Wisconsin Forests at the Millennium

An Assessment © November 2000

Wisconsin Forests *at the* Millennium

An Assessment

November 2000

Wisconsin Forests at the Millennium: an Assessment
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Cover Photo by Robert Queen—stand of white pine in the Menominee Indian Reservation
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Foreword

Wisconsin's forests are ecological, economic and social treasures. Wisconsin's forests provide the raw materials for the forest products industry and the setting for the recreation/tourism industry, both important elements of our State's economy. Our forests purify and maintain the quality of our abundant water resources and provide habitat for a wide array of plant and animal species, including threatened and endangered species. Our abundant forests also mitigate global warming and air pollution through carbon sequestration and oxygen production, and provide settings within which many of Wisconsin's citizens and visitors choose to live, work and recreate.

This statewide assessment of Wisconsin's forests highlights the fact that our forests are constantly changing. They have shown remarkable resilience in their recovery from the effects of the Cutover and subsequent fires that ended about 70 years ago. Our forests continue to expand and grow, becoming ever more valuable for an array of uses and benefits. With almost half of Wisconsin covered in forest, we are blessed with many opportunities to realize the full range of values from our forests.

Having completed this assessment, the DNR's Division of Forestry will now begin work to develop a Statewide Forest Plan. We will be reaching out to seek involvement in the planning process from the full range of those interested in and affected by the forests of the state. Given that every one of Wisconsin's more than five million citizens, and countless visitors to our state, are touched by our forests, we have a large task before us. The trends and issues outlined briefly in the last section of the assessment will, along with additional other issues identified during the planning process, become the basis of the Statewide Forest Plan.

The forests of Wisconsin have a rich history and a great future. I hope you will join us in celebrating the many benefits we receive from our forests and in working together to set a course for their future management and protection.

Gene Francisco
Wisconsin State Forester

Kirsten L. Held

Gene Francisco, State Forester
Division of Forestry
Department of Natural Resources

A Statewide Snapshot of Wisconsin's Forests

Robert Queen

The Northern Mixed Forest is composed of both broadleaf trees and conifers. Peninsula State Park.

DNR Photo Archives

The Southern Broadleaf Forest is mostly composed of broadleaf trees like this oak.

Wisconsin's Forests

In this assessment report, Wisconsin's forest resources are divided into two broad categories, the Northern Mixed Forest and the Southern Broadleaf Forest. These two overall forest types exist in Wisconsin because of the differences in the soil types and climate that support them and to which they have adapted over thousands of years.

These two regions meet in an area called the tension zone. The tension zone stretches across Wisconsin from northwest to southeast in an S-shape. The tension zone forms the northern boundary of many species' ranges, both plant and animal. From Polk and St. Croix Counties southeast to Milwaukee, the tension zone divides the state into the two major ecological regions. The northern region, the Northern Mixed Forest, is more closely related to the forests of northeastern Minnesota, northern Michigan, southern Ontario, and New England. The southern region, the Southern Broadleaf Forest, is warmer and is generally considered closer, ecologically, to the forests of Ohio and Indiana. The tension zone is a diverse area, where representative plant and animal species from both the Northern Mixed Forest and the Southern Broadleaf Forest types can be found, and a significant shift in vegetation occurs.

