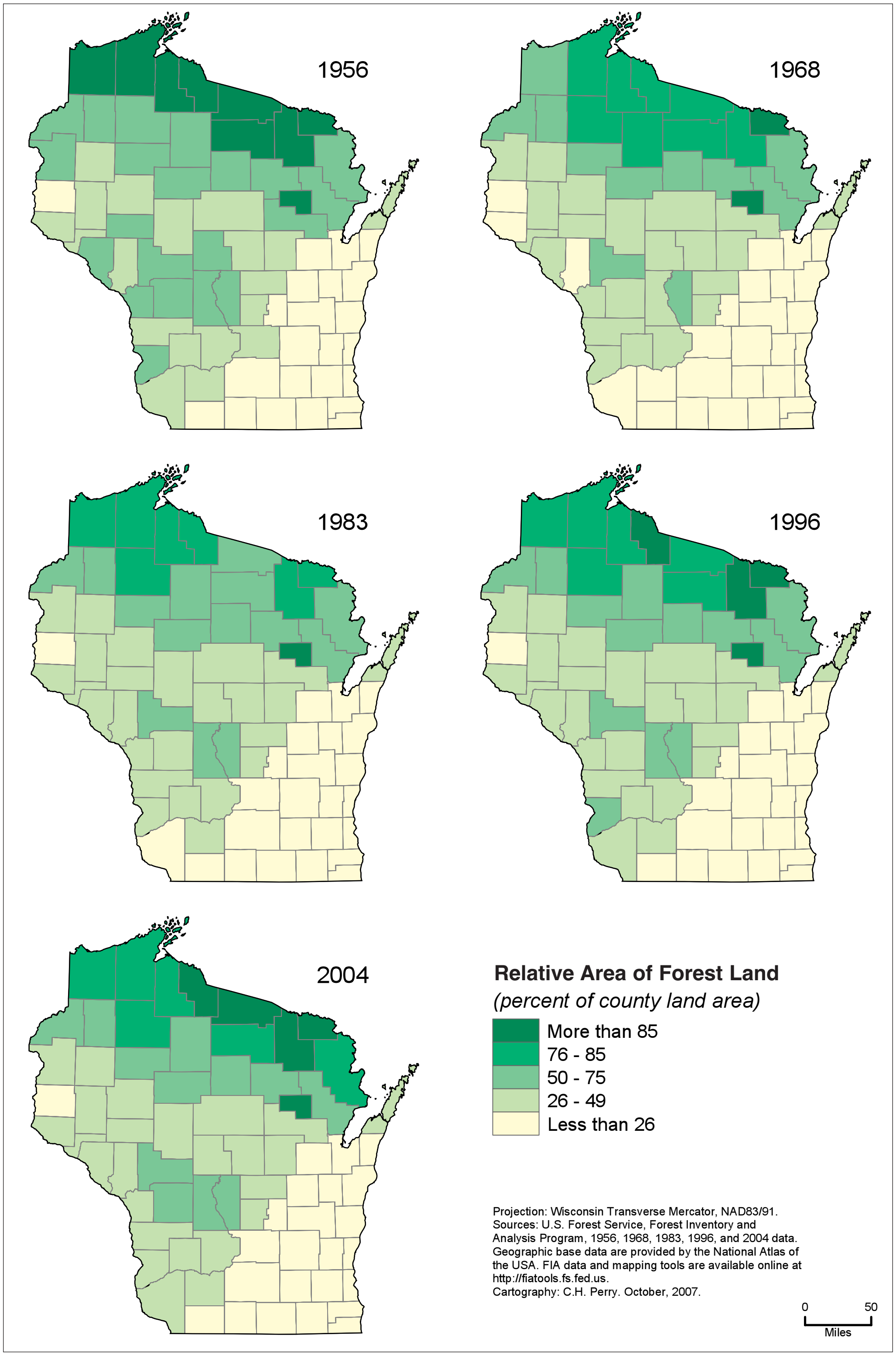
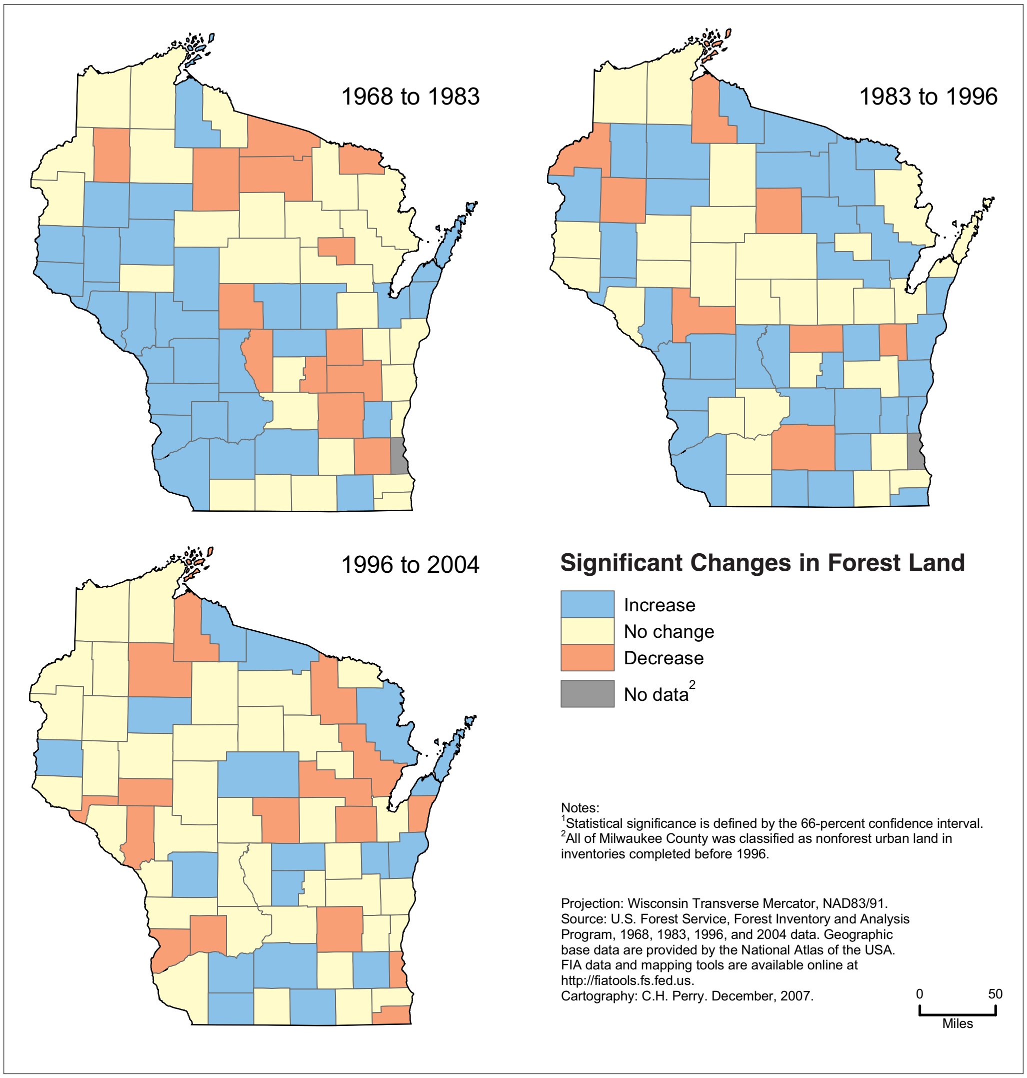


Figure 13.—Distribution of statistically significant changes in forest land area by county, Wisconsin, 1968 to 2004.



Biomass: A Weighty Issue

Background

As with measures of Wisconsin's forest acreage, measuring total biomass and its allocation among stand components, e.g., small-diameter trees, down woody debris, live canopy crowns, helps us understand the components of a forest stand and what is available for different uses. Forest resources beyond a tree's merchantable trunk also are being considered as a significant biofuel component in the quest to gain U.S. energy independence.

What we found

Estimated total live-tree biomass for the forests of Wisconsin exceeds 602 million dry tons on forest land. Seventy percent of this material is on private property (Fig. 14). As expected, the distribution of live-tree biomass (dry tons) among counties is similar to that of forest land (Fig. 12 and Fig. 15). The northern 23 counties in Wisconsin contain 69 percent of the biomass. The more populated counties in southeast Wisconsin contain 8 percent.

The State's forests sequester 1.5 billion metric tons of carbon. The carbon sequestered in the soil accounts for 60.4 percent while the live-tree component above and below ground accounts for 27.8 percent (Fig. 16). Down dead and standing dead wood, understory, and material on the forest floor is 11.8 percent of the carbon sequestered. Increases in forest volumes have been accompanied by increases in the amount of carbon sequestered.

What this means

Over the last 40 years, the management of forest areas across most of Wisconsin has supported the sizable growth of forest biomass. The largest amounts per acre are in the northern 23 counties.

Because most forest biomass resides in the trunks of growing-stock trees on private land, the management of these forests strongly affects the dynamics of carbon storage and emission. When trees are cut, the decomposing slash and exposed soil can emit carbon (a source). Over time, the regrowing forest transitions from a source of carbon to a place that stores it (a sink). Other substantial pools of carbon are found in forest soils, standing and down dead trees, roots, and nontree vegetation (live and dead).

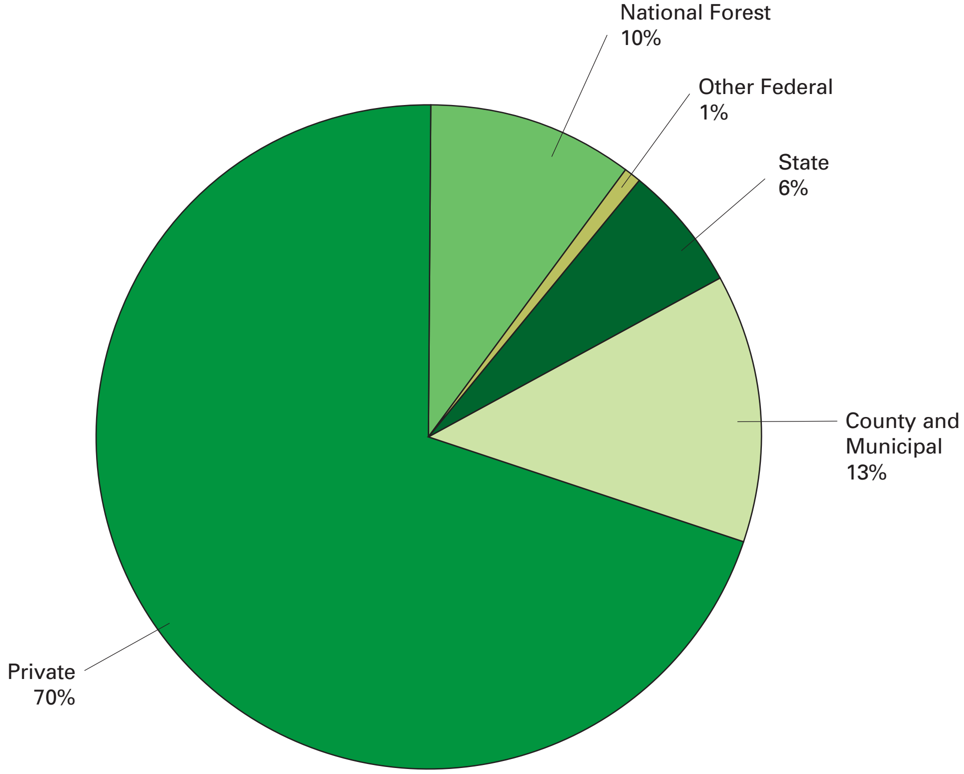


Figure 14.—Ownership of live biomass (oven-dry tons) on forest land, Wisconsin, 2004.

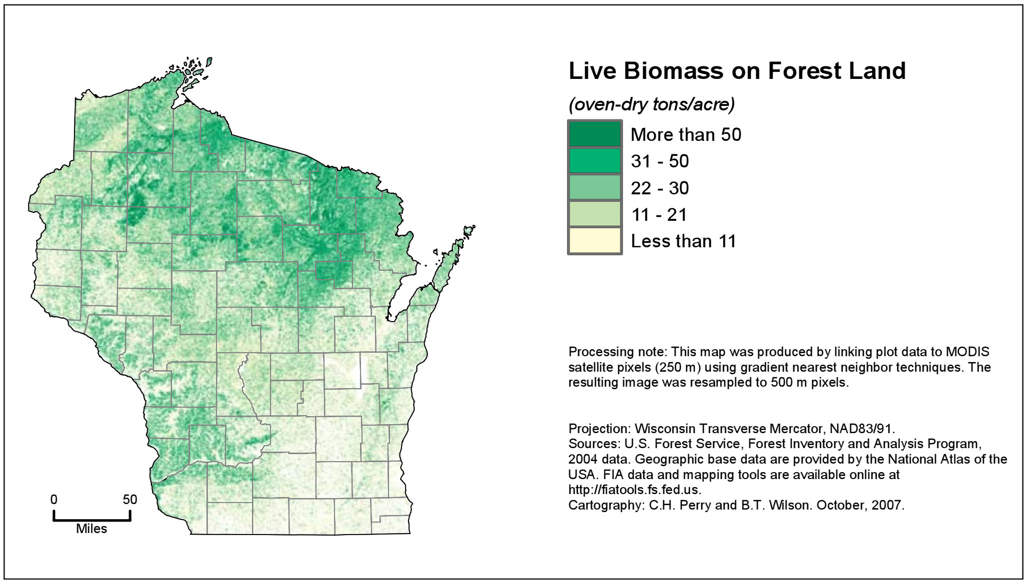
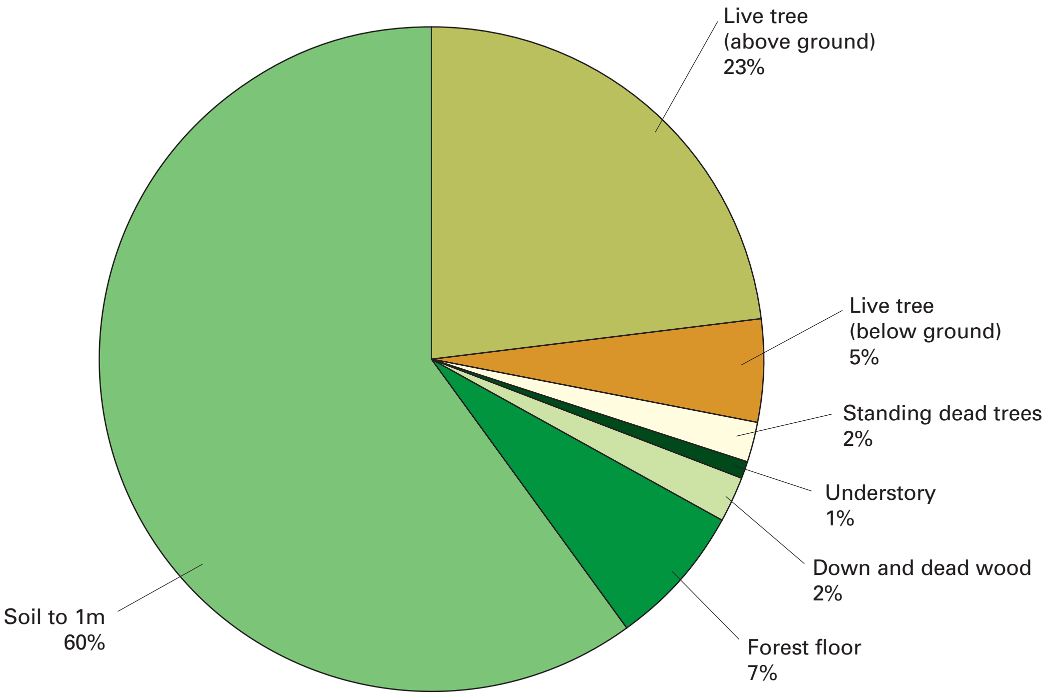


Figure 15.—Distribution of live biomass on forest land by county, Wisconsin, 2004.

Figure 16.—Distribution of organic carbon by ecosystem pool on forest land, Wisconsin, 2004.



Tree Composition of Wisconsin's Forests

Background

Forest-tree 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 changing 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. Tree composition can influence the composition of other plants and animals or be influenced by them.

What we found

Specific tree species. – The estimated number of growing stock trees more than 5 inches d.b.h. has increased by about 32 percent over the last 20 years. In 2004, red maple was the most abundant tree species in Wisconsin's forests (Fig. 17). Other abundant species that have been increasing in number are sugar maple, red pine, and black ash. The number of basswood and northern white-cedar trees has remained fairly stable. Common trees that have exhibited major declines in numbers include: quaking aspen, paper birch, balsam fir, and red oak. Other important trees that have been declining in number are jack pine and bigtooth aspen; neither was among the top 10 declining species in 2004.

Volume of growing stock. – Between 1983 and 2004, the volume of growing stock on timberland increased by about 27 percent. In 2004, sugar maple had the greatest volume in Wisconsin's forests (Figs. 18 and 19). Abundant tree species showing dramatic gains in volume over the last 20 years include sugar maple, red maple, red pine, and eastern white pine. Also abundant in Wisconsin's forests are red oak, white oak, basswood, and bigtooth aspen. Common trees showing major declines in volume over the last 2 decades include: quaking aspen, paper birch, jack pine, and balsam fir; neither of the latter was among the top 10 declining species in 2004.

Forest types. – Eastern white pine, post oak/blackjack oak, black ash/elm/red maple, and red pine are common forest types that have increased in abundance (Fig. 20). Tamarack, black spruce, jack pine, northern white-cedar, upland red maple, and red oak types remained common and relatively stable. The most abundant forest types showing declines or that are trending in that direction include: aspen; sugar maple/beech/yellow birch; white oak/red oak/hickory; and hard (sugar) maple/basswood. Paper birch is another notable forest type that declined.

What this means

Changing forest tree composition can be reflective of one or more variables: natural succession, climatic variability, type and severity of forest disturbances, species adaptations, and modern forest management goals and strategies.

Three species of tree – sugar maple, red maple, and eastern white pine – are abundant, multiplying, and growing. These species can grow under partial shade and they responded well to disturbances resulting from modern forest and land management. By contrast, increases in red pine number, volume, and acreage result from plantation establishment and management.

Aspen, paper birch, and jack pine are associated with the boreal forests characteristic of cold, northern climates. Also, they are adapted to severe disturbance and require open conditions to regenerate. Lacking such severe disturbance, forest succession is favoring other species. Aspen is the most harvested species group by volume (see Timber Product Output on page 90). Continued reductions in aspen volume could have adverse economic consequences. Oak trees and forest types are abundant in Wisconsin but trends in oak representation and distribution are subtle (see Changes in the Oak Forest on page 42).

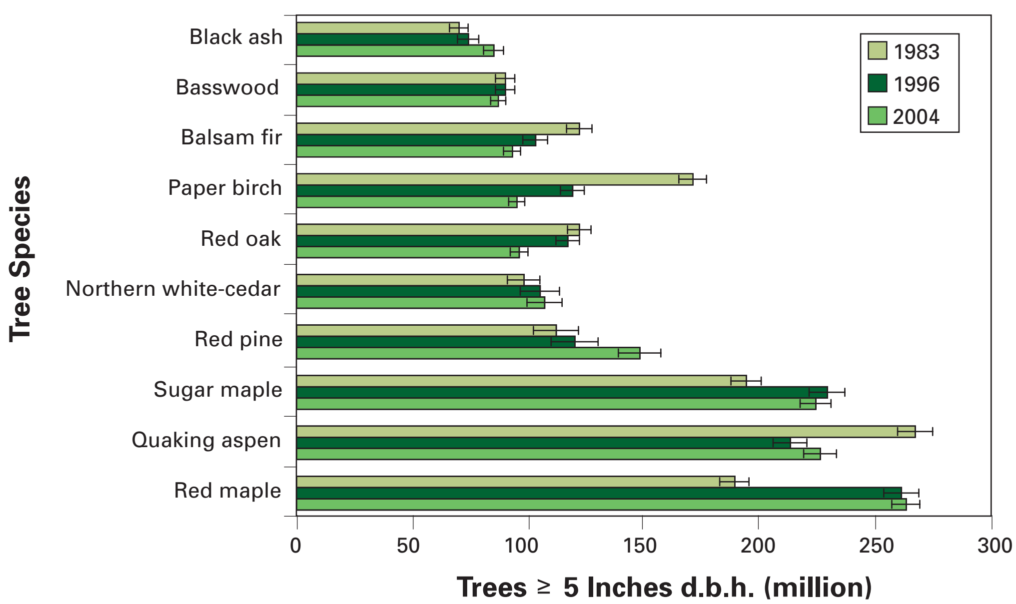
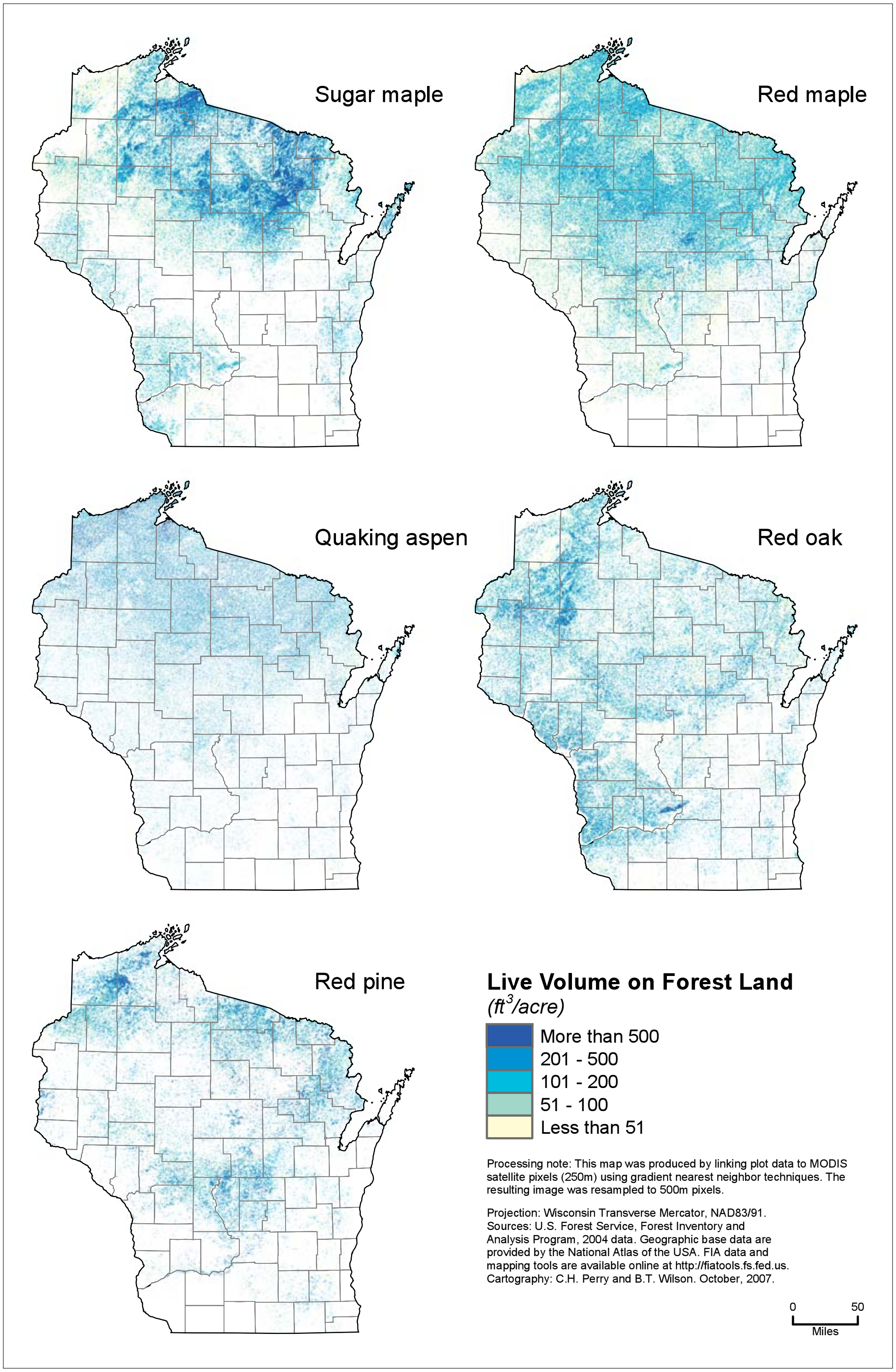


Figure 17.—Number of growing-stock trees greater than or equal to 5 inches d.b.h. on timberland by species and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

Figure 18.—Distribution of live volume on forest land for the five most voluminous species, Wisconsin, 2004.



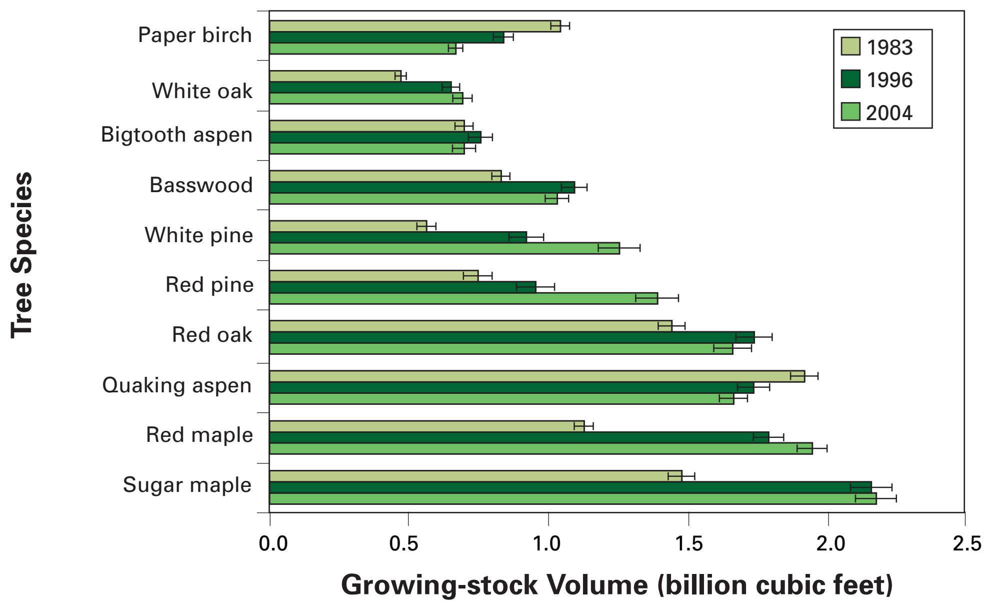


Figure 19.—Growing-stock volume on timberland for the 10 most voluminous tree species in 2004 by inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

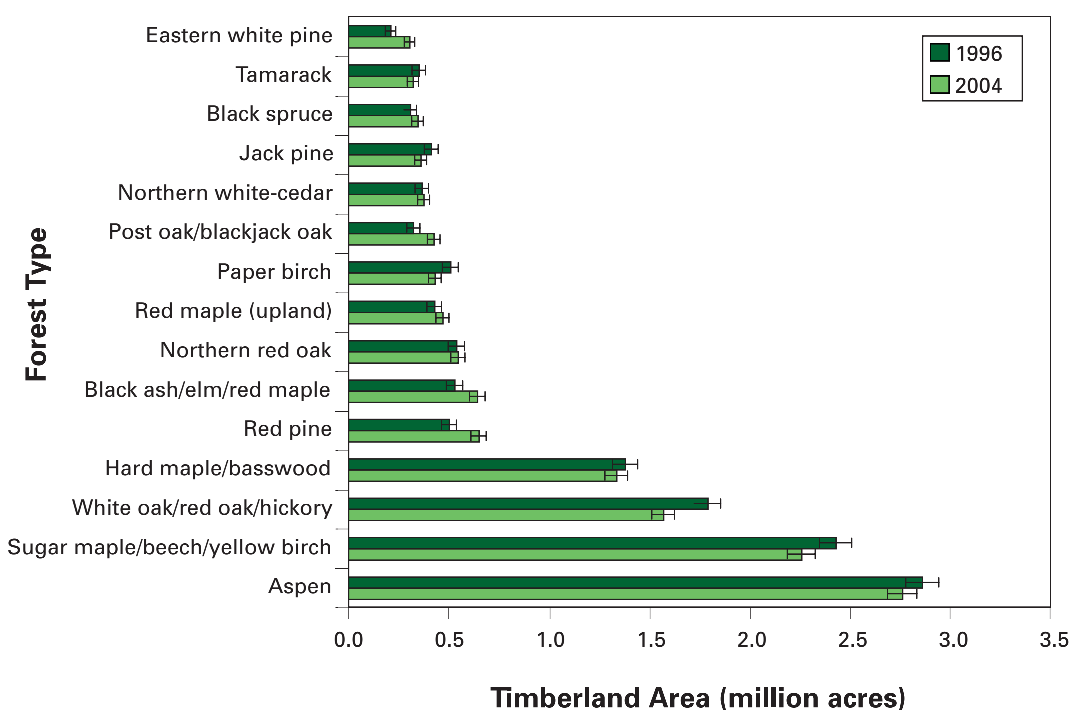


Figure 20.—Area of timberland for the most common forest types by inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

Forest Age and Size Structure

Background

Forest trees and stands regenerate, grow and mature, and senesce (the process of deterioration leading to death), and die. Tree species such as aspen often grow rapidly and typically live less than a century, whereas others, e.g., hemlock, grow more slowly and can live for several centuries. Younger forests tend to grow faster. As stands become older, trees become fewer and larger. Old-growth forests typically contain trees of many different ages and sizes, including old, senescent individuals.

In Wisconsin, most forests were cutover and many acres were burned in the late 1800s and early 1900s. Following the cutover, many areas were temporarily farmed and pastured. Most current forests originated on open land and developed into even-aged stands where most trees are about the same age. Some of these stands, particularly those dominated by shorter lived and faster growing tree species, have been harvested for timber and regenerated. Many stands continue to grow and age but generally are harvested before they approach senescence.

What we found

The 2004 inventory shows that most forest stands, about 58 percent of timberland acres in Wisconsin, are 40 to 79 years old, originating in the early to mid-1900s (Fig. 21). Forests younger than 40 years of age occupy about 28 percent of timberland. Forests 80 years and older occupy 14 percent of timberland; only 4 percent of forests on Wisconsin timberlands are 100 years and older.

The distribution of timberland by forest stand age class has changed between 1983 and 2004 (Fig. 21). Forests less than 20 years old have declined as regenerating stands developed into young forests. Forest stands 20 to 59 years old have been relatively stable, with ingrowth to these classes roughly equaling outgrowth and final harvests. There has been a steady increase in timberland occupied by stands 60 to 99 years old, as forests that originated in the early 1900s continue to develop. Forests older than 100 years have been uncommon and timberland area continues to decline.

The 2004 inventory shows that about 46 percent of the net growing-stock volume in Wisconsin forests occurs on trees 5 to 10.9 inches d.b.h, and 36 percent occurs on trees 11 to 16.9 inches d.b.h. (Fig. 22). The remaining proportion occurs on trees 17 to 20.9 inches d.b.h. (10 percent) and on trees 21+ inches d.b.h. (8 percent).

The distribution of net growing-stock volume by diameter class has changed between 1983 and 2004 (Fig. 22). Total volume in the predominant size class has remained stable, with ingrowth roughly equaling outgrowth and final harvests. Volume has increased in all of the larger size classes.

What this means

Most forest stands in Wisconsin are even-aged, relatively young, and dominated by relatively small trees. Most stands are 20 to 80 years old and most trees are 5 to 17 inches d.b.h. These age and size characteristics can be attributed to several factors:

- Relatively little time has passed since the cutover of forests and the abandonment of farms.
- Timber harvesting traditionally is done to maximize economic returns. This means larger (generally older) trees are cut before smaller trees. These older trees also represent an increased financial risk on managed lands.
- Some species on some sites do not attain large sizes or advanced ages.

Wisconsin's forests are aging. The area of timberland in regenerating stands less than 20 years old is declining and there is an increase in stands that are 60 to 100 years old. That said, harvesting imposes an upper age limit in managed forests. Forests more than 100 years old have declined and are scarce.

Aspen tree. Photo used with permission from Steven J. Baskauf, bioimages.vanderbilt.edu.

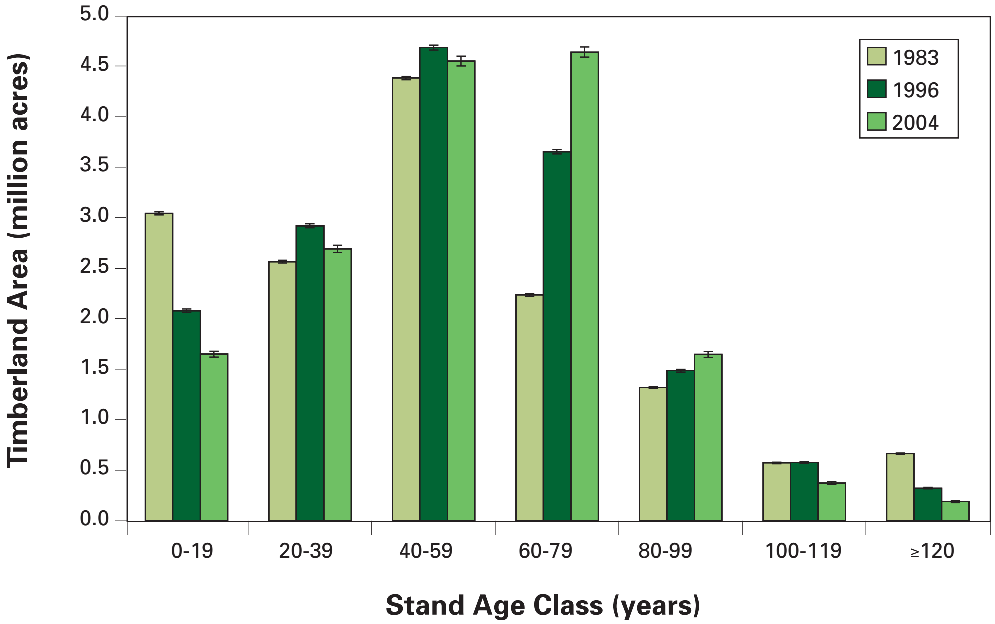


Figure 21.—Area of timberland by stand age class and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

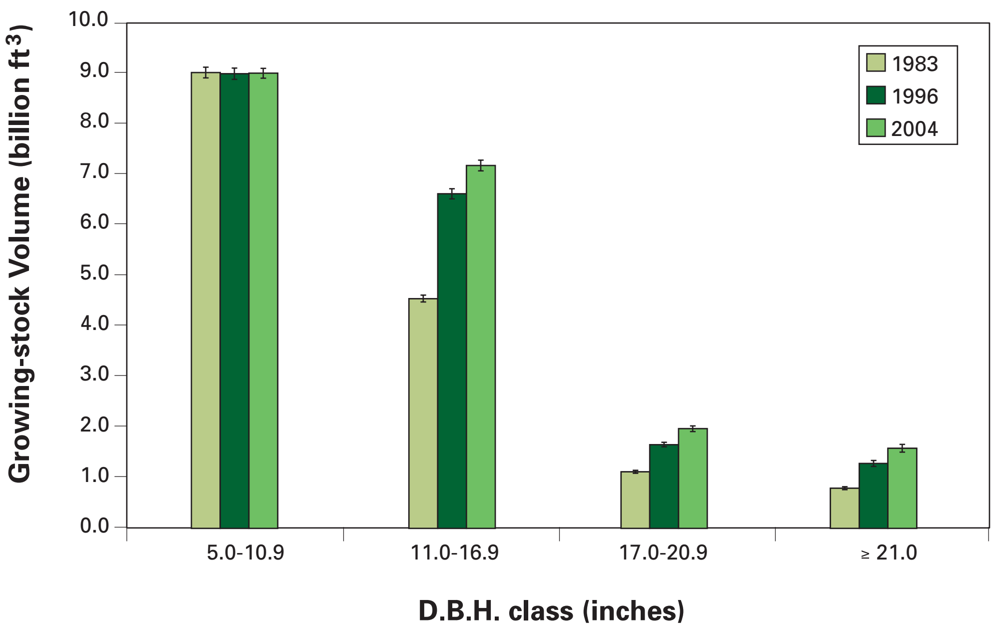


Figure 22.—Total growing-stock volume on timberland by diameter class and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

Changes in the Oak Forest

Background

Site productivity is an important factor in describing changes in the oak forest. Sites of high productivity have distinctly different trends than those of low productivity. Site productivity often is described using site index: the height (in feet) of a 50-year-old dominant or codominant tree. In the following discussion of oak, low-productivity sites are those with site indices less than or equal to 60; medium- to high-productivity sites have site indices greater than 60.

Oak forests on medium- and high-productivity sites throughout the Midwest have been decreasing in extent for several decades. Historically, regeneration in these forests was facilitated by a periodic fire regime. Today, it is difficult to regenerate oaks on these nutrient-rich sites due to competition from native and nonnative plants that outcompete oak seedlings. Browsing by white-tailed deer also limits the survival and growth of oak seedlings. The lack of successful regeneration along with selective harvesting of mature oaks contribute to the gradual succession of oak forests to mixed central hardwoods, which includes species such as red and sugar maple, basswood, elms, green and white ash, and ironwood.

Productive oak forests are important for their ecological and economic values. Many wildlife species depend on oaks for food and foraging. More than 90 North American vertebrate species consume acorns, and oak leaves and bark provide habitat for insects and spiders that are eaten by birds and other foraging animals (Martin et al. 1951, Rodewald 2003). Oaks also are important to Wisconsin's economy because of their high value for lumber.

Bur oak acorns. Photo used with permission from Steven Baskauf, bioimages.vanderbilt.edu.

What we found

The oak-hickory forest-type group covered about 3.5 million acres of Wisconsin in 1996 and was relatively stable in 2004 at 3.4 million acres. Although the extent of this forest has not changed significantly, a closer look at the data reveals trends of concern. Medium- to high-quality sites exhibit an uneven age-class distribution that indicates a scarcity of older and younger forests. Also, growing-stock volume decreased for select oak species, i.e., those that are in most demand for lumber products, including northern red, white, swamp white, and bur oaks.

Medium to high-sites within the oak-hickory forest-type group have little acreage in age classes of 100 years and older, and acreage of the oldest and youngest age classes declined between the 1996 and 2004 inventories (Fig. 23). Previous analyses showed a similar loss between 1983 and 1996.

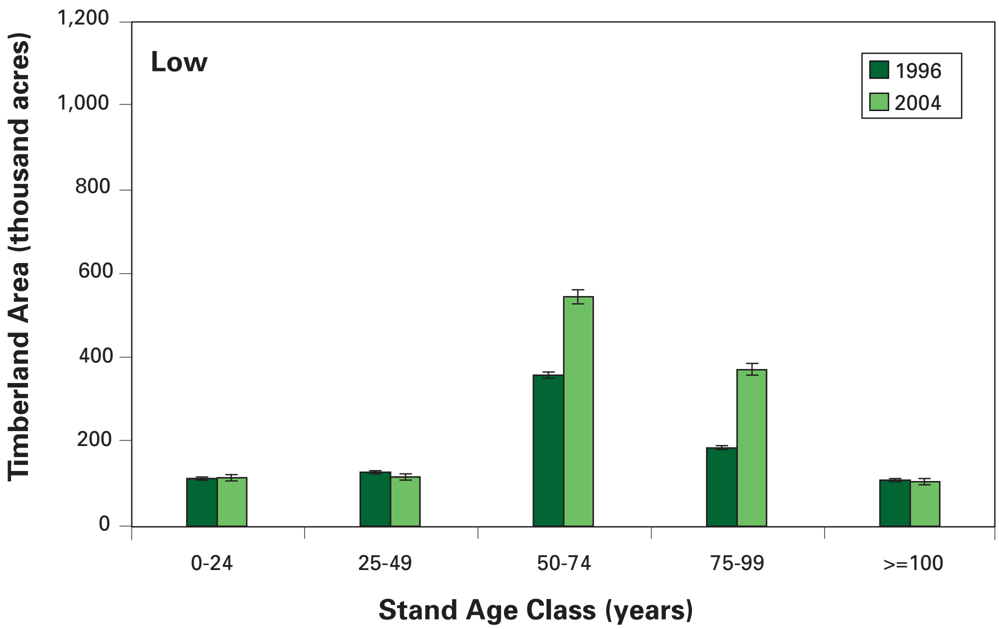
Data that compare seedling numbers with growing-stock volume point to regeneration difficulties for some sites. Low sites (relatively dry and less fertile) have higher ratios of oak seedlings to growing-stock volume, indicating that natural regeneration is relatively successful (Fig. 24). The medium to high sites had lower ratios, indicating poorer regeneration.

The growing-stock volume of select oak species has declined between 1996 and 2004. On medium to high sites, select red oak (northern red oak) declined statewide by 14 percent after increasing between 1983 and 1996 (Fig. 25). For select white oak, a group of species that includes white, swamp white, and bur oaks, growing-stock volume decreased by 12 percent.

What this means

The extent of the oak forest is holding steady but older oak forests on medium to high sites are being lost, and young oak forests are regenerating poorly. Oak regeneration on sites of lower productivity is satisfactory, but while these oaks provide excellent forage and wildlife habitat, they are less desirable as timber products. Select species of oak on medium to high sites are being removed disproportionately, leading to a net loss in growing-stock volume of these ecologically and economically valuable trees.

Figure 23.—Timberland area of sites in the oak-hickory forest-type group for low and medium-high quality sites, by stand age class and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate). Top graph shows low productivity sites with SI≤60. Bottom graph shows medium-high productivity sites with SI>60.



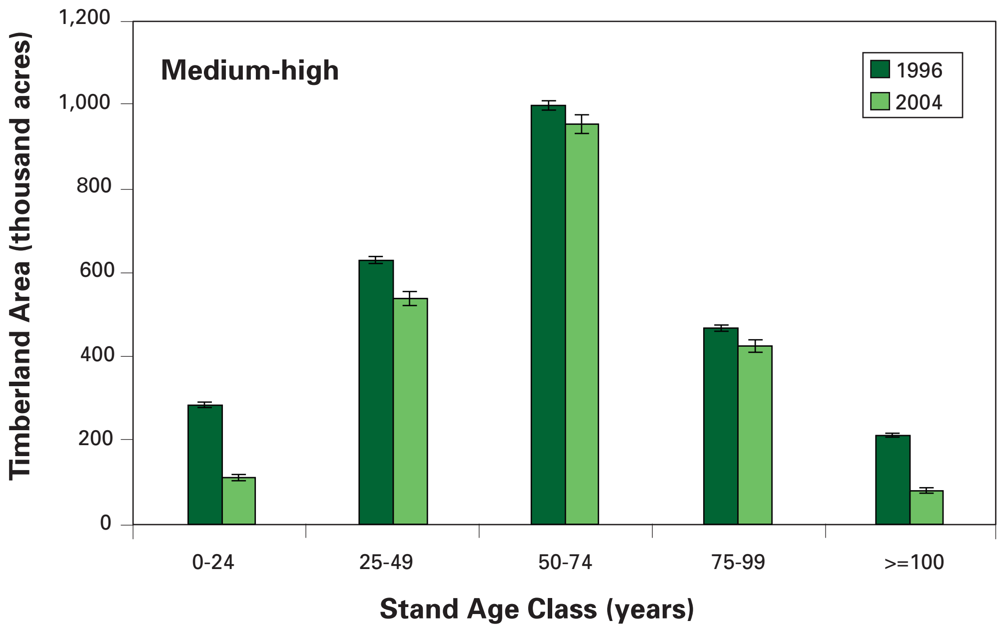
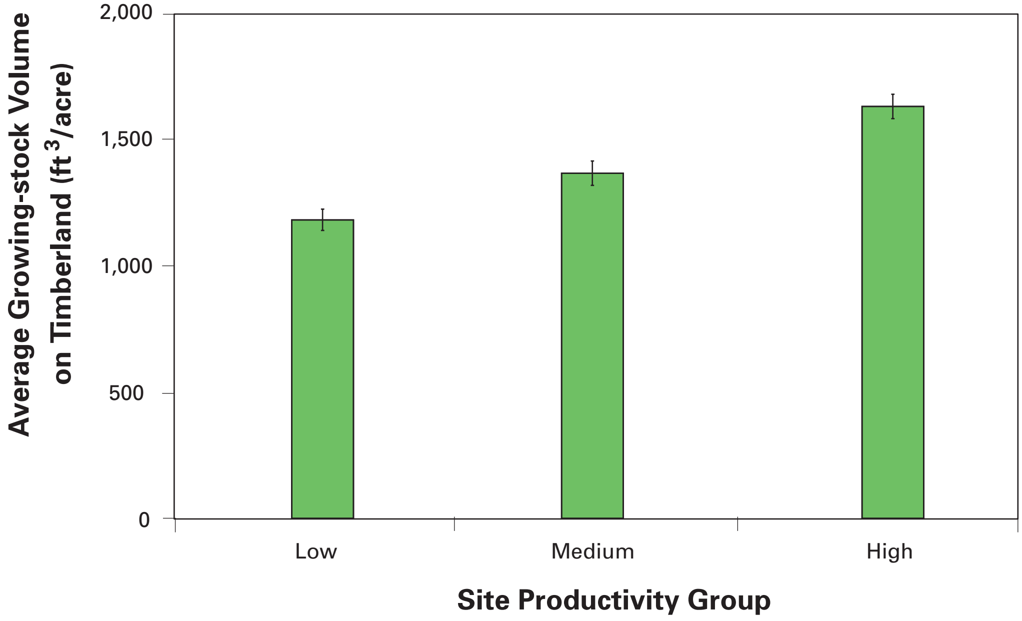
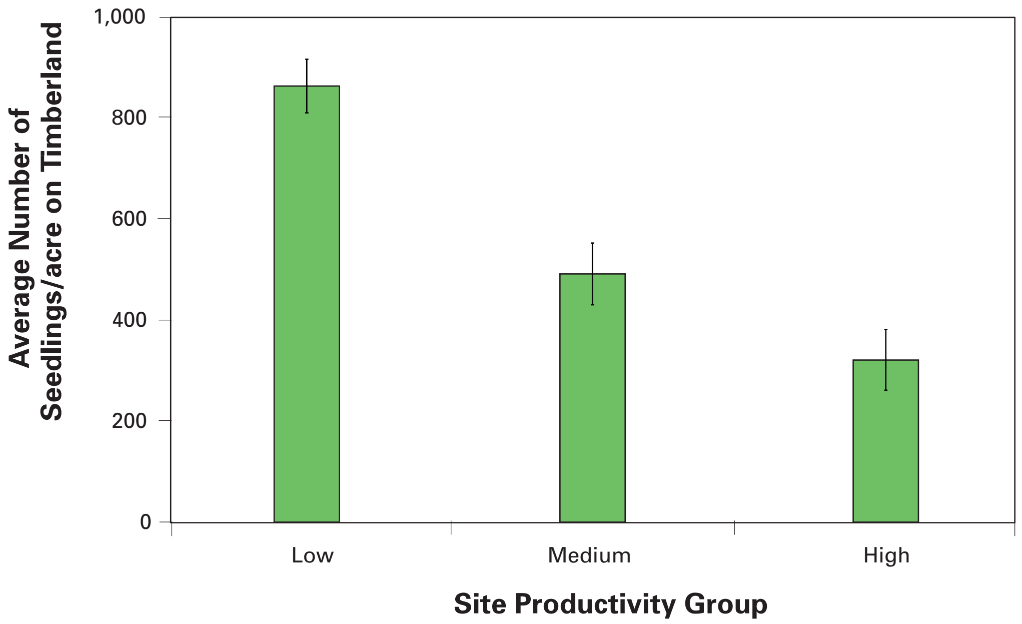


Figure 24.—Comparison of average growing-stock volume and average number of seedlings on timberland in the oak-hickory forest-type group, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate).