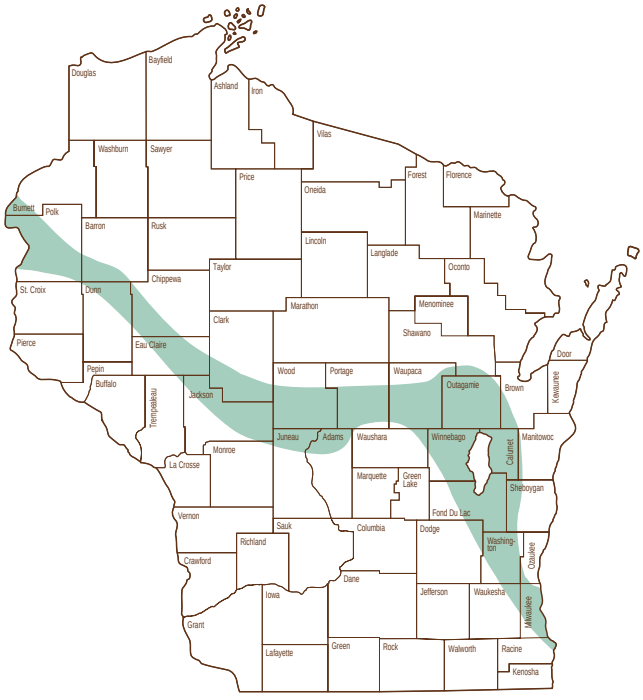


Figure 1

Map of Wisconsin's Tension Zone

Forest Area

Of Wisconsin's 35 million acres of land, about 16 million acres are forested. Forest area in Wisconsin has been steadily increasing since 1968, mostly due to the conversion of marginal agricultural land back to forests. Currently, Wisconsin's forests cover about 46% of the total land area of the state.

Since the last statewide forest assessment, which used data from 1983, Wisconsin's forestland has increased about 4%, or 640,000 acres. Most of this increase is accounted for in the northern area of the state. Forests from 20–80 years old experienced the largest increase in acreage.

Forest Types

The most abundant forest types in Wisconsin are hardwood forest types. Maple-basswood, aspen-birch, and oak-hickory are the most common. Maple-basswood accounts for 5.3 million acres, followed by aspen-birch forest type with almost 3.4 million acres, and oak-hickory with about 2.9 million acres. While 84% of Wisconsin's forests are hardwood types, there are also significant softwood types occupying large areas, especially in the north. Red pine, jack pine, black spruce, northern white cedar, and tamarack are the most common conifer forest types.