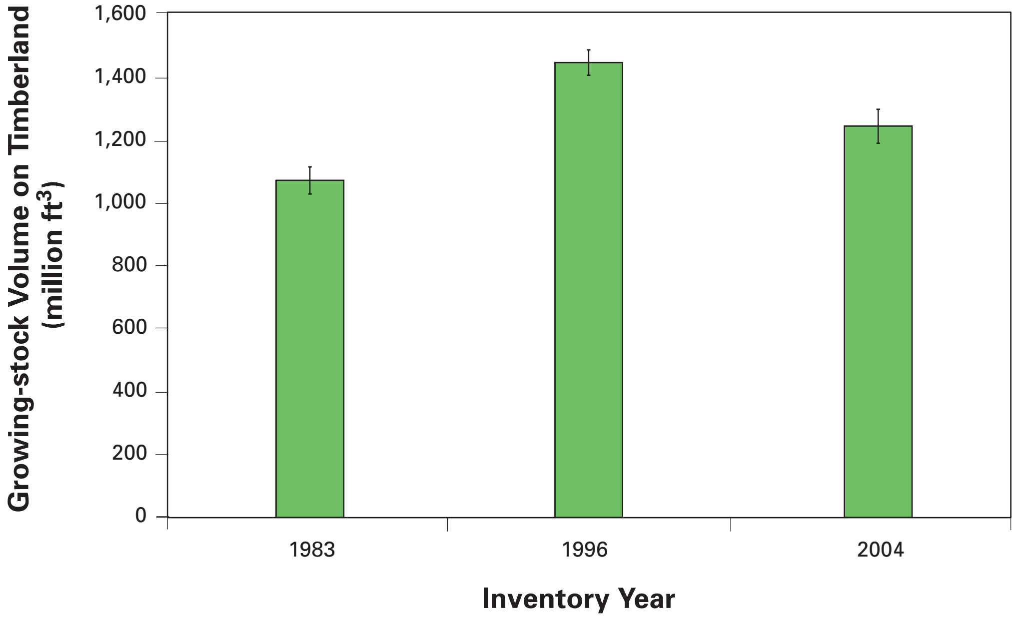


Figure 25.—Growing-stock volume of select red oak on medium-high productivity sites by inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

Growing-Stock Volume

Background

The growing-stock volume distributed across Wisconsin's timberland constitutes an important resource in the State's economy. Wisconsin continues to lead 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 1936; the current (2004) estimate is 19.6 billion cubic feet (Fig. 26). The volumes of several species groups have increased while several others have decreased over the past three inventories (Figs. 27 - 28). Red pine followed by eastern white pine has the largest softwood growing-stock volume across Wisconsin. In the hardwood species groups, aspen followed by soft maple, hard maple, and select red oaks have the largest growing-stock volume in the State. Red pine (softwoods) and soft maple (hardwoods) 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. 29) and hardwoods (Fig. 30). Growing-stock volume in most Wisconsin counties increased between 1983 and 2004, with the largest gains in the heavily forested northern counties (Fig. 31).

What this means

The volume of growing stock on Wisconsin's timberland has been increasing steadily over the past 70 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 such as red pine, eastern white pine, 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 70 years. Wisconsin's growing-stock inventory appears stable and growing, but it could be compromised by invasive species, insects and diseases, and loss of timberland to development.

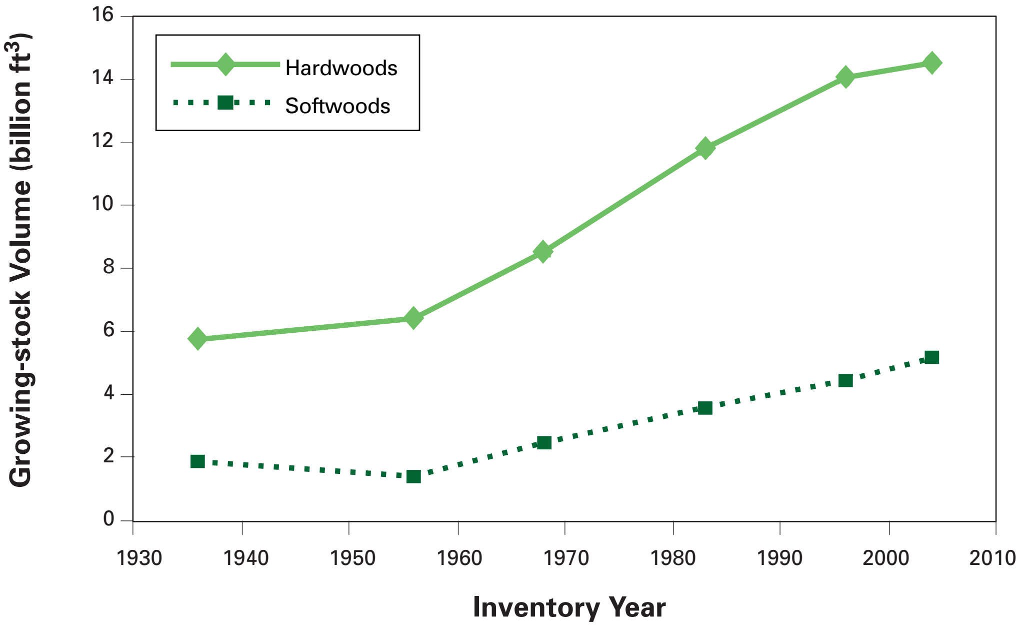


Figure 26.—Growing-stock volume on timberland by species group and inventory year, Wisconsin (error bars – too small to be seen – represent 66-percent confidence interval around the estimate).

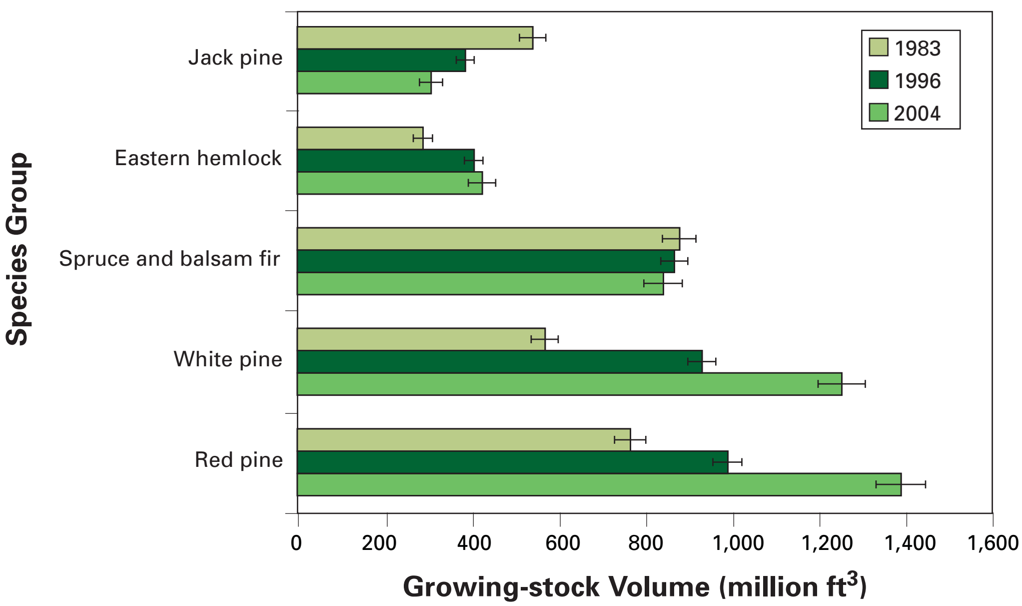


Figure 27.—Growing-stock volume on timberland for selected softwood species groups by inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

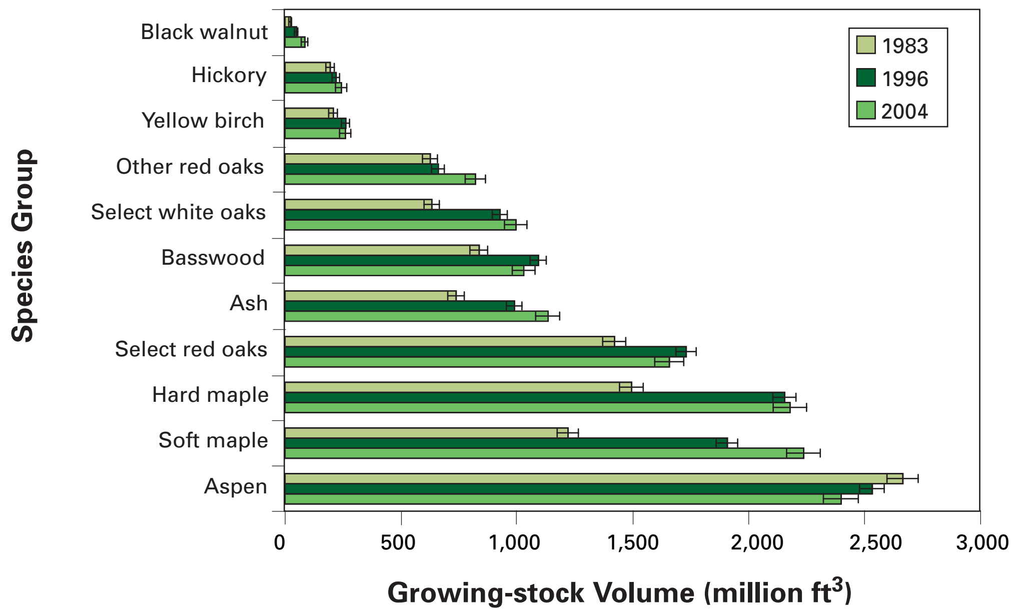


Figure 28.—Growing-stock volume on timberland for selected hardwood species groups by inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

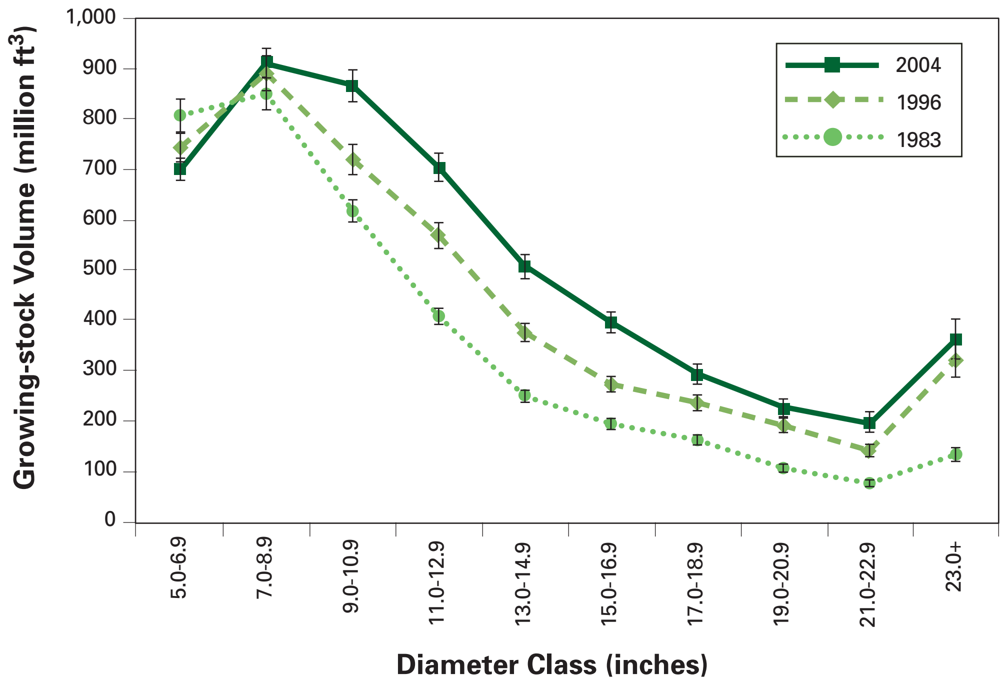


Figure 29.—Softwood growing-stock volume by diameter class and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

Figure 30.—Hardwood growing-stock volume by diameter class and inventory year, Wisconsin (error bars represent 66-percent confidence interval around the estimate).

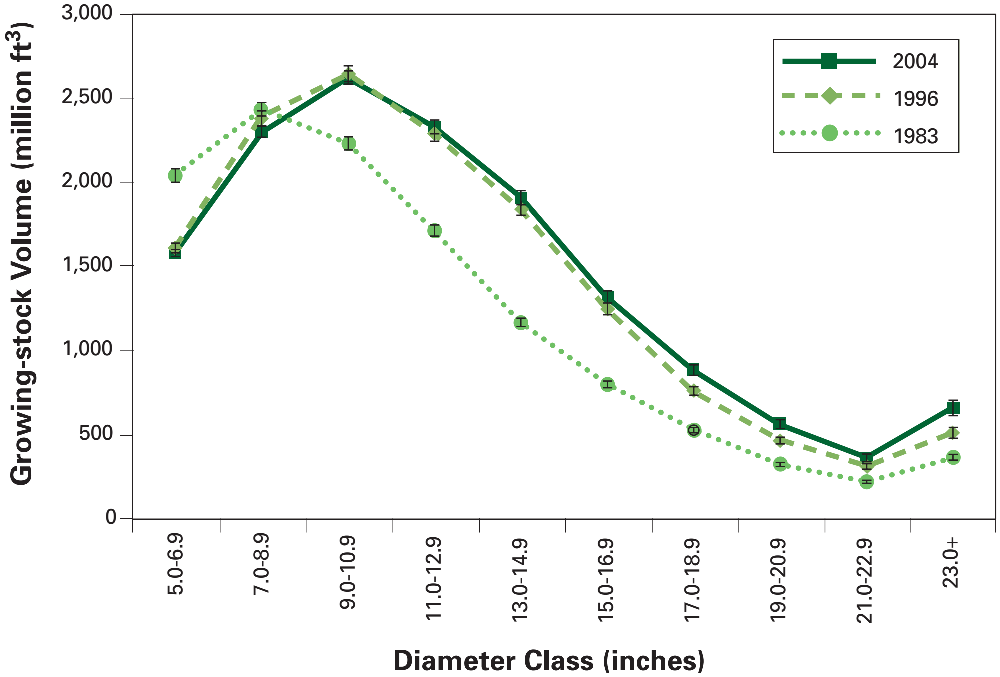
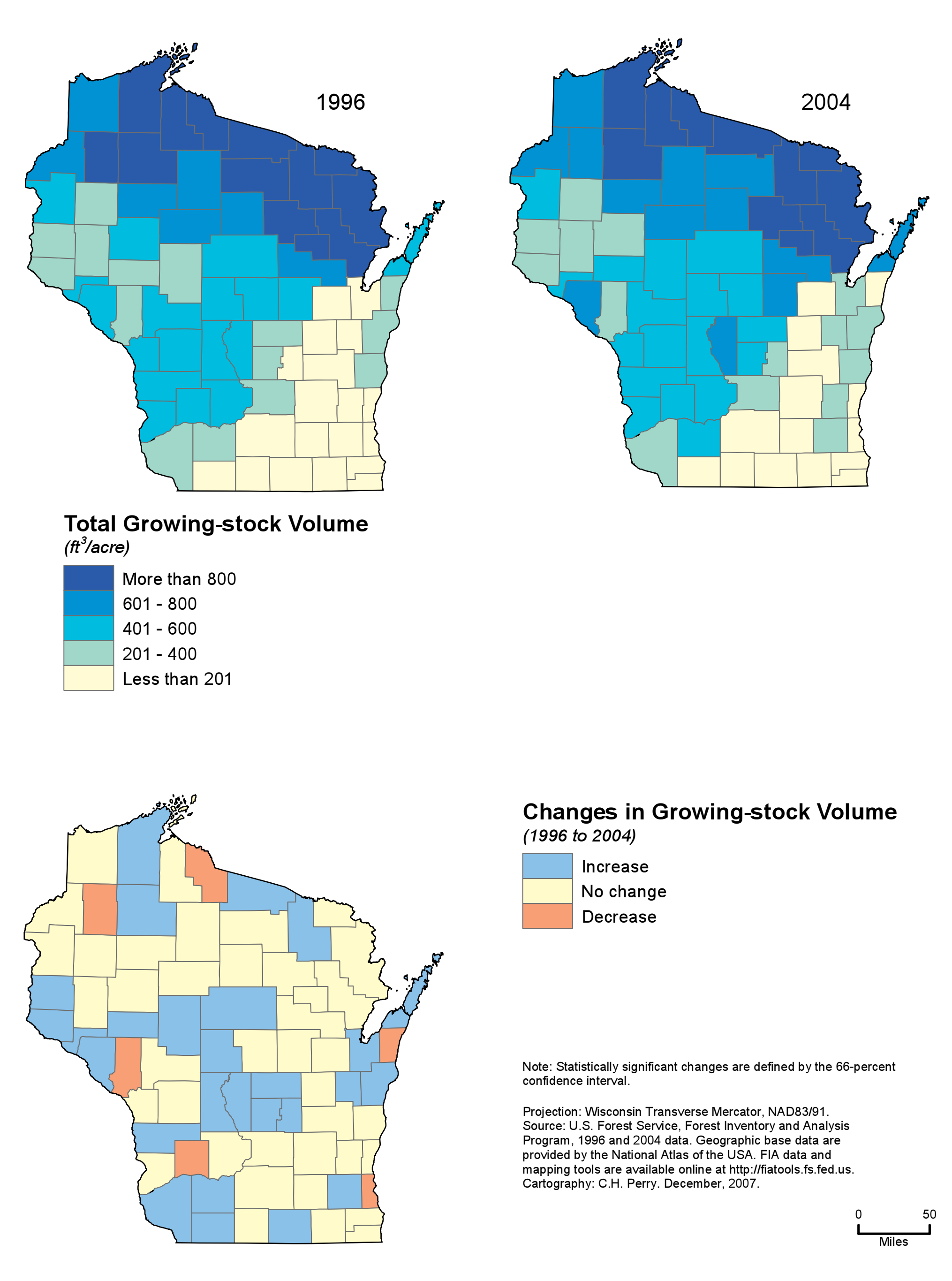


Figure 31.—Growing-stock volume by county and inventory year, Wisconsin.



Sawtimber Quantity and Quality

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. Both the quality and 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 54.8 billion board feet (Fig. 32). The sawtimber volume of most economically valuable species groups increased between 1996 and 2004. Both white and red pines and soft maple have increased by more than 30 percent in sawtimber volume since 1996 (Fig. 33). There was a major decline in jack pine sawtimber volume (18 percent). Average annual volume of net growth, removals, and mortality of sawtimber have remained relatively constant since 1983 (Fig. 34).

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. All grades except grade 1 continued to increase in volume between 1996 and 2004. However, the amount of total sawtimber volume in grade 2 as well as grade 1 declined slightly between 1996 and 2004 (Fig. 35).

What this means

The sawtimber resources of Wisconsin's forests have increased since the 1950s but this increase has not been uniform across all species groups. Sawtimber volumes in some economically important species groups, e.g., select red oak and hard maple, have remained about the same since 1996 while most others generally have increased. Only jack pine showed significant declines in sawtimber volume. Sawtimber growth, removals, and mortality have stabilized since the 1980s; this has resulted in a steady increase in the supply of sawtimber on Wisconsin timberland.

Although all sawtimber volume continues to increase, the trend of increasing high-quality sawtimber volume in the late 1980s and early 1990s was reversed in the 2004 inventory. 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.

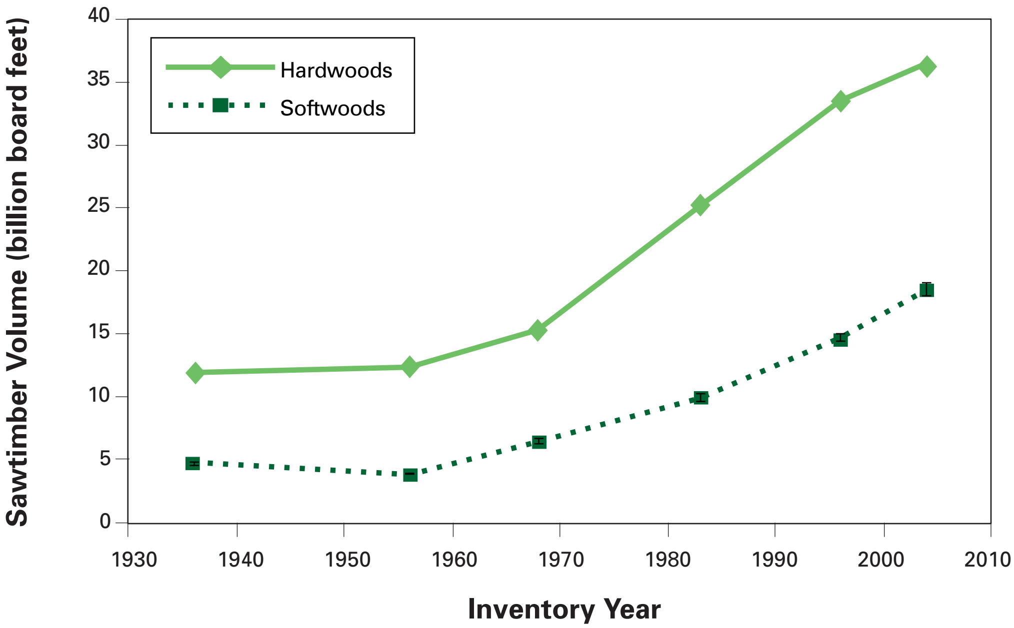


Figure 32.—Sawtimber volume by inventory year, Wisconsin (error bars – too small to be seen – represent 66-percent confidence interval around the estimate).

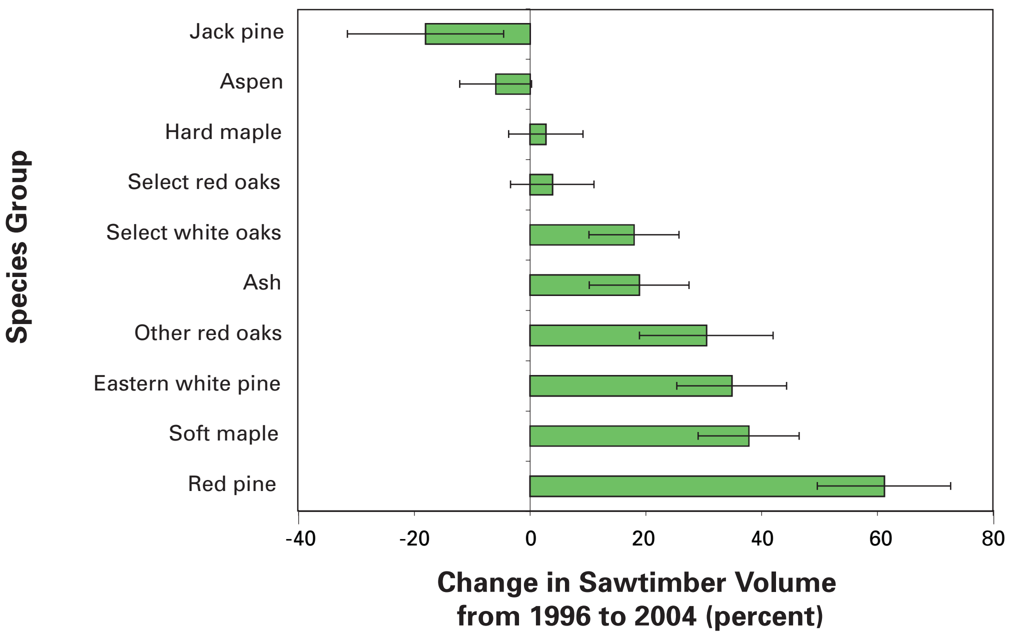


Figure 33.—Changes in sawtimber volume for major species groups, Wisconsin, 1996 to 2004 (error bars represent 66-percent confidence interval around the estimate).

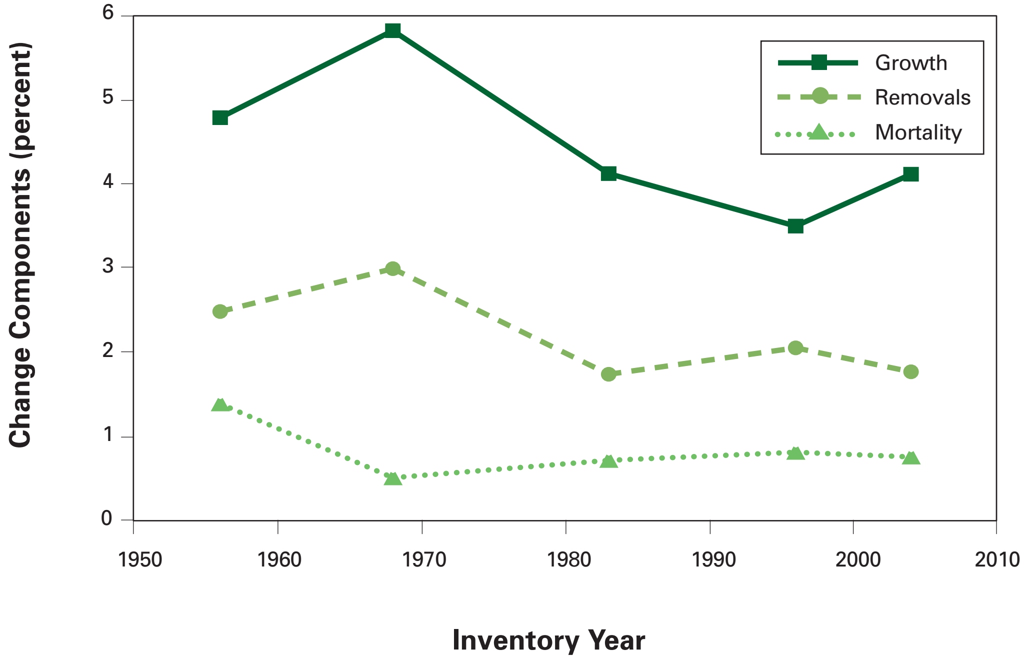


Figure 34.—Change components as a percentage of total sawtimber volume by inventory year, Wisconsin.