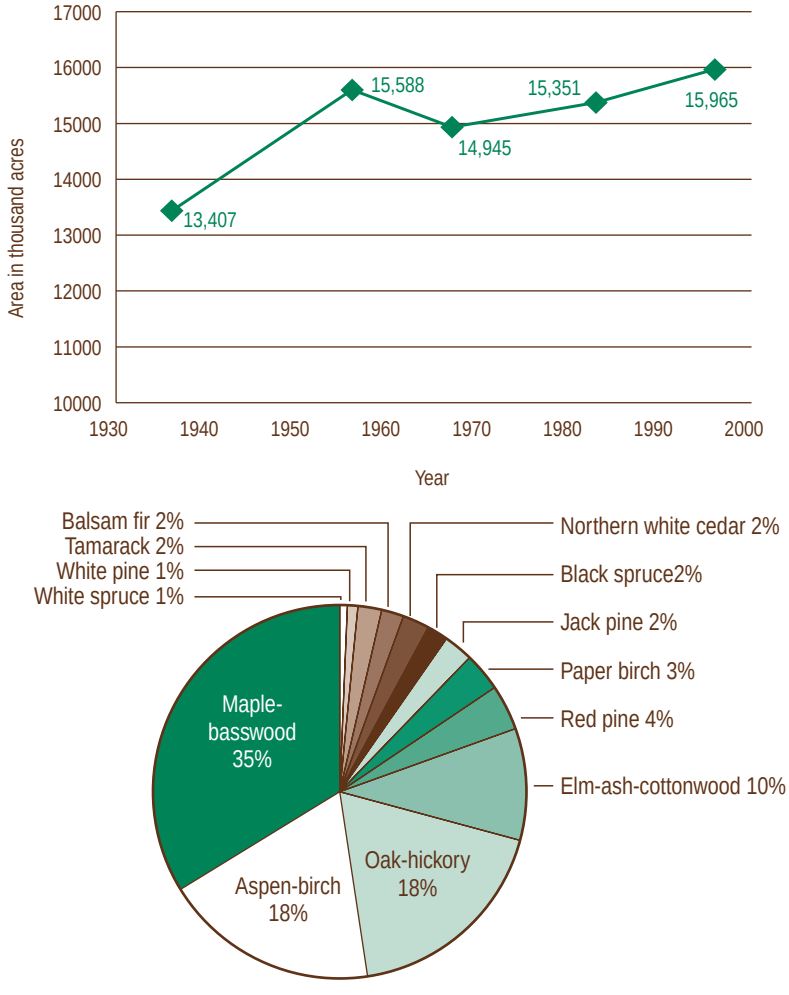


Figure 2

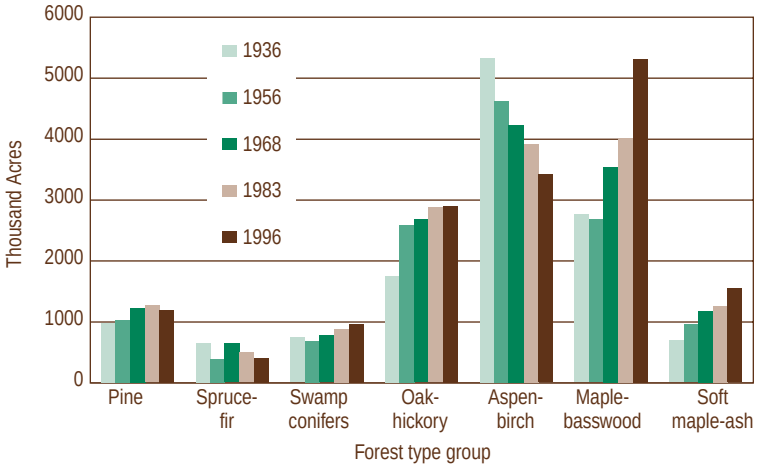
[top] Wisconsin forest area over time

Figure 3

[bottom] Wisconsin forest types, 1996

Figure 4

Wisconsin forest types over time



WHERE TO FIND DISCUSSION OF FOREST TYPES AND SPECIES GROUPS IN THIS REPORT:

Wisconsin's Northern Mixed Forests:

Wisconsin's Southern Broadleaf Forests:

Areas and relative proportion of various forest types have changed significantly over the last 70 years. Hardwood succession is very apparent. Since the first official statewide forest inventory in 1936, aspen-birch forest area has decreased steadily, although it is still much more common than at the beginning of the Cutover. The Cutover was the period of intense timber harvest in the Lake States, lasting about 40 years, from 1880–1920. Since 1936, maple-basswood, soft maple-ash, and oak-hickory forests have increased just as steadily. Conifer forest area has remained roughly constant over the last 70 years.

DNR Photo Archives

Although early succession forest types, like aspen and birch, are much more common now than in the 1850s, they have been decreasing since the 1930s as the forests of Wisconsin have continued to recover from the Cutover period.

Curt Wilson

Most of Wisconsin's plantations are pine, accounting for about 4.5% of Wisconsin's total forestland. Waukesha County.

Plantations Over 95% of Wisconsin's standing forests are a result of natural regeneration. The remaining 4.5% of Wisconsin's forests are plantations. In this context, *plantations* refer to areas reforested through planting that are sufficiently productive to qualify as timberland. The planted species is not necessarily dominant. The majority of plantations are conifer types and located in the central and northern parts of the state.

Number of trees

Predictably, along with an increase in forest area, there has been a corresponding increase in number of trees. Between 1983 and 1996 trees over 10 feet tall increased by 1.4 billion individual trees. In 1996, there were about 9.8 billion trees in Wisconsin.

Timber Volume

Between the 1983 forest inventory and the 1996 forest inventory, overall growing stock volume in Wisconsin's forests has increased by almost 12%—about two billion cubic feet. In 1996, there were 18.5 billion cubic feet of growing stock volume, of which 4.4 billion were conifer, and 14.1 were hardwood. Along with this overall increase, the state's maples, oaks, basswood, ashes, white and red pines, white and black spruces, and balsam fir are some of the commercially important species whose growing stock volume increased. Aspen, paper birch, and jack pine volumes decreased between inventories.