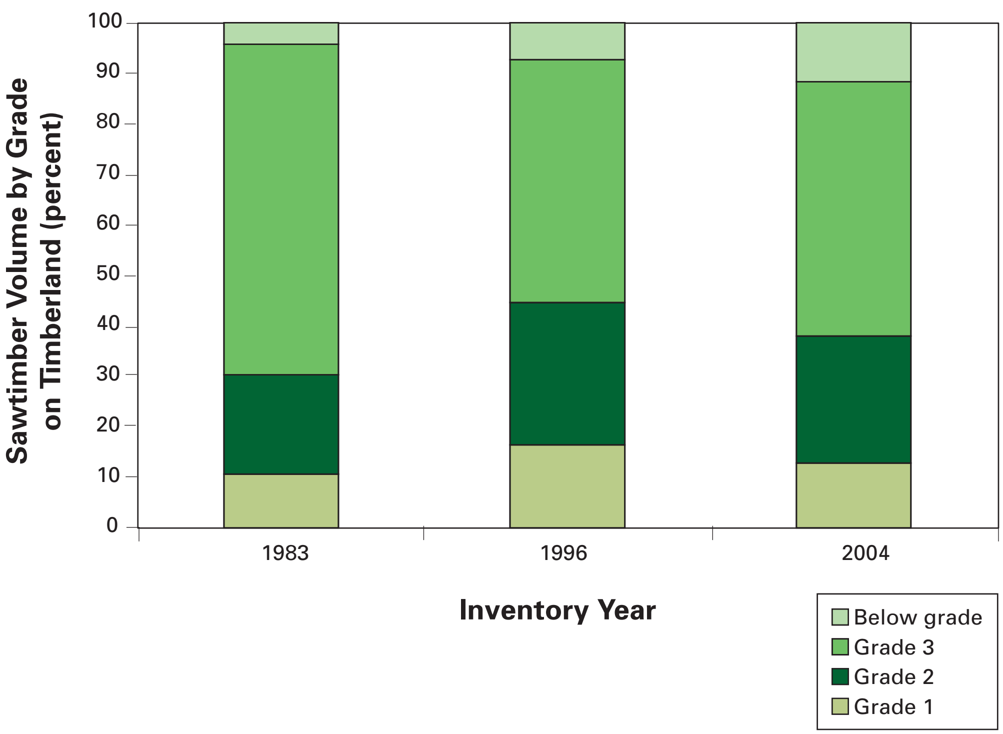
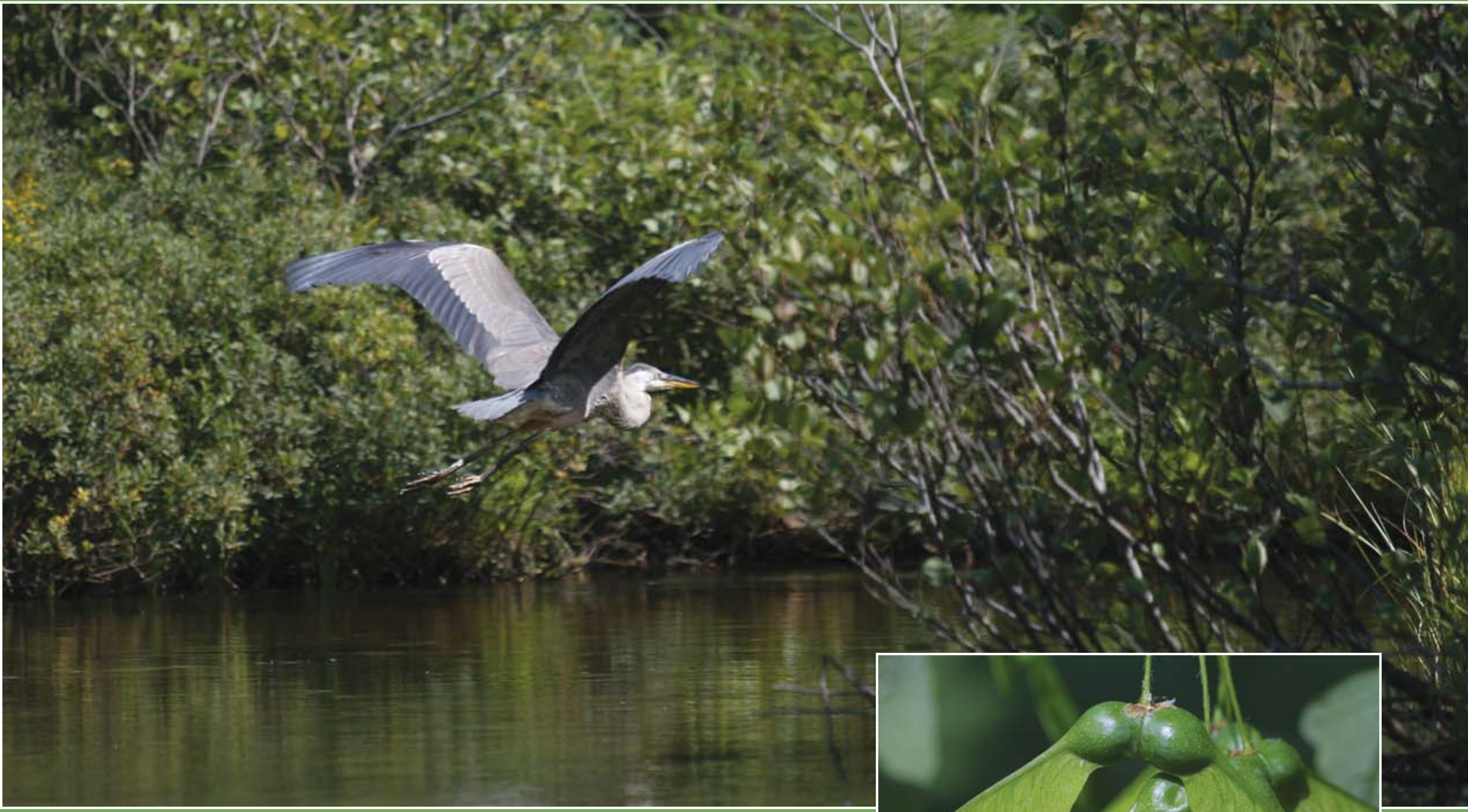


Figure 35.—Sawtimber volume on timberland by grade and inventory year, Wisconsin (grade 1 is the highest quality (largest diameter) grade available).

Forest Health Indicators



Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted. – Albert Einstein

Above: Great Blue Heron. Photo by Charles H. (Hobie) Perry. Inset: Sugar maple seeds. Photo used with permission from Steven J. Baskauf, bioimages.vanderbilt.edu.

Down Woody Materials

Background

Down woody materials in the form of fallen trees, branches, litterfall, and duff, fulfill a critical ecological niche in Wisconsin's forests. These materials provide habitat for wildlife and are important carbon stocks, but they also can be fire hazards.

What we found

Down woody material can be measured in hours of fuel loadings, or the number of hours it takes material to burn. Material that takes a long time to burn typically is large and contains a considerable amount of moisture. The fuel loadings of down woody materials (fuel-hour classes) are not exceedingly high in Wisconsin (Fig. 36). Compared to neighboring Michigan and Minnesota, Wisconsin's loadings of 1-, 10-, and 100-hr fuels are not significantly different. However, the loadings of the largest fuels (1,000+hr) are less than those in Minnesota and Michigan. There is no apparent trend for the State's total down woody fuel biomass – fine woody debris, coarse woody debris (CWD), duff, and litter – among classes of live-tree density. However, on average, the highest amounts of down woody biomass were found in stands with the highest amounts of standing live-tree density (Fig. 37).

The distribution of CWD by size class appears to be heavily skewed (85 percent) toward pieces less than 8 inches in diameter at point of intersection with plot sampling planes (Fig. 38A); most tops and logging residue generally are less than 8 inches in diameter. With regard to the distribution of CWD by decay class, the distribution of stages of coarse woody decay across the State appears to be fairly uniform (Fig. 38B). The spatial distribution of CWD carbon stocks indicates that the amounts of CWD carbon are highest in the northern and western areas of Wisconsin (Fig. 39).

What this means

The down woody fuel loadings in Wisconsin's forests are not exceedingly different from those in neighboring states. Therefore, only in times of extreme drought would these low amounts of fuels pose a fire hazard across the State. Of all down woody components, duff and CWD account for the majority of biomass. The distribution of CWD carbon stocks is dispersed evenly across the State with only localized areas of heavy stocks. However, most CWD pieces are small and reflect a forest resource that may decay rapidly. In fact, 67 percent of coarse woody pieces are in advanced stages of decay. Because fuel loadings are not exceedingly high across Wisconsin, possible fire dangers are outweighed by the wildlife habitats and carbon sinks provided by down woody material.

Figure 36.—Estimates of mean fuel loadings by fuel-hour class for Minnesota, Wisconsin, and Michigan, 2004 (error bars represent 66-percent confidence interval around the estimate).

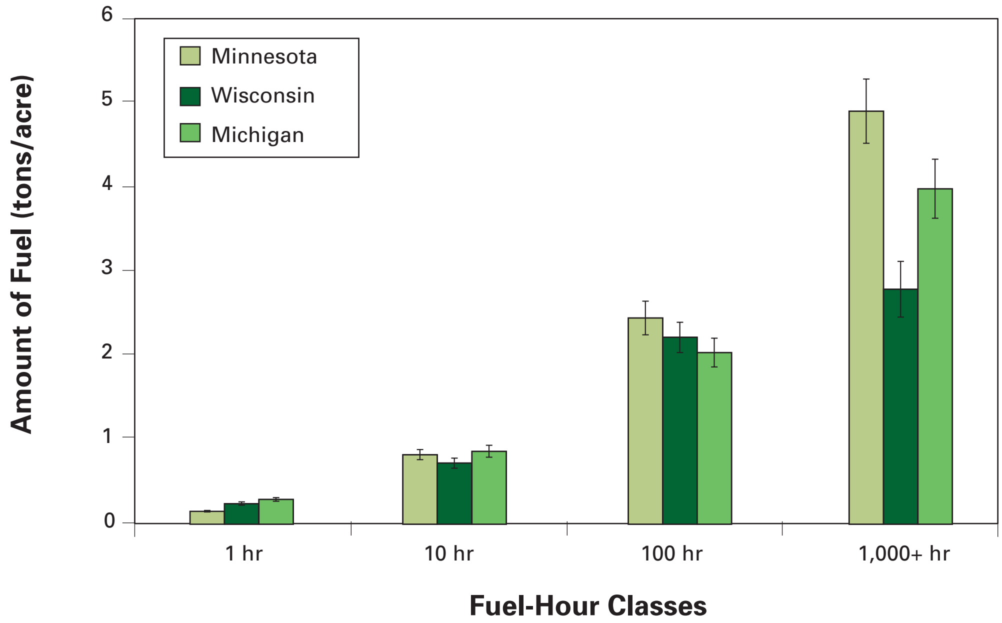


Figure 37.—Estimates of mean biomass from down woody material (woody debris, duff, litter) by stand density, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate).

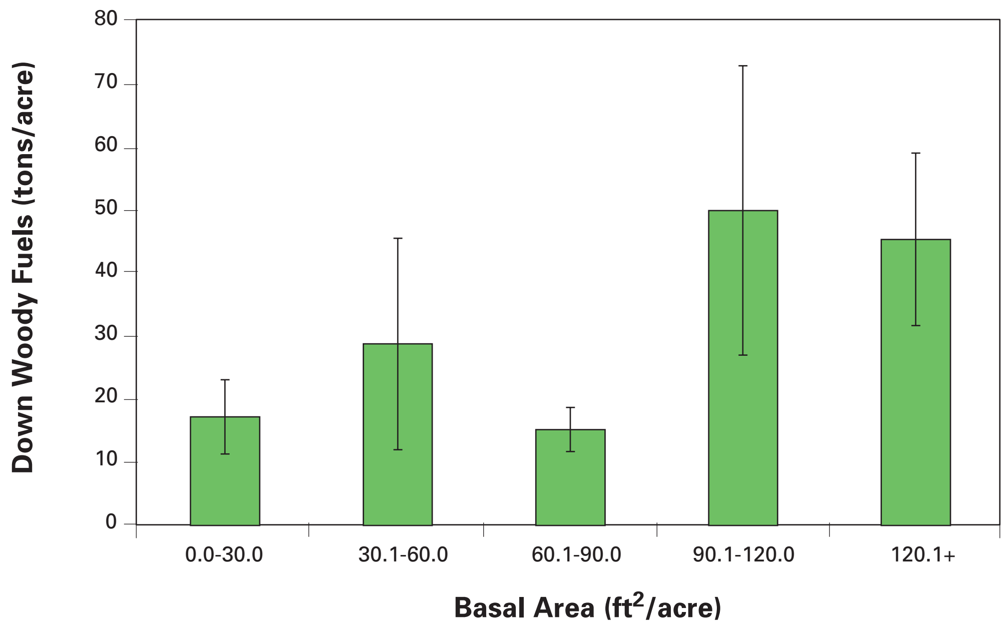


Figure 38.—Mean distribution of coarse woody debris (pieces per acre) by (A) size class (inches) and (B) decay class (1 = least decayed, 5 = most decayed), Wisconsin, 2004.

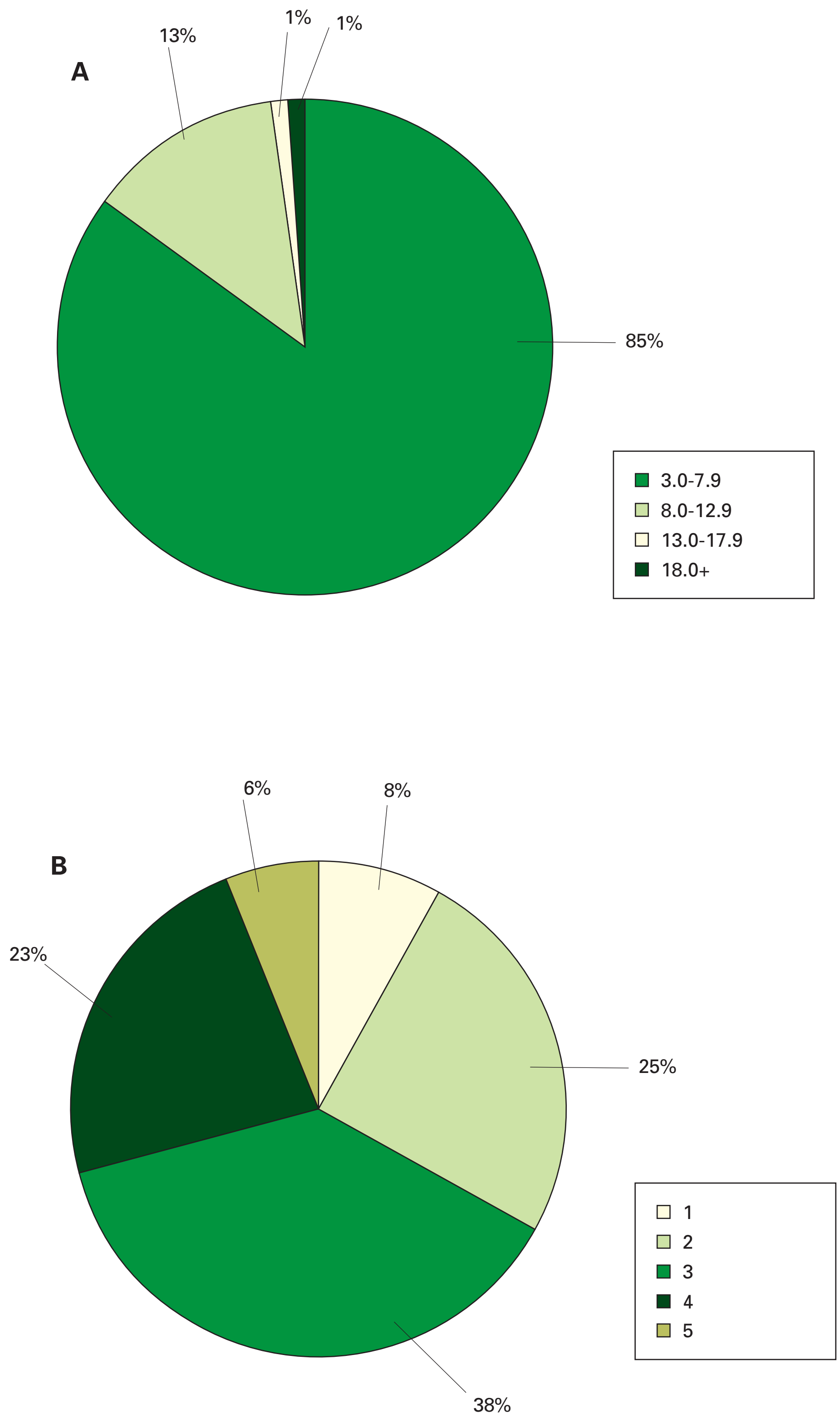
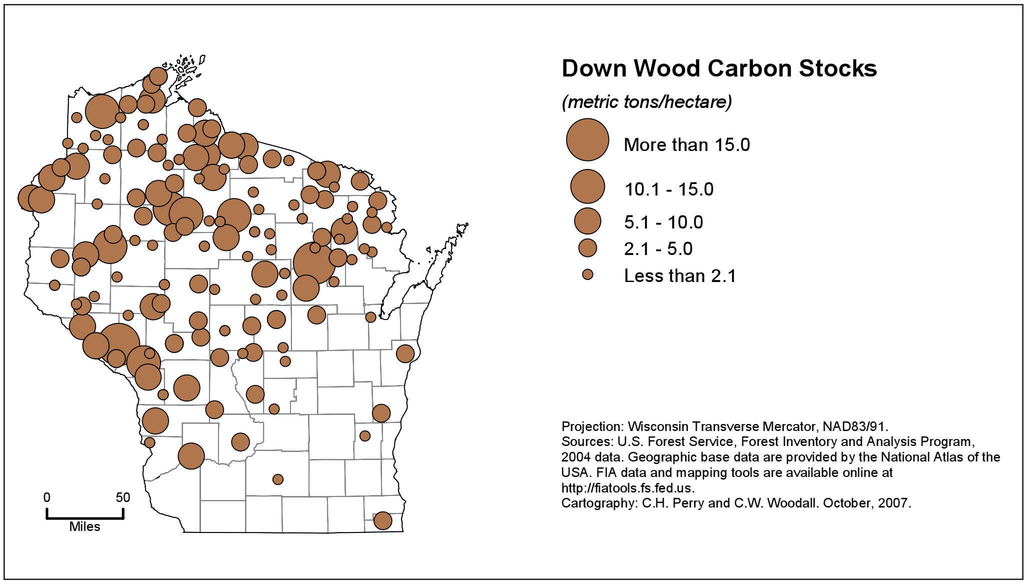


Figure 39.—Distribution of coarse woody debris carbon stocks, Wisconsin, 2004.



Tree Crowns

Background

The condition of tree crowns within a stand may reflect the overall health of a forest. For example, a forest suffering from a disease epidemic will have obvious dieback, low crown ratios, and high transparency.

What we found

Insect and disease pests, both native and exotic, continue to damage and kill trees in the State's forests, but all major tree species have shown a decrease in the percentage of standing dead basal area since 1996 (Fig. 40).

Dieback is the percentage of branch tips in the crown that are dead. 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). Tree crowns generally are healthy across Wisconsin for most species (Fig. 41). Only northern red oak has more than 5 percent of the total basal area in the ≥ 25 percent dieback categories.

What this means

Outbreaks of gypsy moth (*Lymantria dispar*) around the turn of the 21st century resulted in significant mortality in localized areas, but overall estimates of standing dead basal area from the 2004 inventory actually are lower than those from the 1996 inventory for all oak species (Fig. 40). Also, the crowns of the oak species across the State appear to be healthy. That northern red oak and white oak have the highest amount of basal area in the highest dieback category (Fig. 41) may correspond to defoliation by gypsy moth.

Crown dieback. Photo by USDA Forest Service – Region 8 Archive, bugwood.org.

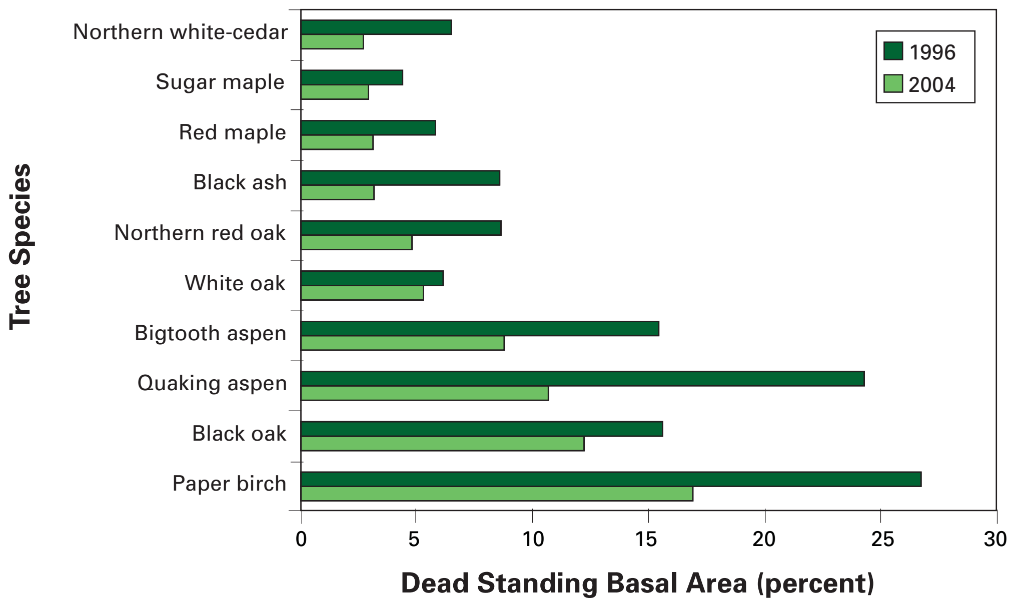


Figure 40.—Distribution of standing basal area that is dead by species and inventory year, Wisconsin.

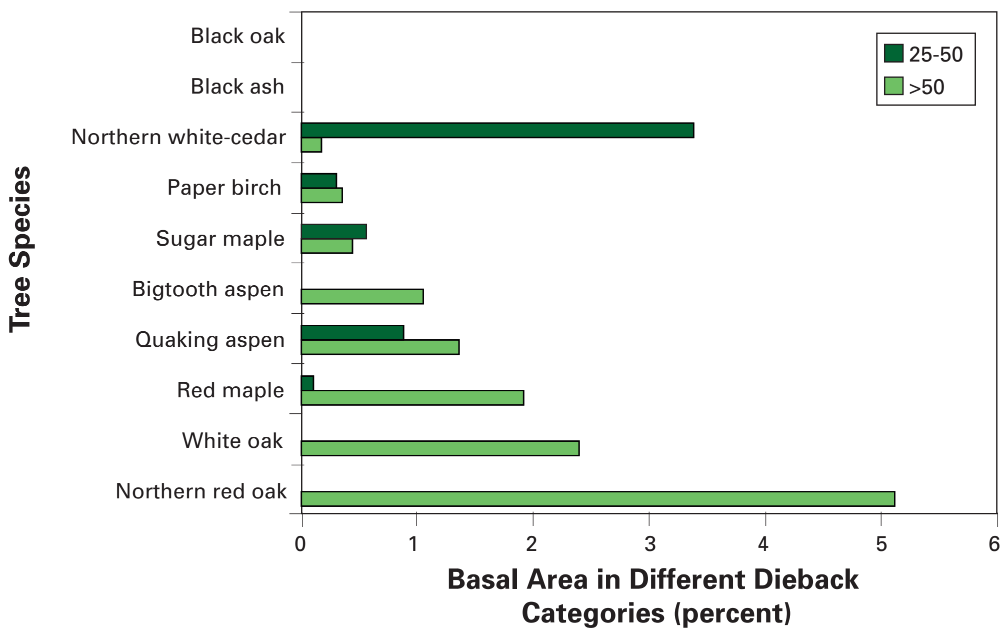


Figure 41.—Distribution of standing basal area of selected tree species by dieback category, Wisconsin, 2004.

Forest Soils

Background

Rich soils are the foundation of productive forest land. Hole (1976) used combinations of several factors – climate, local vegetation, topography, and parent material – to identify soil regions that were related to specific native forests (Fig. 42). The soils of the northern loamy uplands and plains formed under northern hardwoods and pines. The northern silty uplands and plains primarily support northern hardwoods. Pine barrens are common in the northern sandy uplands and plains while oak savannas are added to the mixture in the central sandy uplands and plains. Boreal forests hug the southern shore of Lake Superior on the northern clayey and loamy reddish drift uplands and plains. The NRS-FIA soil inventory points out the unique niches that different forests now occupy to maximize their competitive advantage. As an initial inventory, the collected data also provide critical baseline information for documenting changes in forest health resulting from natural or human influences.

What we found

There is substantial variety within Wisconsin's soil regions and forest trees compete for these specialized niches. For example, spruce-fir stands accumulated more forest-floor material than other forest-type groups (Fig. 43). A close review of the raw data indicated that several of these stands were on wet landscapes that tend to have low decay rates. Pines were found on soils with higher bulk densities (Fig. 44). Elm/ash/cottonwood, maple/beech/birch, and oak/hickory forest-type groups were on landscapes with greater effective cation-exchange capacities (ECEC), i.e., more mineral nutrients are available (Fig. 45).

What this means

The forest floor results from the slow accumulation of organic matter. Carbon is the primary component of soil organic matter, which increases water-holding capacity, retains certain nutrients by cation exchange (e.g., Ca^{2+}, Mg^{2+}, K^{+}), releases other nutrients as it decays (N, P, and S), and captures potential toxic agents, e.g., Hg (McBride 1994). Carbon also is inventoried to track the sequestration of certain greenhouse gases. It traps nutrients and improves water-holding capacity. Thicker forest floors indicate greater carbon storage. Wet sites tend to accumulate carbon, so draining these sites can lead to increased emissions as the material decays. Thick forest-floor material also can be a fire threat in some settings, though the wet location of these spruce/fir stands mitigates the threat.

Bulk density or the mass of dry soil in a fixed volume is an important physical property of soils. Trees have greater difficulty rooting in soils with higher bulk densities, and there is less pore space available for air and water exchange. Soil texture affects bulk density; sandy soils tend to have higher bulk densities than finer textured soils like silts, clays, and loams. In Wisconsin, half of the white/red/jack pine samples were collected on sandy sites, but the other forest-type groups were much more common on loamy and clayey sites.

ECEC is the sum of five key mineral elements: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, and Al^{3+}. High ECEC values are associated with higher fertility. In Wisconsin, the aspen/birch and white/red/jack pine forest-type groups were on sites with low relative fertility. This could be important as aspen/birch forests transition to later successional forest types that may require greater mineral nutrition.

Figure 42.—Soil regions underlying the forests of Wisconsin (adapted from Hole 1976).

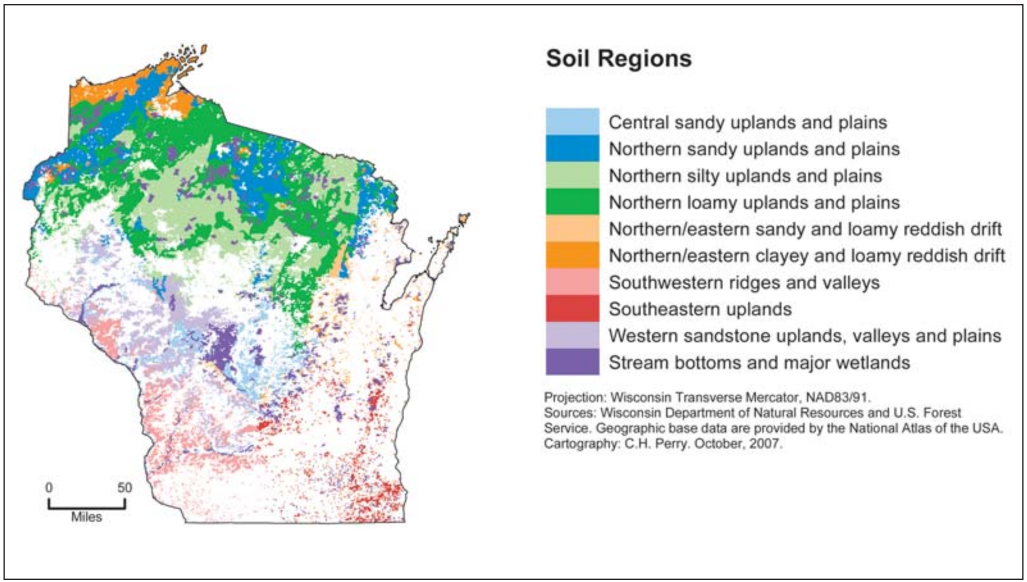


Figure 43.—Mean forest floor thickness by forest-type group (error bars represent 66-percent confidence interval around the estimate).

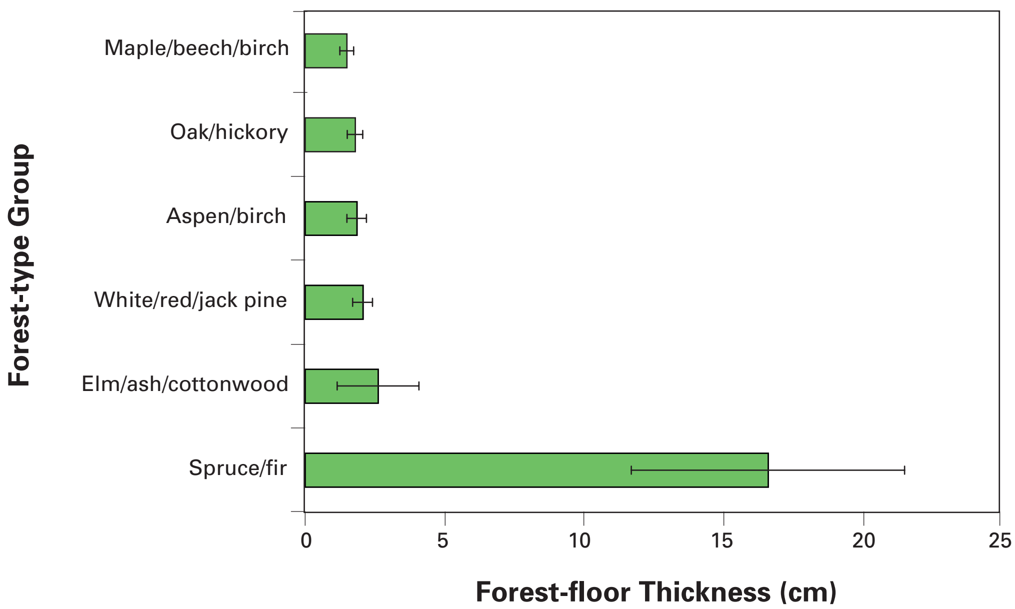


Figure 44.—Mean bulk density for the 0-10 cm soil layer by forest-type group (error bars represent 66-percent confidence interval around the estimate).

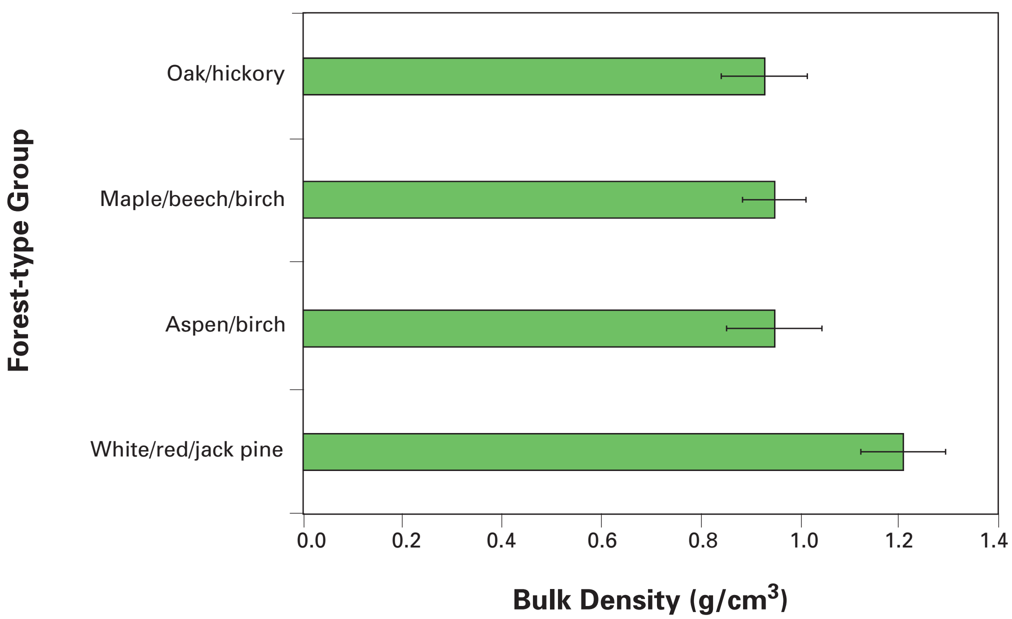
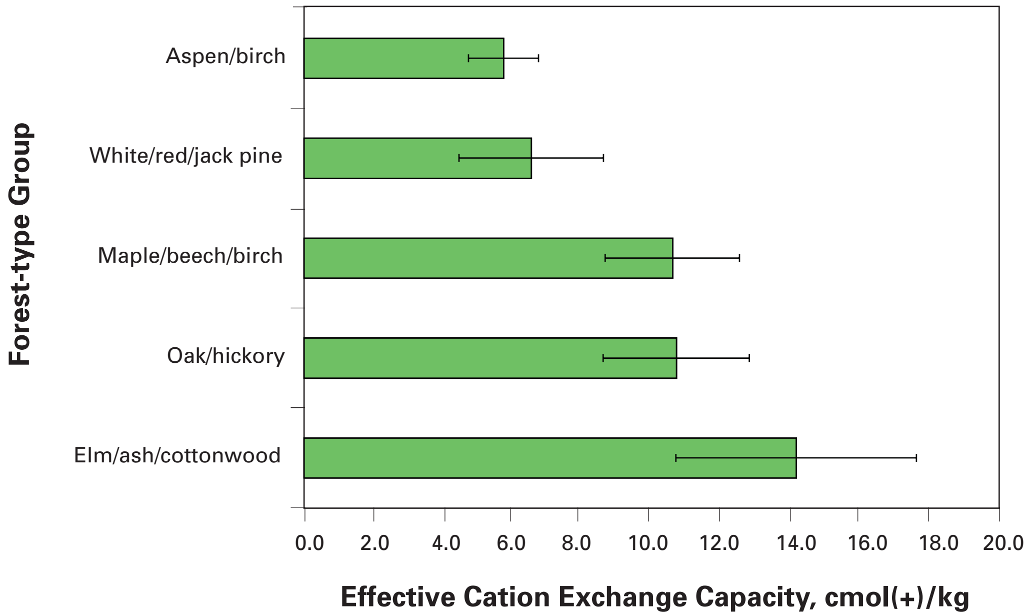


Figure 45.—Effective cation exchange capacity for the 0-10 cm soil layer by forest-type group (error bars represent 66-percent confidence interval around the estimate).



Ozone Damage

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 (in seedlings and saplings) have been reduced in controlled exposure studies in eastern Wisconsin. These ozone exposures routinely exceed thresholds suggested by the interagency Federal Land Managers Air Quality Group to protect vegetation. Individual species and sensitive populations within species may have lower productivity, thus influencing overall competitiveness and forest composition.

What we found

National biomonitoring of ozone includes 31 biosites in Wisconsin, but an intensified grid was surveyed in southern Wisconsin from 2001 to 2004. Field biomonitoring detected foliar injury related to ground-level ozone stress on bioindicator species each year from 2001 to 2004 (Fig. 46). Ozone enters a plant through its stomates, so injury observations are indirectly related to the occurrence of drought (cf. Fig. 62). The amount and severity of the foliar injury is greatest at biosites along the Lake Michigan shoreline where ozone exposures are highest. Injury is low to absent in the other regions of the State.

Ground-level ozone exposure is frequently reported as SUM06, the total duration of exposure to concentrations exceeding 0.06 parts per million (ppm). Ozone can lead to leaf damage at levels exceeding 8 ppm-hours, and the growth of seedlings in natural forest stands is affected at 10 to 15 ppm-hours (Heck and Cowling 1997). The bulk of the State's forests in southern, central, and northern Wisconsin were subjected to the lowest levels of

Ozone damage on black cherry leaf. Photo by Tim Tigner, Virginia Department of Forestry, bugwood.org.

ozone observed in Wisconsin between 2000 and 2004 (Fig. 47). Eastern forests are exposed to the highest seasonal ozone exposures, and biomonitoring plots in this region typically have the greatest injury scores.

Typical national ozone biomonitoring sites have three to four bioindicator species present and 20 to 30 individuals of each species. The surveys in Wisconsin assessed 22,502 plants over 5 years; 355 of them had verified ozone leaf injury. The most commonly sampled species in the State in rank order by most injured were common milkweed, black cherry, white/green ash, dogbane, blackberry, and big leaf aster. Ozone injury occurred on 1.7 percent of the plants evaluated between 2001 and 2004.

What this means

Most of Wisconsin's forest land is exposed to slightly to moderately elevated ozone concentrations relative to background levels. The forests are at low risk of foliar injury and growth and productivity losses. The potential effects of ozone stress should be 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.

Figure 46.—Biosite injury observations by assessment year, Wisconsin.

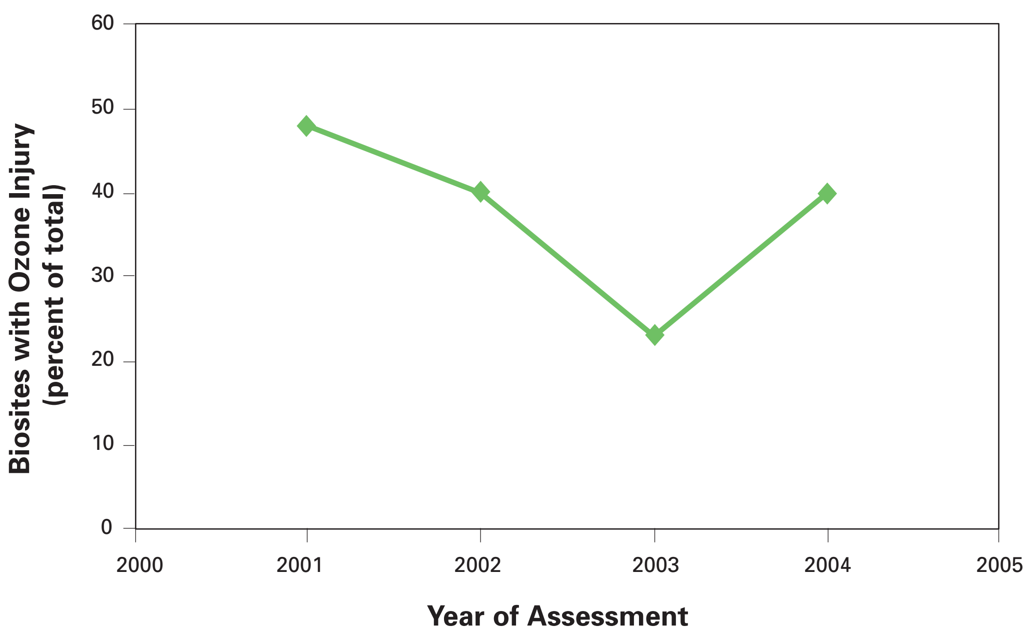
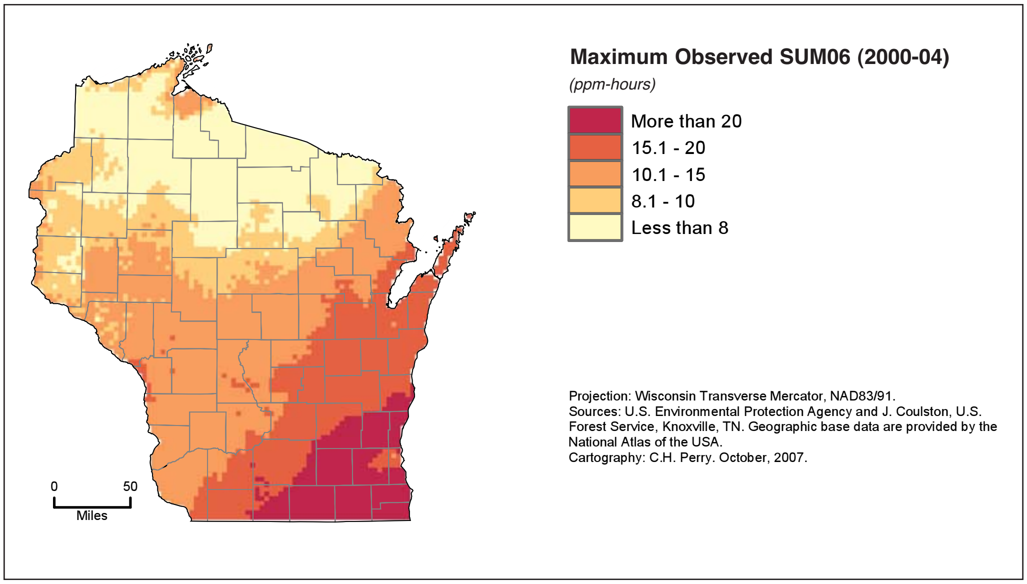


Figure 47.—Maximum observed ground-level ozone reported as SUM06 (total amount of time ozone concentration exceed 0.06 ppm), Wisconsin, 2000-04.



Forest Invaders: Nonnative Plant 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 91 vegetation diversity plots in 2001, 2002, and 2003. A regional guide to nonnative invasive plants was used to identify species of interest.[1] Nine different species were identified in Wisconsin's forests (Fig. 48). The two most common nonnative invasive species were woody plants; both multiflora rose and common buckthorn were found on 13 plots. One or more species were found on 38 plots (42 percent; Fig. 49), but it was relatively uncommon to find two or more species occurring on the same plot (13 percent). The number of nonnative invasive species appeared to be related weakly to stand density (Fig. 50). Those plots with 0 to 50 ft^2/acre of basal area averaged about 1.53 nonnative invasive species and plots with more than 150 ft^2/acre of basal area averaged 1.26. Other analyses have found correlations between invasives and proximity to roads. The spatial distribution of these plants was not consistent (Fig. 51). From the 1930s through the 1960s, multiflora rose was planted as a "living fence" and then for wildlife habitat. Seeds are now transported by birds. It is believed to be range-limited by minimum temperatures of -28 °F, which thus far have prevented movement into northern Wisconsin. Common buckthorn, by contrast, is distributed more evenly. Garlic mustard, an herb, also appears to be moving to the north. Reed canary grass is distributed evenly across the State.

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 outcompete 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.

[1]Olson, C.; Cholewa, A.F. 2004. Non-native invasive plant species of the North Central Region: a guide for FIA field crews. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. Unpublished field guide. On file with: Forest Inventory and Analysis Program, Northern Research Station, 1992 Folwell Avenue, St. Paul, MN 55108.

Figure 48.—Occurrence of nonnative invasive species on vegetation diversity plots (n=91), Wisconsin, 2001-03.

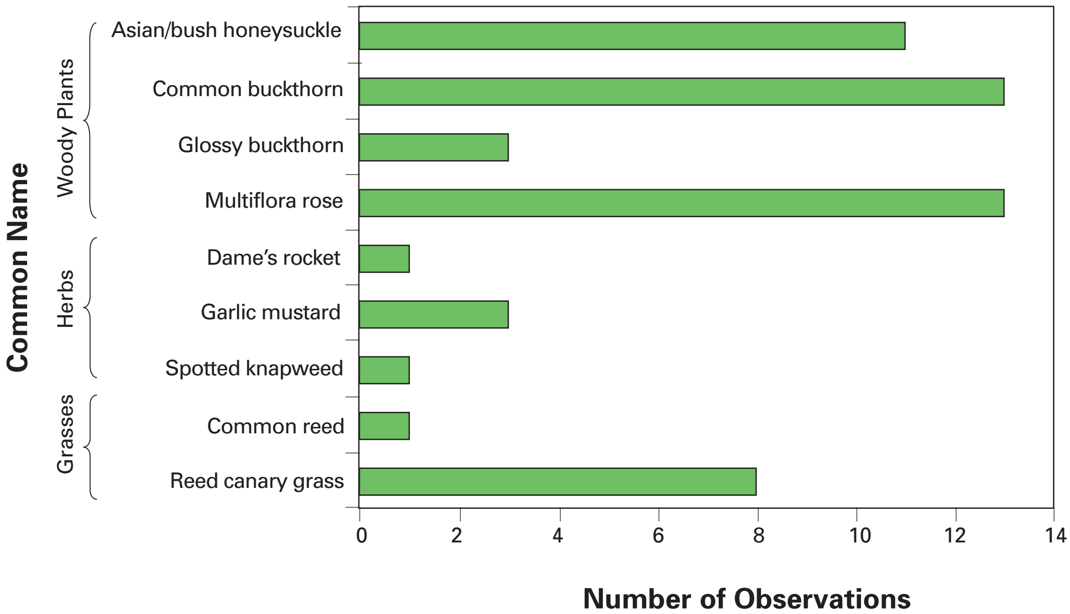


Figure 49.—Distribution of nonnative invasive species on vegetation diversity plots (n=91), Wisconsin, 2001-03.

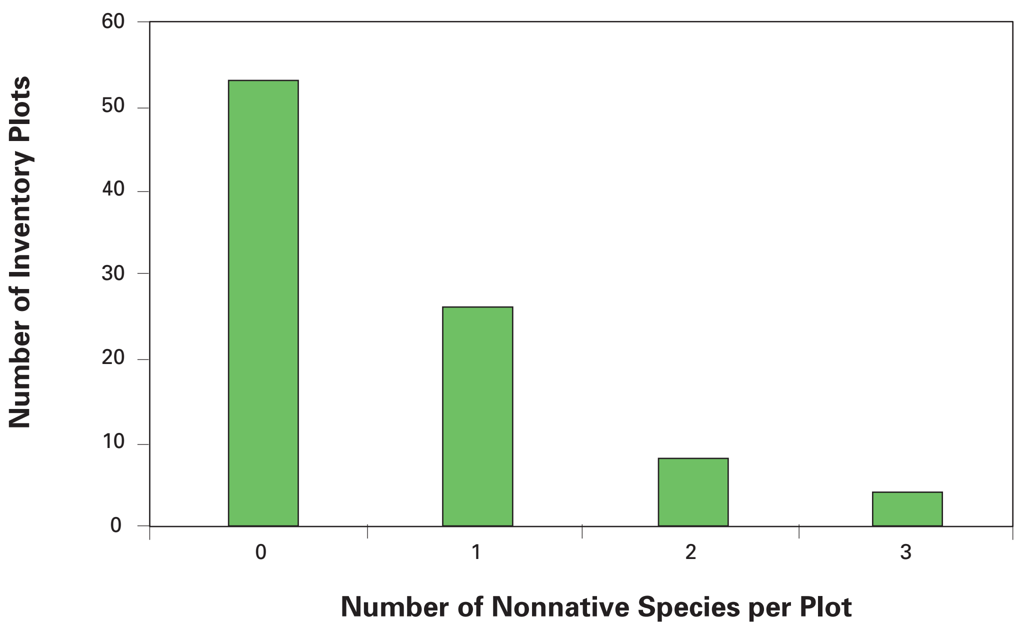


Figure 50.—Mean number of nonnative species on vegetation diversity plots (n=91), Wisconsin, 2001-03 (error bars represent 66-percent confidence interval around the estimate).