During the same period, sawtimber volume increased dramatically—by over 30%, or 11 billion board feet. Sawtimber is the largest timber size class. These trees tend to be older, more economically valuable, mature seed-producers, and are important to the forest's structure. As Wisconsin's forests age, continued growth of sawtimber volume is likely.

Robert Queen

On average, sawtimber removals totaled 986 million board feet per year between 1983 and 1996, accounting for 59% of net annual growth. Skidder, Northern Highlands American Legion State Forest.

Robert Queen

New development along lakeshores is influencing Wisconsin's forests.

Growth and Removals

In Wisconsin, our forests are growing at a rate that significantly exceeds harvest. Between 1983 and 1996, average net annual growth exceeded harvests and other removals by almost 158 million cubic feet. During the period between inventories, average net annual growth was 490 million cubic feet. Average annual removals were 332 million cubic feet, about 68% of average net annual growth. Between 1968 and 1983, average annual removals were 45% of average net annual growth.

Average net annual growth of sawtimber in particular also exceeded average annual removals, resulting in a net increase in sawtimber volume between 1983 and 1996. Each year, on average, sawtimber volume increased 1.68 billion board feet. About 59% of that growth was offset by removals—986 million board feet each year. One important measure of sustainability is that the Wisconsin timber net growth:removals ratio is greater than one, statewide.

Robert Queen

Much of Wisconsin's forestland is being divided into smaller parcels and sold to new forest owners.

Ownership

Individual, private owners own the majority of Wisconsin's forestland, about 57%. The state owns just 5% of the forest and the federal government about 10%. In the public sector, counties and municipalities own the largest percentage—15% of Wisconsin's forestland, followed by forest industry 7%, private corporations 4%, and tribal lands 2%.

Ownership is increasingly important to Wisconsin forests. The demographics of Wisconsin forestland owners are changing, as are those owners' values and goals for their land. The increase in second homes and non-resident landowners has resulted in more forest owners of smaller parcels. Lakeshore

Robert Queen

Urban forest space is very important for ecological and aesthetic benefits.

development is another trend related to this phenomenon. This increase in second homes and non-resident landowners results in a significant increase in the number of individual private owners. Increased human presence in the forest has significant impact on the integrity of forest communities.

Between 1984 and 1997, the number of Wisconsin's non-industrial private owners increased 20% to about 262,000. Every year an average of 3,385 new parcels are carved out of Wisconsin's forested land base. As a result, ownership size is decreasing and development is increasing [Roberts. et. al., 1986 and Schmidt, 1997].

Urban Forests

Many of Wisconsin's residents associate most closely with urban forests. Urban forests surround people every day. The trees, lawns, landscape plantings, gardens, urban wildlife, and people of the cities compose the urban forest ecosystem. Wisconsin has about 1.7 million acres of urban forest, about 4.7% of the state's total land area. Statewide, the average urban canopy cover is 29% of the urban area. In the northern region, urban canopy cover is closer to 38%, in the south it is about 26%.

Biodiversity

Wisconsin's forests are significant reservoirs of biodiversity. Our forest ecosystems harbor a wide array of species. Wisconsin's forests themselves are very diverse—including many different forest types. Over 657 vertebrates live in Wisconsin, and over 1,800 native vascular plants are found in the state.

DNR Photo Archives

Wisconsin's forests are important reservoirs for biodiversity. Fisher.

A Brief History of Wisconsin's Forests

Wisconsin's forests are reservoirs of vast ecological, economic, and social wealth. Throughout Wisconsin's history, forests have played a primary role in supporting the people who lived here. The forests of Wisconsin are dynamic, living systems that change with the human demands placed on them as well as through natural occurrences such as succession, severe weather events, fire, insect infestations, and disease.

Staber W. Reese

Before European-American settlement, a good portion of Wisconsin was covered in old forest, like this white pine forest. Menominee Indian Reservation.

Forests Before European-American Settlement

At the time of European-American settlement (1825–1880), forests stretched over most of the area that would become the state of Wisconsin. Between 22 and 30 million acres—between 63% and 86% of the total land area of the state—were covered with forests. A complex array of habitats supported wildlife, plants, and humans [Curtis, 1959].

The last glaciers receded from northern Wisconsin between 10,000 and 12,000 years ago. Their departure opened the area for colonization by plants, animals, and humans.

There are two major forest divisions in Wisconsin, the Northern Mixed Forest and the Southern Broadleaf Forest, with several ecosystems represented in each [Wisconsin Department of Natural Resources, 1995].

The native vegetation of the northern region is more cold tolerant. Pine, spruce, and tamarack are more abundant. Before European settlement, sugar maple, hemlock, and yellow birch dominated the mesic forests of northern Wisconsin. Various pine species were also important. Aspen and white birch were important successional species that followed natural disturbance across northern Wisconsin. Acid bogs were a significant ecosystem in the northern Wisconsin forest. Pine forests and barrens were important on the sandy soils of central and northwest Wisconsin. In the southern part of the state, oak-hickory and maple-basswood forests were especially prevalent. The southern and western parts of the state also supported oak savanna and prairie habitats. Forested and non-forested wetlands were found throughout the state [Finley, 1976].

Early Human Influence

There is evidence of human presence in Wisconsin as early as 11,000 years ago. The post-glacial ecology of Wisconsin was influenced by humans from its very beginning. The extent of that influence in times before European settlement is remarkable.

Robert Queen

Savannas and prairies, like this one, were maintained by Native Americans through use of fire. New Richmond.

New research indicates that before European contact beginning in 1492, there were up to 100 million people living in North America. In Wisconsin, fifteenth century population is estimated at 60,000–70,000. Between 1492 and 1634, the population was reduced to as few as 4,000 individuals, primarily as a result of introduced European diseases and war [Gartner, 1997].

Especially prior to this population collapse, native people profoundly influenced the land and ecology of Wisconsin in areas where they lived. Perhaps most significant was their use of fire. It is thought that native people used fire throughout the state to varying degrees to encourage the establishment of favored plant and animal communities. Prairie and savanna were likely maintained by these fires [Gartner, 1997].

Robert Queen

Whitetail deer were an important food resource to native people.

Hunting and trapping also influenced the ecological communities of the area that later became Wisconsin. Native people hunted a broad spectrum of animals. Deer and elk were the cornerstone of the Woodland Indians' diet, but mussels, birds, fish, and over 25 other mammal species were utilized as well [Gartner, 1997]. Many animals' populations may have been limited by human hunting rather than by other carnivores or food supply [Meltzer, 1999].

Nuts and fruits were also important to native people, and there is evidence that they planted orchards to ensure a supply. There are accounts from early European explorers describing the "planted tree groves" of chestnuts, locusts, oaks, ashes, basswoods, beeches, cottonwoods, maples, pecans, medlars, mulberries, and plums. These "orchards" may have resulted in the forest islands seen on the prairies by early European explorers [Gartner, 1997].

Foraging also influenced the ecology of Wisconsin. Collected plants may have become over-represented in biotic communities because of Indian dispersal. It was said of wild rice by the Menominee, "whenever the Menomini [sic] enter a region the wild rice spreads ahead, whenever they leave it the wild rice passes." [Gartner, 1997]

Mining, trails, agriculture and placement of settlements in pre-contact times had a large impact on the landscape. Many of our major highways began as roads between native people's settlements hundreds of years ago [Gartner, 1997].

When early explorers arrived in Wisconsin in the 1630s, they found a greatly reduced population. Because of this, until recent archeological research contested the belief, it was assumed that there were very few people living in Wisconsin before European settlement. The forest early European explorers saw had likely changed as a result of the decrease of human population. Many areas which had been maintained by fire as grassland or early successional forest were now mature forests as there was no longer either the need or the capacity to burn or clear the land.

The tribes living in Wisconsin in the mid-1600s included the Winnebago, Ojibwe, Menominee, Dakota, Illinois, Sauk, Fox and Cheyenne. However, some of these groups have stories of migrating from other areas to Wisconsin. For example, the Ojibwe tell of their migration from the eastern ocean in the 1400s. This era corresponds to the "Little Ice Age," a period of significant cooling of the North American continent [Sultzman, 1998]. Temperature between 1450 and 1850 averaged 1.5 degrees Fahrenheit cooler than today.