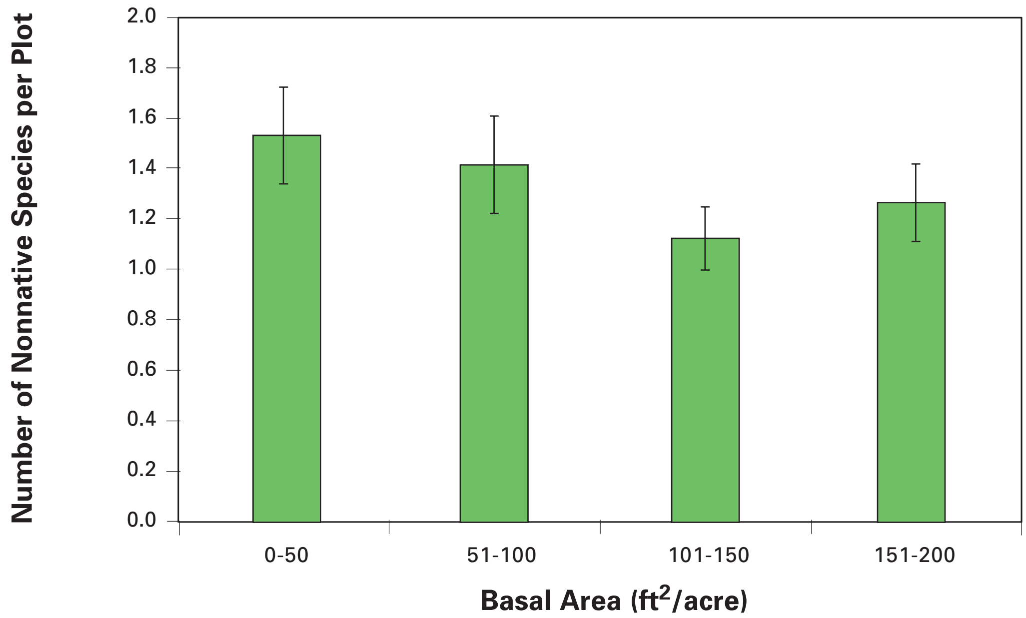
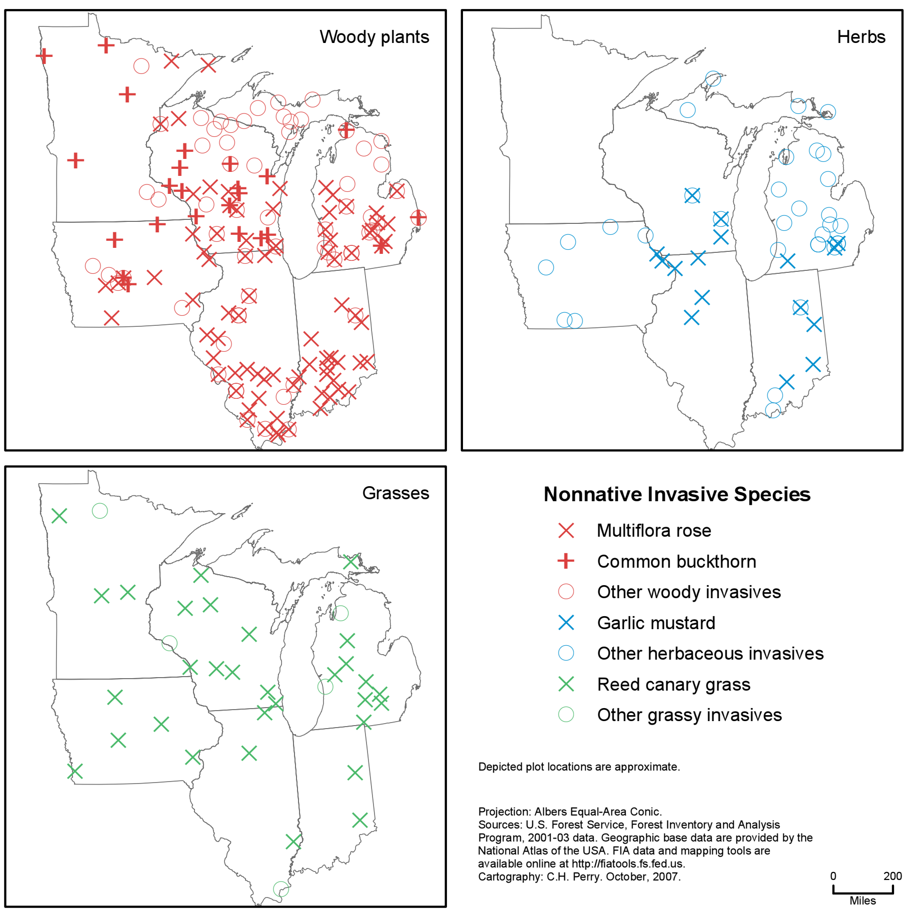


Figure 51.—Distribution of nonnative invasive species in Wisconsin and its neighbors, 2001-03.



The Urban Forest

Background

There are substantial environmental benefits associated with Wisconsin's urban forests (trees in and around communities): pollution removal, carbon sequestration, and energy reduction. Each year, trees within urban areas and immediately surrounding forest remove $36.4 million worth of pollution (ozone, particulate matter, nitrous oxide, etc.) in Wisconsin. These same trees store $42 million worth of carbon, and an additional $2.4 million worth of carbon is sequestered every year. Urban trees also reduce heating and cooling expenses by $24.3 million annually, with an additional $1 million in carbon production avoided because of reduced energy demand. These values tend to increase with increased size and numbers of healthy trees. Sustaining forest health and longevity is critical to sustaining these benefits through time.

Relatively little is known about the health of Wisconsin's urban forests. A partnership between the USDA Forest Service and the Wisconsin Department of Natural Resources resulted in a pilot study of the composition and condition of the State's urban forests and the benefits they provide.

What we found

The pilot study established and sampled 111 urban field plots during the summer of 2002. Urban areas were delimited using the 1990 U.S. Census definition of urban and crossed all ownership boundaries (Fig. 52). The inventory included trees on all land uses, e.g., residential, rights-of-way, and commercial. Residential was the dominant land use, covering 38 percent of urban areas (Fig. 53). The sampled urban areas contained nearly 27 million trees, or an average of 36.9 trees per acre with an estimated total structural/replacement value of $10.9 billion. Tree size averaged 5.4 inches d.b.h. and residential landscapes had the largest trees (Fig. 54). Of the 56 different species found in the study, boxelder, white ash, green ash, and eastern white pine were the most common (Fig. 55).

Data on forest health collected on crown conditions and occurrence of damage indicated the urban forests of Wisconsin generally are healthy and vigorous. Nineteen percent of urban trees showed signs of damage (conks, vines, open wounds, etc.); white ash and boxelder were the most frequently damaged trees. Estimated average annual mortality within urban areas was 7.3 percent.

The urban forest is vulnerable to pests, particularly the emerald ash borer, which pose a risk to 20 percent of Wisconsin's urban forest. There are 5.2 million ash trees larger than 1 inch d.b.h. in urban areas with an associated structural/replacement value of $1.5 billion. These are conservative estimates that do not consider the cost to remove dead trees and stumps, nor the lost environmental, social, and economic services provided by the trees.

What this means

The urban forests of Wisconsin provide substantial social, economic, human health, and environmental benefits. The resource itself is worth billions of dollars and annually provides functional benefits exceeding $64 million for pollution removal, carbon sequestration, and reduced consumption of building energy. Many other environmental, economic, and social benefits, such as storm water reduction, increased property values, and improved neighborhoods have not yet been quantified.

Urban trees affect about 80 percent of the State's population daily. Nearly 2.6 million trees need to be established annually to sustain urban tree cover at the current level (14 percent). Some of these trees will be established naturally through regeneration but many likely will require planting. This translates to one new tree per year for every 10 existing trees within urban areas. The benefits associated with this resource will be realized only with conscientious forest management over time.

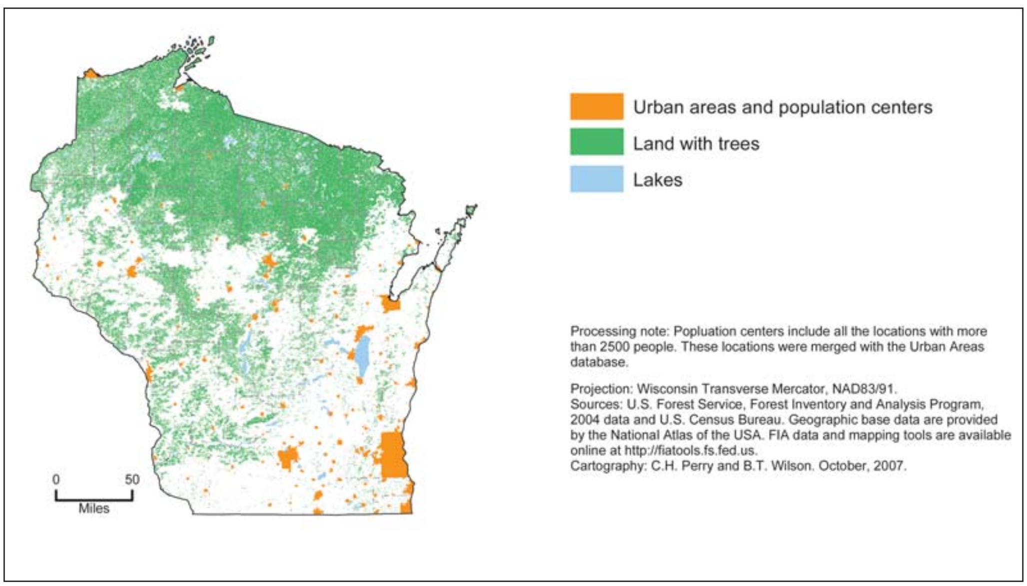


Figure 52.—Distribution of urban areas and other population centers, Wisconsin.

Figure 53.—Distribution of urban forest by land-use category, Wisconsin, 2002.

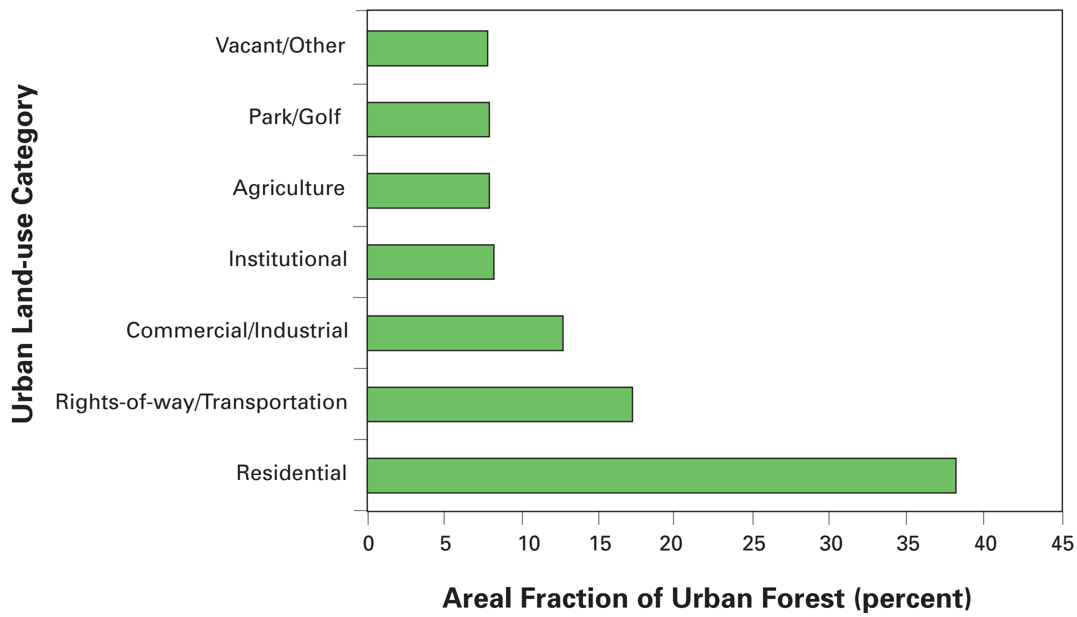


Figure 54.—Mean basal area of trees in urban forests by land-use category, Wisconsin, 2002.

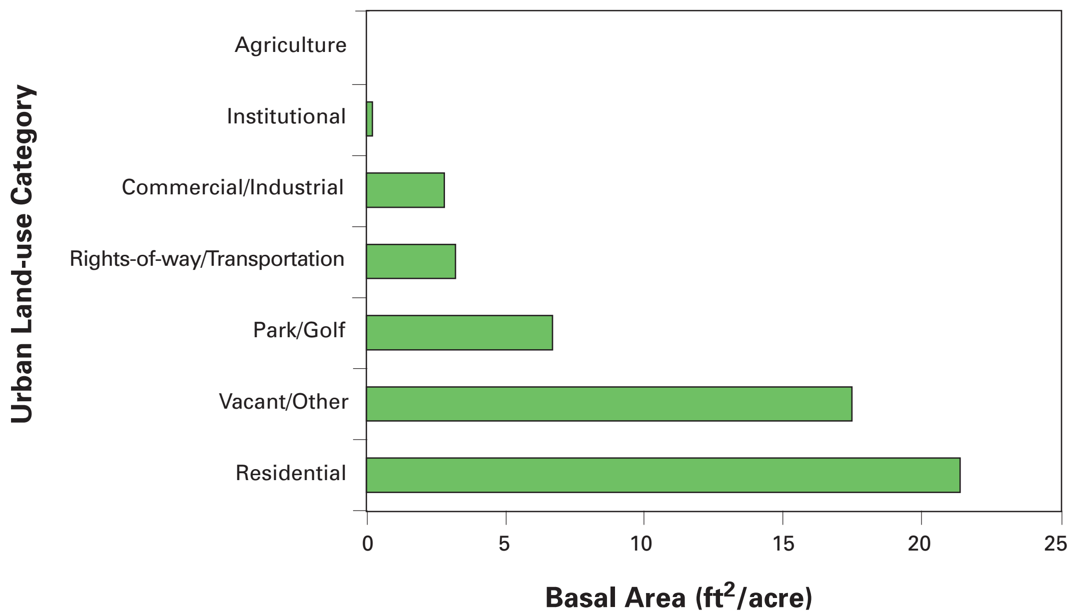
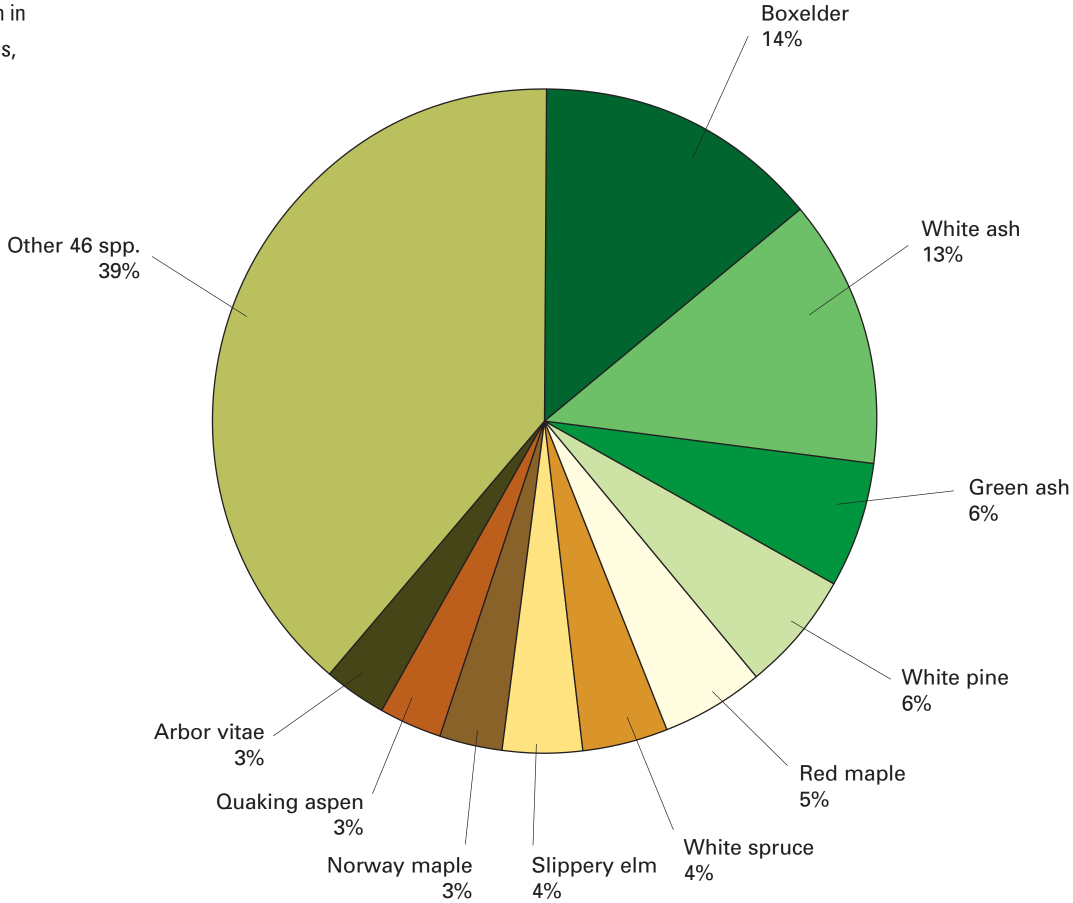


Figure 55.—Species distribution in urban forests by number of trees, Wisconsin, 2002.



Forest Change Issues

Because things are the way they are, things will not stay the way they are.
– Bertold Brecht

Above: Northern hardwood forest. Photo by Steven Katovich, USDA Forest Service, bugwood.org. Inset: Forest hiker. Photo by Charles H. (Hobie) Perry.

Nonindustrial Private Landowners

Background

Those who own the forest have a great deal of influence over its structure. Forest land can be managed for objectives such as aesthetics, land investment, nature protection, recreation and solitude, and timber production. Understanding the objectives, opportunities, and constraints of forest-land owners aids in predicting the future of this resource.

What we found

Families and individuals are the dominant land-ownership group in the State. FIA conducts the National Woodland Owner Survey to complement its inventory of the biophysical forest resources (www.fs.fed.us/woodlandowners). An estimated 322,000 families and individuals collectively own 9.1 million acres of forest land in Wisconsin. The majority of family forest owners (52 percent) hold fewer than 10 acres of forest land, but 53 percent of family forest land is owned by people with landholdings of 10 to 99 acres (Fig. 56). Between 1993 and 2004, the number of private forest owners increased significantly due primarily to an increase in the number of owners with small parcels (1 to 9 acres). The number of owners with larger parcels (10+ acres) did not change significantly over this period.

Family forest owners have diverse ownership and forest-management objectives. The most common reasons for owning forest land are related to aesthetics and hunting (Fig. 57). Other common reasons for ownership include privacy, nature protection, family legacy, and the land being part of a home or cabin site. An estimated 35 percent of family and individual owners have harvested trees from their land in the past 5 years (Fig. 58). Less than 7 percent of family forest owners reported having a written forest management plan, but 28 percent sought management advice from a natural resource professional, most commonly those working for the Wisconsin Department of Natural Resources or a Federal resource agency. It is noteworthy that 20 percent of family forest owners (holding 1.8 million acres) intend to sell their land or pass it on to their heirs in the next 5 years (Fig. 59). When combined with owners who intend to subdivide or convert their land from forest to other uses, this number of acres grows to 2.2 million (24 percent).

What this means

Any report or program that is designed to influence the forest resources of Wisconsin must consider this important, diverse, and dynamic group of forest owners. As the size of an owner's landholdings increases, so does the likelihood that she or he has harvested trees, has a written management plan, and has sought management advice. As current family forest owners pass along property to heirs or sell it, a dramatic shift is anticipated that will change the characteristics of family forest owners and how they interact with and relate to their land. As a result, future forest characteristics also will be altered.

As more individuals sell their property, the size of family forest parcels may decrease, creating economic, social, and ecological issues. Smaller forest parcels can be more expensive to manage due to higher per-acre costs. As the number of family forest owners grows, so does the challenge for foresters, agencies, and others in education and extension who try to inform the new owners. Species such as migratory birds and large carnivores benefit from management at a landscape scale rather than on a small forest-by-forest basis. Several state and Federal cost-share programs are available for forest tracts that area are least 10 acres in size. Large forests sold in sections smaller than 10 acres would restrict the ability of future owners to participate in cost-share programs.

Photo used with permission from Wisconsin DNR.

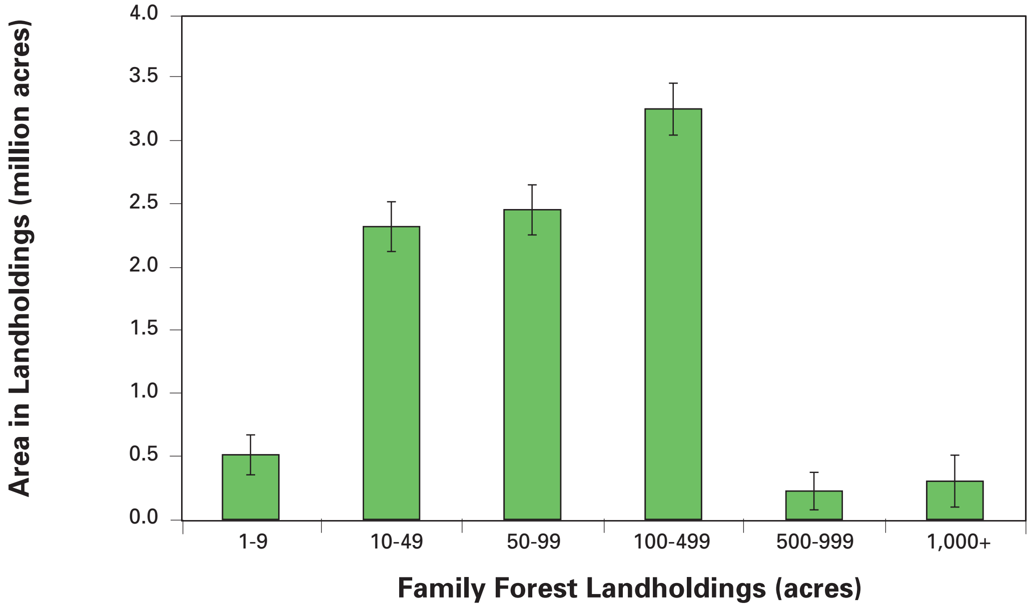


Figure 56.—Area of family-owned forests by size of holdings, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate).

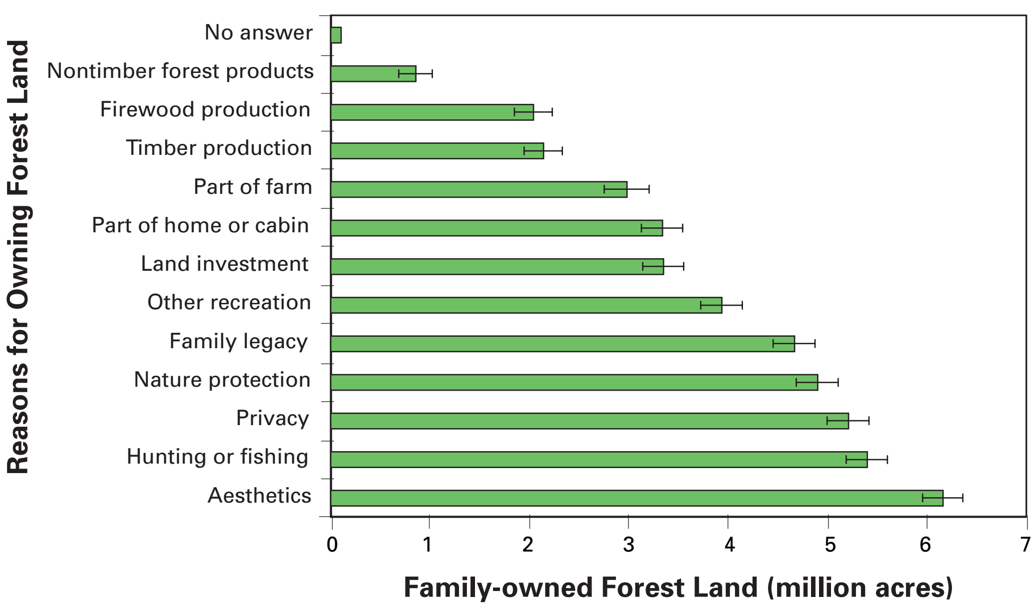


Figure 57.—Area of family-owned forests by reason for ownership, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate; categories are not exclusive).

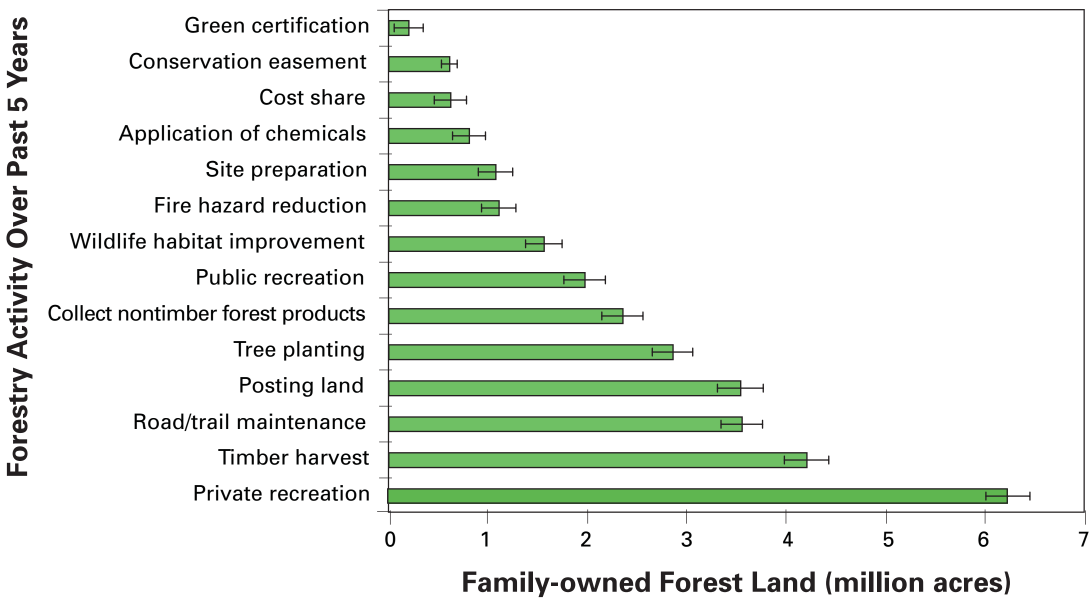


Figure 58.—Area of family-owned forests over the past 5 years by forestry activity, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate; categories are not exclusive).

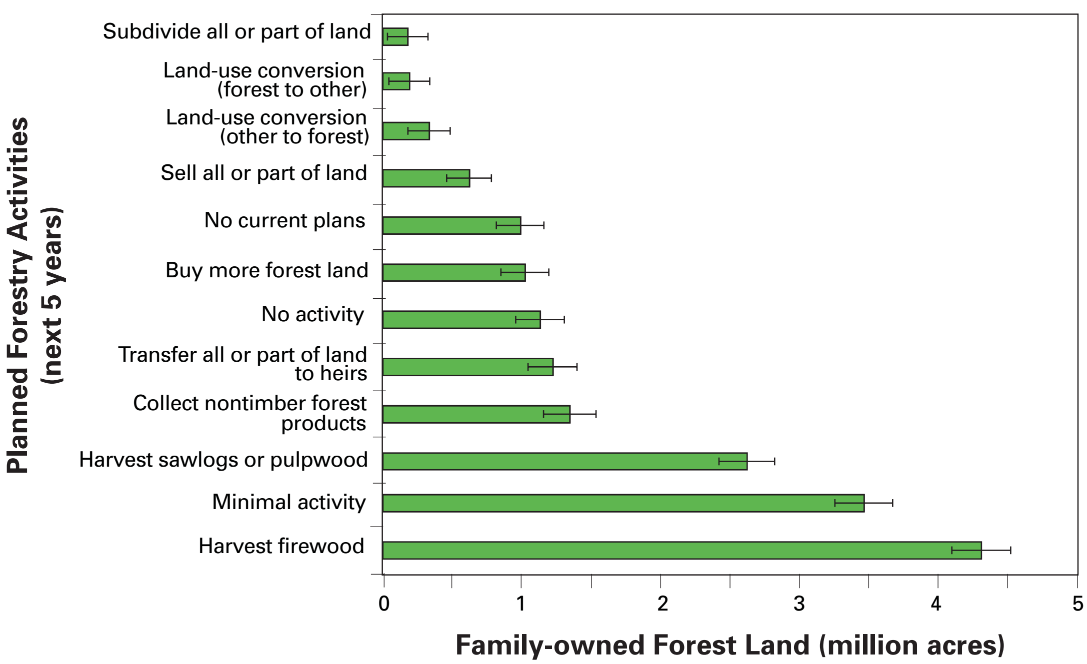


Figure 59.—Area of family-owned forests by planned (next 5 years) forestry activity, Wisconsin, 2004 (error bars represent 66-percent confidence interval around the estimate; categories are not exclusive).

Forest Insects and Diseases

Background

Insects and diseases always have been a part of Wisconsin's forest ecosystems. Detection and monitoring of these organisms has occurred since the mid 1950s. In the past decade, the threat from exotic insects and diseases has increased as the number detected in the United States increases.

What we found

Wisconsin's forests experienced impacts from numerous insects and diseases during the inventory period. The most significant impacts resulted from defoliation by insects followed by a severe drought and subsequent infestations by insects and diseases that thrive on stressed trees. Native insects including the forest tent caterpillar (*Malacosoma distria*) and jack pine budworm (*Choristoneura pinus*) caused widespread defoliation. The forest tent caterpillar population peaked in 2001, defoliating aspen and oak on about 5.5 million acres in northern Wisconsin (Fig. 60). Defoliation by the jack pine budworm occurred in northwestern and west-central Wisconsin, peaking at 36,000 acres in 2004. The gypsy moth, an exotic insect, defoliated about 65,000 acres of oak and aspen in northeastern and southeastern Wisconsin in 2003 (Fig. 61). Populations of the gypsy moth declined significantly in 2004 following a cool, wet spring. A severe drought from 2001 to 2003 (Fig. 62) provided additional stress to trees that resulted in infestations of pine bark beetles (*Ips pini*) in red, white, and jack pine, two-lined chestnut borers (*Agrilus bilineatus*) in oak species, and larch beetles (*Dendroctonus simplex*) in tamarack. A root disease caused by several species of the fungus *Armillaria* was common on many species of stressed trees. Mortality of tamarack was observed in eastern Wisconsin; mortality of oak and pine was most common in central Wisconsin. Oak wilt, caused by the fungus *Ceratocystis fagacearum* which has been active in Wisconsin for many decades, continued to kill northern red, northern pin, and black oak throughout the southern two-thirds of Wisconsin's forests (Fig. 63). Butternut canker, first observed in Wisconsin in 1967, continued to cause significant levels of mortality of butternut throughout the State. Caused by the fungus *Sirococcus clavigignenti-juglandacearum*, this disease is of unknown origin. *Annosum* root rot of pine caused by the fungus *Heterobasidion annosum* was observed in nine additional counties from 2001 to 2004 (Fig. 64).

What this means

Native insects and diseases along with drought affected the health of Wisconsin's forests during the inventory period. This combination of stress factors has been documented as occurring in previous decades and will continue to cause tree decline and mortality. Populations of the gypsy moth, though set back severely by cool spring weather in 2004, are expected to increase and cause widespread defoliation over the next decade. Overmature oak or oak growing on nutrient-poor, droughty soils are particularly at risk.

Wisconsin's forests also are at risk from the introduction of the emerald ash borer (*Agrilus planipennis*), hemlock woolly adelgid (*Adelges tsugae*), and beech bark disease (*Cryptococcus fagisuga* and *Nectria coccinea* var. *faginata*).

Figure 60.—Distribution of forest tent caterpillar defoliations by year, Wisconsin.

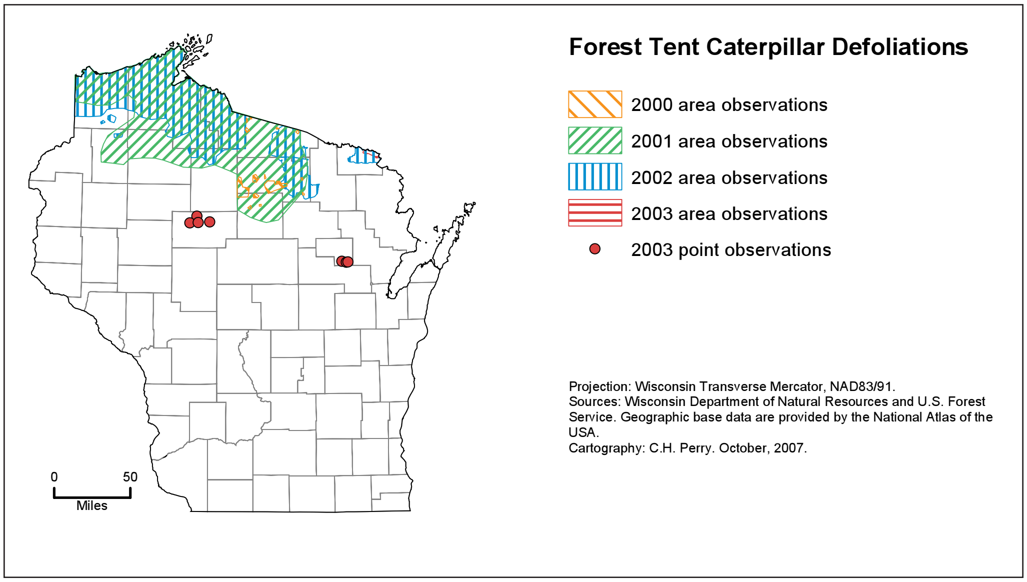


Figure 61.—Distribution of gypsy moth defoliations by year, Wisconsin.

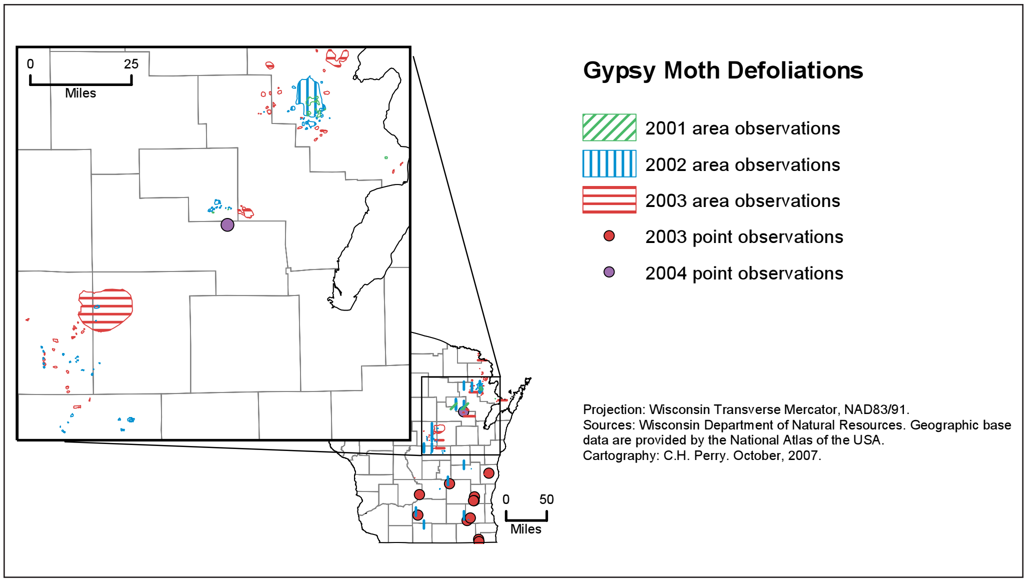
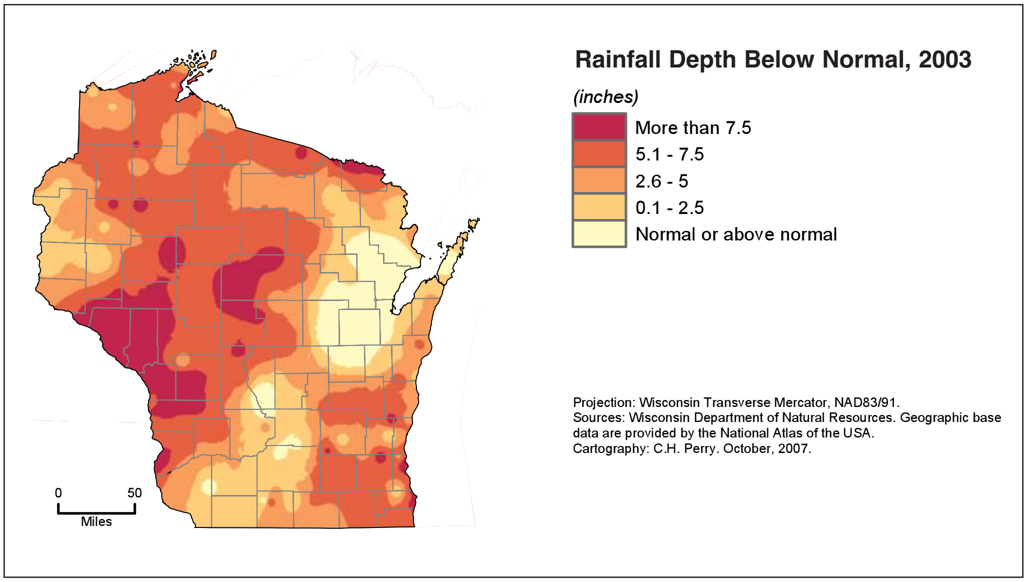


Figure 62.—Distribution of rainfall deficits associated with the end of the drought in 2001-03, Wisconsin.



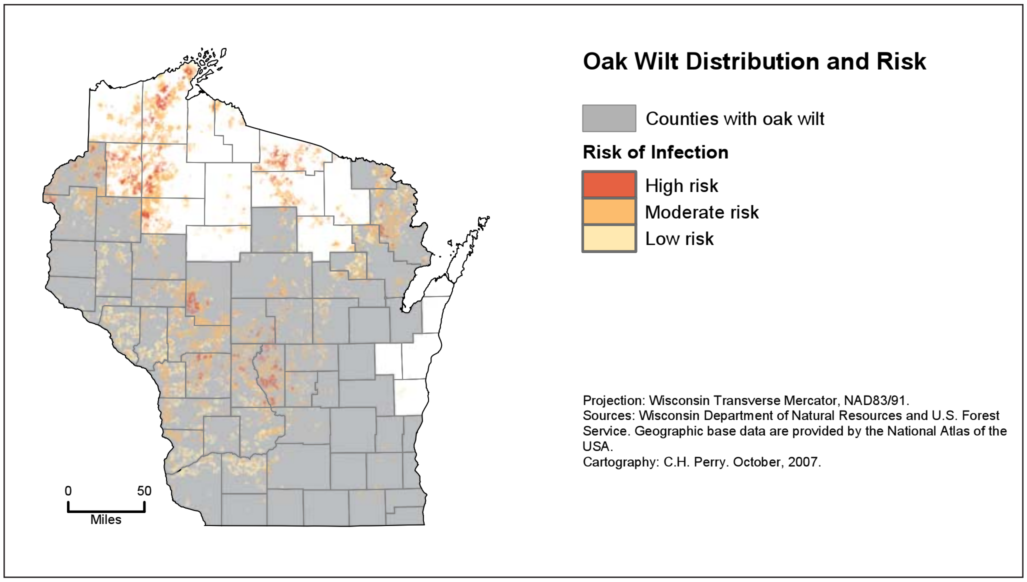


Figure 63.—Distribution of oak wilt and the risk of infection associated with different forest stands, Wisconsin.

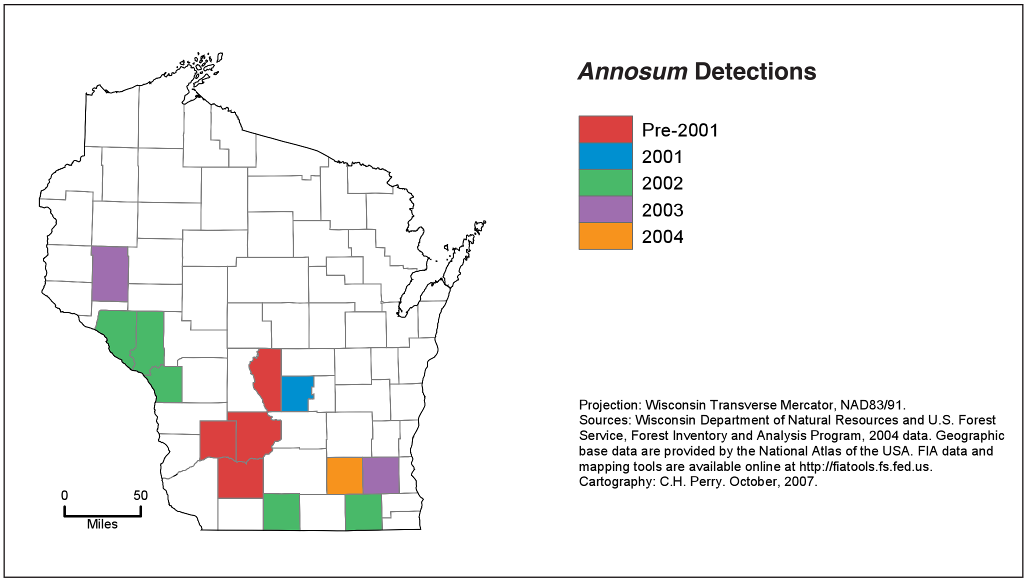


Figure 64.—Distribution of *Annosum* detections by year, Wisconsin.

Emerald Ash Borer

Background

The emerald ash borer (EAB) (*Agrilus planipennis*) is native to Asia. It has not yet been detected in Wisconsin but is present in Michigan and Illinois. This insect kills ash trees when hundreds of larvae feed just under the bark, cutting the flow of water and nutrients. All North American species of ash are susceptible. EAB was first observed in 2002 in southeast Michigan, but it was probably present for a decade before detection.

What we found

Wisconsin has about 717 million ash trees larger than 1 inch in diameter. Black ash, which grows on mesic and wet sites, is the most common species of ash. Green ash usually is found growing with other hardwoods on bottomland sites. White ash may be a component of several timber 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. 65).

The risk of introduction to Wisconsin is thought to be highly dependent on the basal area of ash, on human population density, and to a lesser extent on the number of campsites and the number of seasonal homes (Fig. 66). The risk model developed by the Wisconsin Department of Natural Resources has helped guide state and Federal officials on where to conduct detection surveys.

What this means

The EAB has the potential to kill millions of ash trees on several timber types throughout Wisconsin. Its impact is expected to rival that of chestnut blight and Dutch elm disease. Of particular concern is the loss of black and green ash on mesic to wet sites. These sites may have few to no other tree species present. Regenerating other species on these sites is limited by our current knowledge of regeneration practices and challenged by invasions of exotic plants such as reed canary grass (*Phalaris arundinacea*).

Emerald ash borer. Photo by David Cappaert, Michigan State Univesity, bugwood.org.

Figure 65.—Distribution of ash basal area, Wisconsin, 2004.

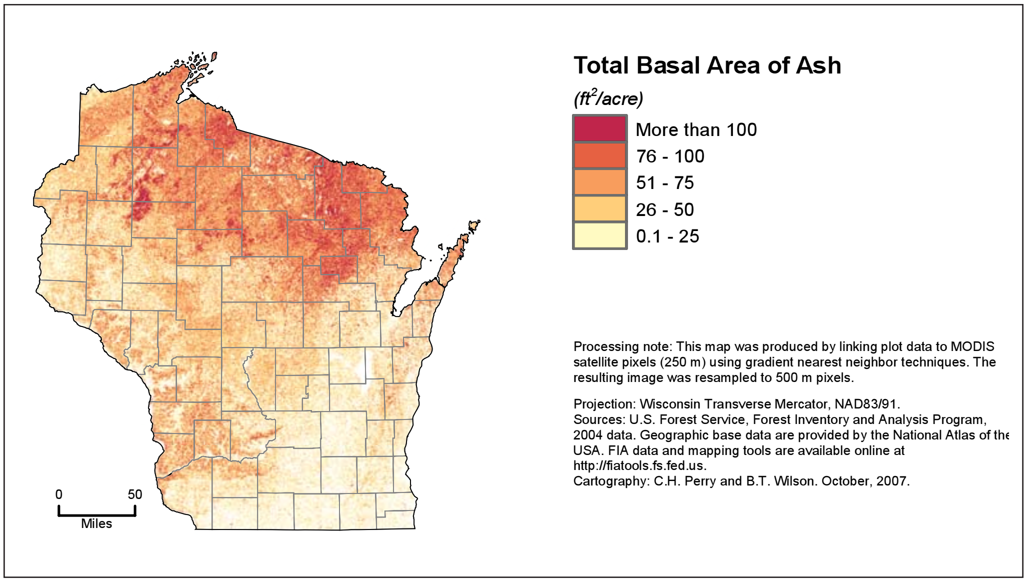
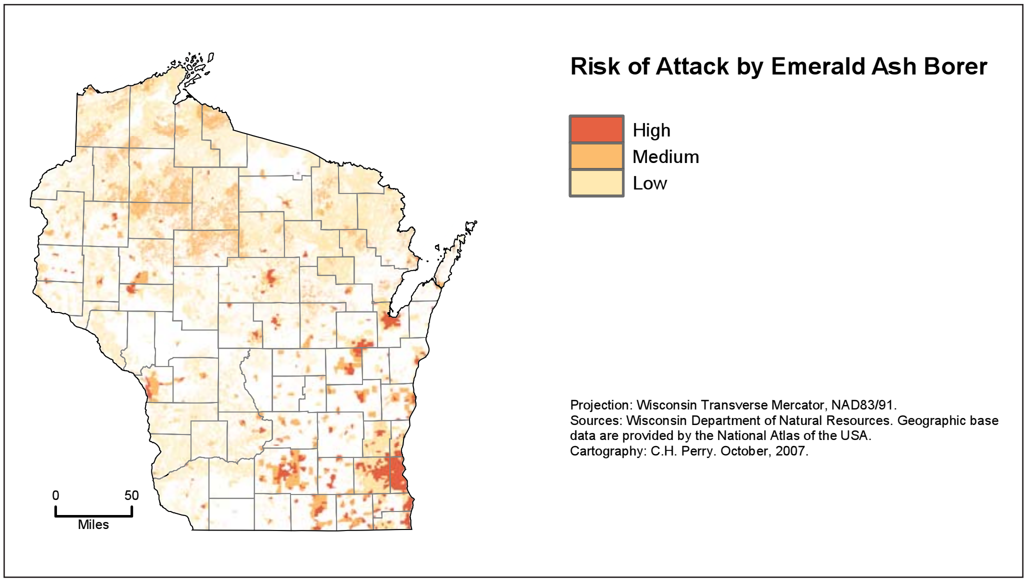


Figure 66.—Risk of emerald ash borer introduction into Wisconsin's forests (adapted from Wisconsin Department of Natural Resources).



Forest Products

On the fall of an oak, every man gathers wood.
– Menander

Above: Red pine stand. Photo by Steven Katovich, USDA Forest Service, bugwwod.org. Inset: Northern red oak leaves. Photo used with permission from Steven J. Baskauf, bioimages.vanderbilt.edu.

Timber Product Output

Background

Wisconsin's wood-products and processing industry employs more than 93,000 workers with an output of about $23.9 billion (MIG Group 2007). The primary roundwood-using industry is included in the wood-products and processing industry and includes sectors such as pulpmills and sawmills, wood-preservation plants, and veneer and plywood manufacturers. To properly manage and sustain the State's forests, it is essential to have information on the location and species of timber that will supply these industries.

What we found

A mill survey of all the primary wood-using mills in Wisconsin in 2003 (Fig. 67) included data on the size of the industry, the amount of roundwood harvested (logs, bolts, or other round sections cut from trees, including chips from roundwood), and its uses (Reading and Whipple 2007). Information on the generation and distribution of wood residues also was included. Total industrial roundwood production in 2003 totaled nearly 361 million cubic feet. Approximately two-thirds of the roundwood produced in Wisconsin came from the combined northeastern and northwestern regions (Fig. 68). Aspen (27 percent of all species), hard maple (13), soft maple (11), red oak (10), and paper birch (6) made up the top five hardwood species harvested, while red pine (10 percent of all species) was the top softwood species harvested (Fig. 69). Pulpwood accounted for nearly 70 percent of the roundwood harvested (251 million cubic feet). Saw logs accounted for 27 percent (98 million cubic feet) and veneers, fuelwood, and miscellaneous items made up the remaining 3 percent (12 million cubic feet) (Fig. 70). Wisconsin mills processed 89 percent of the State's sawlog production and 81 percent of its pulpwood production; the remainder was processed in other states and provinces. Wisconsin mills imported 8 percent of the saw logs and 13 percent of the pulpwood they processed. The industrial roundwood harvest left 20 million cubic feet (6 percent) of growing-stock material on the ground as logging residue.

What this means

As in the past, the two most northerly inventory units were the largest producers of roundwood. This is not surprising as it is the most heavily wooded part of the State. Aspen remains the most commonly harvested species in the State and, as a result, pulpwood is the most common form of roundwood produced, though production has declined slightly since 1999. Given the importance that paper and paper products play in Wisconsin's economy, it is necessary that a ready supply of pulpwood be available and in close proximity to the pulp and hardboard mills.

The relatively large amount of hard and soft maple produced is most likely a function of both their availability and desirability as a commercial species. A comparison of the 1999 and 2003 timber products inventories shows a decrease in the production of saw and veneer logs of 11.5 and 33 percent, respectively. This may have been caused by the recent closing of some secondary producers in Wisconsin whose operations moved overseas in pursuit of less expensive wood and lower wages.

Figure 67.—Distribution of mills by type and total processed volume relative to forest land, Wisconsin, 2003 (adapted from Reading and Whipple 2007).

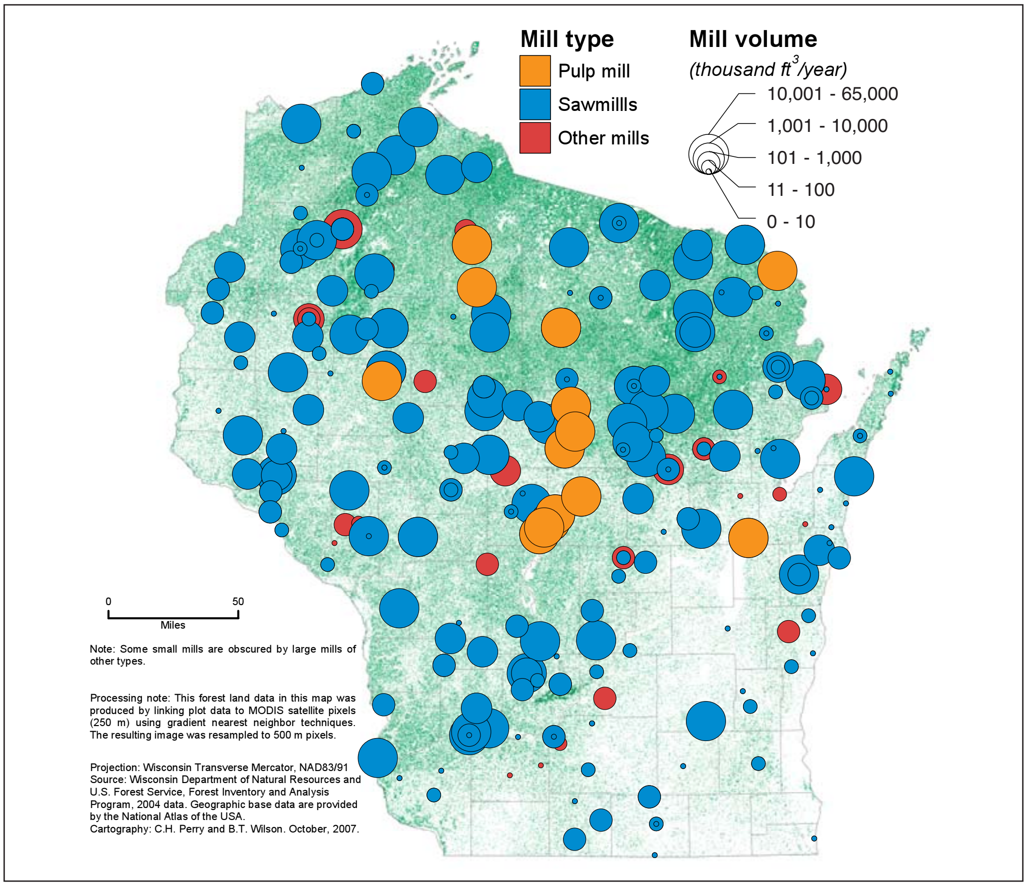


Figure 68.—Industrial roundwood production by inventory unit, Wisconsin, 2003.

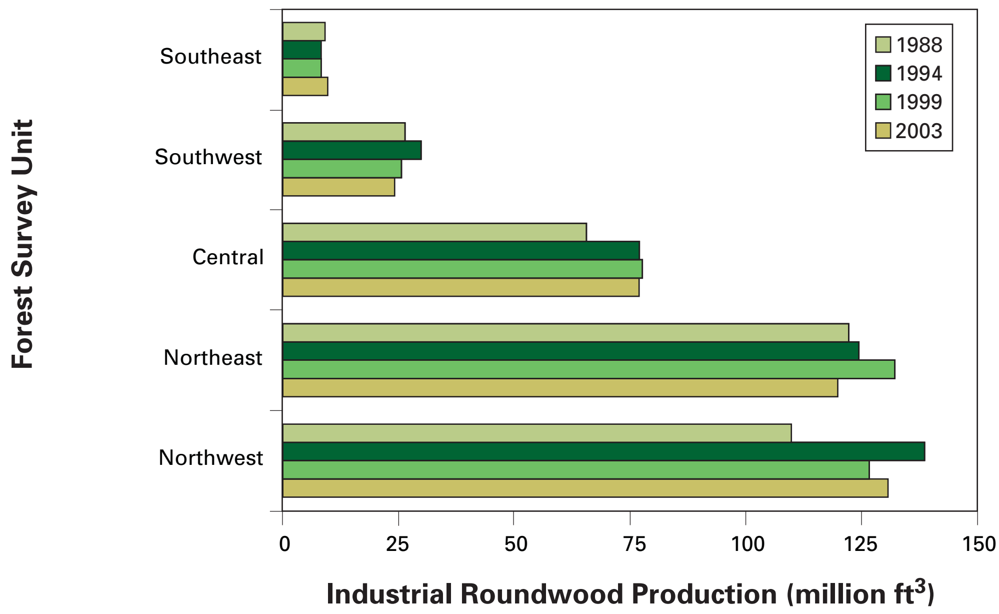


Figure 69.—Industrial roundwood production by species group, Wisconsin, 2003.

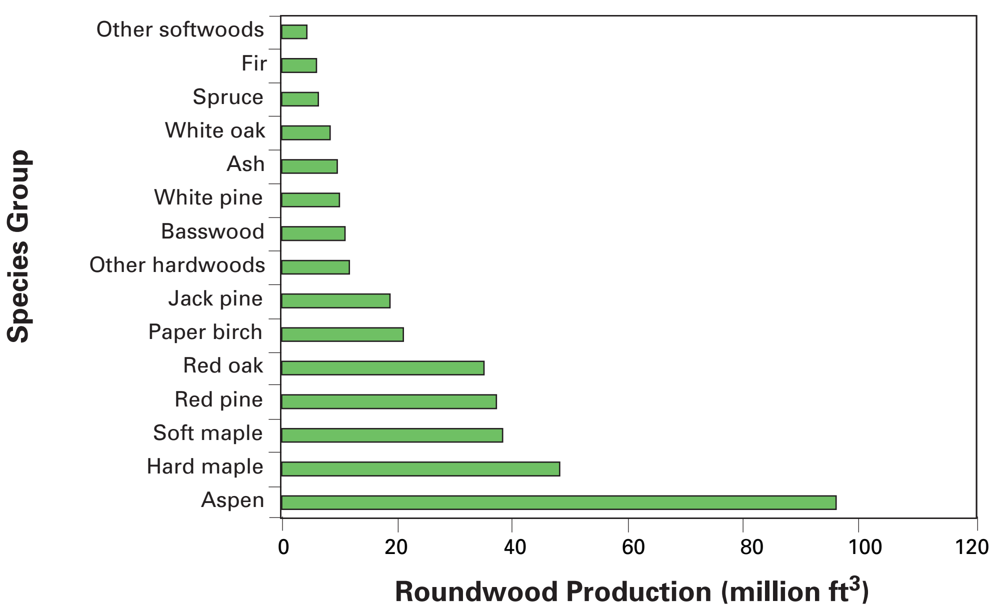
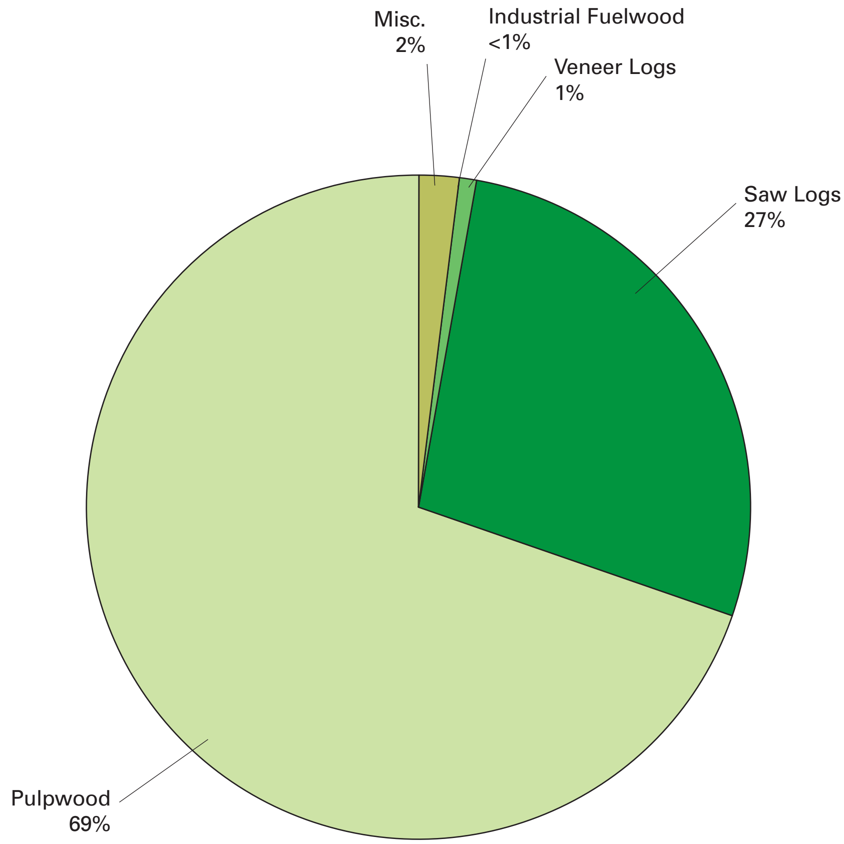


Figure 70.—Industrial roundwood production by product, Wisconsin, 2003.



Certification: Documenting Sustainability

Background

Three major land management programs administered by the Wisconsin Department of Natural Resources are verified under third-party forest certification programs. They include:

- State forests – 512,000 acres.
- County forests – about 2.4 million acres in 27 counties.
- Private forests (Managed Forest Law) – 2 million acres under nearly 37,000 contracts with private landowners.

Independent, third-party certification means management of Wisconsin's forests meets strict standards for ecological, social, and economic sustainability. Publishers, building contractors, and other manufacturers are expanding their use of certified wood to assure customers that their products are not tainted by timber theft or the destructive timber cutting practices that plague some parts of the world. Forest certification helps Wisconsin remain competitive in global markets that increasingly demand certified raw materials.

What we found

Of Wisconsin's approximately 16.1 million acres of forest land, about 4.8 million acres are under some form of third-party certification. State forests include about 500,000 acres that are certified by both the Forest Stewardship Council (FSC) and the Sustainable Forestry Initiative (SFI.) Within the county forests there are about 0.9 million acres that are dual certified by FSC and SFI. In addition, there are about 160,000 acres that are FSC certified only and 1.26 million acres are SFI certified only. Two million acres of private forest land in Wisconsin are certified by the Tree Farm Group through participation in the State's Managed Forest Law program.

What this means

About 30 percent of Wisconsin's forest land is third-party certified. This is a significant source of certified raw material available to companies seeking to become chain-of-custody certified. A world-recognized manufacturer that buys paper from Wisconsin's largest paper firms is requiring that 80 percent of its fiber be from certified sources. Several Wisconsin flooring producers have become FSC certified and one of the largest sawmills in the State has become certified for a portion of its production. To date, certification has created market opportunities for Wisconsin's forest industries, but it has not yet led to consistent revenue increases.

Data Sources and Techniques

If you don't know where you are going, you might wind up someplace else.
– Yogi Berra

Above: Eastern hemlock by stream. Photo used with permission from Steven J. Baskauf, bioimages.vanderbilt.edu. Inset: Algoma. Photo used with permission from Wisconsin DNR.

Forest Inventory

Vissage (2002) described the annualized inventory methods for Wisconsin. Since the 1996 inventory, several changes in FIA methods have improved the quality of the inventory and have met increasing demands for timely forest-resource information. The most significant change between inventories has been the shift from periodic to annual inventories. Historically, FIA inventoried each state on a cycle that averaged about 12 years. However, the need for timely and consistent data across large geographical regions along with national legislative mandates resulted in FIA implementing an annual inventory. This system was initiated in Wisconsin in 2000.

With the NRS-FIA annual inventory system, approximately one-fifth of all field plots are measured in any single year. After 5 years, the entire inventory is completed. After this initial 5-year period, NRS-FIA will report and analyze results using a moving 5-year average. For example, NRS-FIA will be able to generate inventory results for 2000 through 2005 or for 2001 through 2006.

Other significant changes between inventories include implementing new remote-sensing technology as well as a new field-plot configuration and sample design, and gathering additional remotely sensed and field data. The use of new remote-sensing technology allows NRS-FIA to use classifications of Multi-Resolution Land Characterization data and other remote-sensing products to stratify the total area of Wisconsin and to improve estimates.

New algorithms were used in 2000-04 to assign forest type and stand-size class to each condition observed on a plot. These algorithms are being used nationwide by FIA to provide consistency from state to state and will be used to reassign the forest type and stand-size class of every plot in the 1996 inventory when it is updated. As a result, changes in forest type and stand-size class will reflect actual changes in the forest and not changes due to differences between algorithms. The list of recognized forest types, groupings of these forest types for reporting purposes, models used to assign stocking values to individual trees, definition of nonstocked (stands with a stocking value of less than 10 percent for all-live trees), and names given to the forest types changed with the new algorithms. As a result, comparisons between the published 2000-04 results and those published for the 1996 inventory may be invalid. Contact NRS-FIA for additional information on the algorithms used in both inventories.

Sampling Phases

The 2004 Wisconsin inventory was conducted in three phases. In the first phase, satellite imagery was used to stratify the State and aerial photography was used to select plots for measurement. The second phase entailed measuring the traditional suite of mensurational variables; the third phase focused on a suite of variables related to forest health.

Land that could not be sampled included private tracts where field personnel were unable to obtain permission to measure a Phase 2 plot and plots that were inaccessible because of a hazard or danger to field personnel. The methods used in preparing this report were adjusted to account for such sites.

Phase 1

For the Wisconsin inventory, FIA used a classification of satellite imagery for stratification. The imagery was used to form two initial strata: forest and nonforest. Pixels within 60 m (2-pixel widths) of a forest/nonforest boundary formed two additional strata: forest edge and nonforest edge. Forest pixels within 60 m of the boundary on the forest side were classified as forest edge and pixels within 60 m of the boundary on the nonforest side were classified as nonforest edge. All strata were divided into public or private ownership based on information available in the Protected Lands Database (DellaSala et al. 2001). The estimated population total for a variable is the sum across all strata of the product of each stratum's area (from the pixel count) and the variable's mean per unit area (from plot measurements) for the stratum.

Phase 2

Phase 2 of the inventory consisted of the measurement of an annual sample of field plots in Wisconsin. Current FIA precision standards for annual inventories require a sampling intensity of one plot for about every 6,000 acres. FIA has tessellated the entire United States using nonoverlapping hexagons, each of which contains 5,937 acres (McRoberts 1999). An array of field plots was established by selecting one plot from each hexagon based on the following rules: (1) if an Forest Health Monitoring (FHM) plot (Mangold 1998) fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within the hexagon, the existing NRS-FIA plot nearest the hexagon center was selected as the grid plot; and (3) if neither FHM nor existing NRS-FIA plots fell within the hexagon, a new NRS-FIA grid plot was established (McRoberts 1999). This array of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in Wisconsin is funded by the Federal government. In 2003, two additional plots were established and measured in each hexagon. In 2000-02 and 2004, an additional plot was established and measured in each hexagon. The measurement of this intensified sample was funded by the State.

The total Federal base sample was divided systematically into five interpenetrating, nonoverlapping subsamples or panels. Each year, the plots in a single panel are measured and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots can be considered an independent random sample of all land in the State. Field crews measured vegetation on plots forested at the time of the last inventory and on plots classified as forest by trained photo-interpreters using aerial photos or digital orthophotoquads.

Phase 3

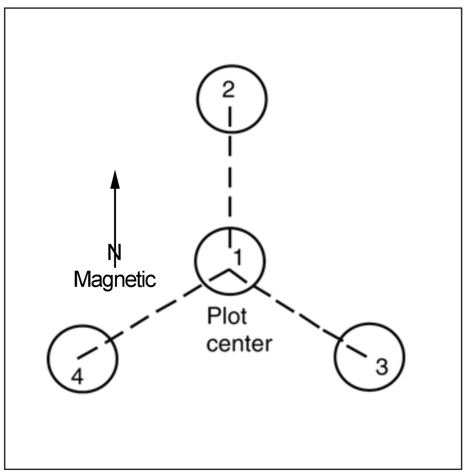
NRS-FIA has two categories of field measurements: Phase 2 and Phase 3 (formerly FHM) field plots. Both types are distributed systematically geographically and temporally. Phase 3 plots are measured with the full array of vegetative and health variables as well as the full suite of measures associated with Phase 2 plots. Phase 3 plots must be measured between June 1 and August 30 to accommodate measurement of nonwoody understory vegetation, ground cover, soils, and other variables. The complete 5-year annual inventory of Wisconsin includes 165 forested Phase 3 plots. On the remaining plots, only variables that can be measured throughout the entire year are collected. In Wisconsin, the complete 5-year annual inventory includes 6,478 forested Phase 2 plots. Of these, 6,375 plots were established on timberland and 47 plots were established on reserved forest land.

The national FIA four-subplot cluster configuration (Fig. 71) was first used for data collection in Wisconsin in 2000 and will be used in subsequent years. The national plot configuration requires mapping all forest conditions on each plot. Due to the small sample size each year, precision associated with estimates of components of change such as mortality will be relatively low. Consequently, we report estimates of components of change only after multiple annual panels have been measured. With completion of the annual inventory in 2004, the full range of change estimates now is available.

The overall plot layout for the new configuration consists of four subplots. The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 0, 120, and 240 degrees, respectively. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed at the location. Trees that are 5 inches and larger in d.b.h. are measured on a 24-foot-radius (1/24-acre) circular subplot. All trees less than 5 inches d.b.h. are measured on a 6.8-foot-radius (1/300- acre) circular microplot located 12 feet due east of the center of each of the four subplots. Forest conditions on each subplot are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, regeneration status, reserved status, ownership, and density. Each condition that occurs on one of the subplots is identified, described, and mapped so long as the area of the condition is at least 1 acre.

Field-plot measurements are combined with Phase 1 estimates in the compilation process and table production. The number of tables presented here is limited but others can be generated at http://fiatools.fs.fed.us. For additional information, contact: Program Manager, Northern Research Station, Forest Inventory and Analysis, 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.

Figure 71.—Current NRS-FIA field-plot design.



Timber Products Output Survey

The timber products inventory study was a cooperative effort between the Wisconsin Department of Natural Resources (WIDNR) and the Northern Research Station (NRS) (Reading and Whipple 2007). The WIDNR canvassed all primary wood-using mills within the State using mail questionnaires supplied by the NRS and designed to determine the size and composition of Wisconsin's primary wood-using industry, its use of roundwood, and its generation and disposition of wood residues. The WIDNR then contacted nonresponding mills through additional mailings, telephone calls, and personal contacts until a nearly 100-percent response was achieved. Completed questionnaires were forwarded to NRS for compilation and analysis.

As part of data processing and analysis, 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 previous NRS logging utilization studies. Data on Wisconsin's industrial roundwood receipts were added to a regional timber removals database and supplemented with data on out-of-state uses of State roundwood to provide a complete assessment of Wisconsin's timber product output.

National Woodland Landowner Survey

The National Woodland Landowner Survey is conducted annually by the USDA Forest Service to increase our understanding of private woodland owners – the critical link between society and forests. Each year, questionnaires are mailed to individuals and private groups who own the woodlands where NRS-FIA has established inventory plots (Butler et al. 2005). Twenty percent of these ownerships (about 50,000 nationwide) are contacted each year with more detailed questionnaires mailed in years that end in 2 or 7 to coincide with national census, inventory, and assessment programs. The target accuracies of the data are plus or minus 10 percent at the state level.

Ozone Bioindicator Species and Survey History

Several bioindicator species have been tested in both laboratory and field settings over several decades and have proven to be reliable indicators of ground-level ozone stress. These include white ash, black and pin cherry, dogbane, milkweed, big leaf aster, and blackberry. In Wisconsin, the annual ozone biomonitoring by FIA began in 1994. A revised national grid emphasizing ozone exposures and forested acreage was activated in 2002.

Foliar injury can be related to seasonal exposures as well as peak concentrations. Seasonal exposures measure ozone stress by summing hourly concentrations above a threshold concentration over a period of several months. For example, a common growing-season exposure index (SUM06) is the sum of all daylight hourly ozone concentrations greater than 0.06 parts per million (ppm) between June 1 through August 31. Ozone can lead to leaf damage at levels exceeding 8 ppm-hours, and the growth of seedlings in natural forest stands is affected at 10 to 15 ppm-hours (Heck and Cowling 1997). SUM06 values in Wisconsin ranged from about 3 to 24 ppm-hours during 2001-05. Presettlement seasonal SUM06 values probably would have been in the range of 0.5 to 2 ppm-hours.

Literature Cited

Belcher, D.M.; Holdaway, M.R.; Brand, G.J. 1982. **A description of STEMS – the stand and tree evaluation and modeling system.** Gen. Tech. Rep. NC-79. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 18 p.

Butler, Brett J.; Leatherberry, Earl C.; Williams, Michael S. 2005. **Design, implementation, and analysis methods for the National Woodland Owner Survey.** Gen. Tech. Rep. NE-336. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 43 p.

Cunningham, R.N.; Moser, H.C. 1938. **Forest areas and timber volumes in the Lake States.** Econ. Notes No. 10. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station. 84 p.

Cunningham, R.N.; Moser, H.C.; White, H.G. 1939. **Timber supplies, growth and depletion in the three Lake States.** Econ. Notes No. 11. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station. 38 p.

DellaSala, D.A.; Staus, N.L.; Strittholt, J.R.; et. al. 2001. **An updated protected areas database for the United States and Canada.** Natural Areas Journal. 21(2): 124-135.

Hahn, J.T. 1984. **Tree volume and biomass equations for the Lake States.** Res. Pap. NC-250. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 10 p.

Heck, W.W.; Cowling, E.B. 1997. **The need for a long term cumulative secondary ozone standard-an ecological perspective.** Environmental Management. January: 23-33.

Hole, F.D. 1976. **Soils of Wisconsin.** Madison, WI: University of Wisconsin Press. 223 p.

Kotar, J.; Kovach, J.A.; Brand, G.J. 1999. **Analysis of the 1996 Wisconsin forest statistics by habitat type.** Gen. Tech. Rep. NC-207. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 165 p.

Leatherberry, E.C. 2001. **A profile of Wisconsin's private forest landowners.** Woodland Management. 22(1): 16-18.

Mangold, R.D. 1998. **Forest health monitoring field methods guide (national 1998).** Research Triangle Park, NC: U.S. Department of Agriculture, Forest Service, National Forest Health Monitoring Program. 429 p.

Martin, A.C.; Zim, H.S.; Nelson, A.L. 1951. **American wildlife and plants: a guide to wildlife food habits.** New York: Dover Publications. 500 p.

McBride, M. 1994. **Environmental chemistry of soils.** New York: Oxford University Press. 406 p.

McRoberts, R.E. 1999. **Joint annual forest inventory and monitoring system, the North Central perspective.** Journal of Forestry. 97(12): 27-31.

MIG Group 2007. 2003 data. Stillwater, MN: Minnesota IMPLAN Group.

Raile, G.K. 1982. **Estimating stump volume.** Res. Pap. NC-224. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 4 p.

Reading, W.H., IV; Whipple, J.W. 2007. **Wisconsin timber industry: an assessment of timber product output and use in 2003.** Resour. Bull. NRS-19 Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 93 p.

Rodewald, A.D. 2003. **The decline of oak forests and implications for forest wildlife conservation.** Natural Areas Journal. 23: 368-371.

Schmidt, T.L. 1998. **Wisconsin's forest statistics, 1996.** Resour. Bull. NC-183. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 150 p.

Smith, W.B. 1991. **Assessing removals for North Central forest inventories.** Res. Pap. NC-299. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 48 p.

Spencer, J.S.; Smith, W.B.; Hahn, J.T.; Raile, G.K. 1988. **Wisconsin's fourth forest inventory, 1983.** Resour. Bull. NC-107. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 158 p.

Spencer, J.S.; Thorne, H.W. 1972. **Wisconsin's 1968 timber resource: a perspective.** Resour. Bull. NC-15. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 80 p.

Stone, R.N.; Thorne, H.W. 1961. **Wisconsin's forest resources.** Stn. Pap. 90. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station. 52 p.

U.S. Department of Agriculture, Forest Service. 1999. **Wood handbook – wood as an engineering material.** Gen. Tech. Rep. FPL-113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 463 p.

U.S. Department of Agriculture, Forest Service. In press. **Ecological subregions: sections and subsections for the conterminous United States.** Gen. Tech. Rep. WO-76. Washington, DC: U.S. Department of Agriculture, Forest Service.

Vissage, J.S. 2002. **Wisconsin's forest resources in 2000.** Res. Note NC-380. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 8 p.

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The first full, annualized inventory of Wisconsin's forests was completed in 2004 after 6,478 forested plots were visited. There are more than 16.0 million acres of forest land in the Wisconsin, nearly half of the State's land area; 15.8 million acres meet the definition of timberland. The total area of both forest land and timberland continues an upward trend that began in the 1960s. Red maple, sugar maple, and quaking aspen are the most common trees with diameters at breast height greater than 5 inches; there are 298, 250, and 244 million trees of these species, respectively. Aspen is the most common forest type, followed by sugar maple/beech/yellow birch, and white oak/red oak/hickory. This report includes detailed information on forest attributes and health and on agents of change such as the introduction of nonnative plants, insects, and diseases and changing land-use patterns.

KEY WORDS: inventory, forest statistics, forest health, third-party certification, urban forest, sustainability, timberland, forest land, volume, biomass, growth, removals, mortality

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