Forests Since European-American Settlement

Today, Wisconsin's forests are significantly different than those before European-American settlement. A variety of historical reasons can account for this.

Staber W. Reese

Eight million acres of forest were cut by 1898, the height of Wisconsin's Cutover. Langlade County.

Exploration and Settlement

In 1634, Frenchman Jean Nicolet landed on the southern shore of Green Bay to arrange a truce between the Winnebago and their enemies so that the French fur trade would be protected, a task at which he succeeded. This was the first direct European influence felt on the land that would become the state of Wisconsin [Sultzman, 1998]. However, for two hundred years, the forests remained sparsely settled while providing for the lucrative fur trade and continuing to support native people [Wisconsin Conservation Department (WCD), 1955].

Various treaties in the early 1800s, which either removed or confined native populations, opened up Wisconsin to intensive European-American settlement [Sultzman, 1998]. With the dramatic increase in human population came increasing demands on resources. Much of the southern part of the state was converted to agriculture. The fertile soil in this area, including much that was previously forested, became the base for some of the most productive farms in the growing nation. During this process, southern forests were cut and burned to aid in clearing the land and to create nutrient-rich ash to fertilize crops. Timber was not a major economic contributor until the 1870s [WCD, 1955].

The Cutover

In the late 1860s, following the Civil War, logging became an important component of Wisconsin's economy. By 1893 Wisconsin had reached its logging zenith and was a world leader in lumber production with over 3.5 billion board feet produced annually. Pulpwood consumption was about 211,000 cords. Sawmills sprang up everywhere along Wisconsin's many rivers, which transported logs to the mill and the finished products to the burgeoning cities to the south and west.

Sargent

Rivers transported much of the timber cut from Wisconsin's forests in the late 1800s. This is a picture of a logjam on the St. Croix River in 1886.

In 1898 the federal government conducted and published a survey of Wisconsin's northern forests. By this time, a first wave of cutting was well underway, and a second beginning. In the survey's introduction, B. E. Fernow estimates the 1850s pine (red and white pine) volume at 130 billion board feet. By 1898, all but 17 billion had been removed, and cutting was continuing at a rate of 2 billion board feet per year. Fernow wrote, "In almost every town in this region logging has been carried on and 8,000,000 of the 17,000,000 acres of forest are 'cut over' lands largely burned over and waste brush lands, and one-half of it as nearly desert as it can become in the climate of Wisconsin." [Roth, 1898]

By the 1930s, most of the valuable timber in the northern area of the state had been removed or destroyed by fire. The harvest occurred in two waves; the pines were harvested first and floated down the rivers to cities to the south. When railroad shipping became available, valuable hardwoods were cut and taken by train to the south. Then the other, less economically desirable trees were cut.

Harvest techniques varied in cutover lands. Some lands were clear-cut, but most were *high-graded*. The largest and most valuable trees were removed, many times leaving species and individuals less dominant to re-seed an area. At the time of the first statewide inventory in 1936, the approximately 16 million acres of forestland in the state was primarily young, early succession second growth.

The Cutover led to a variety of problems for contemporary and future residents. Not least among the challenges was the wave of forest fires that cinched the destruction of millions of acres of trees and took thousands of human lives. Slash (wood residue from logging operations) burned easily and quickly. Fires spread over large areas, leaving ashes in their path.

Another result of the Cutover was the land boom of the early 1900s. In northern Wisconsin, logging companies sold sizable tracts of cut over land to speculators who then sold smaller farms to the immigrant population arriving in Wisconsin, enticed by the promise of land. Farmers diligently removed stumps left from the Cutover, sometimes disposing of them through fire, which further contributed to the frequent and intense forest fires of the era.

Diemer

The Civilian Conservation Corps fought fires, planted trees, and contributed in substantial ways to Wisconsin's growing conservation ethic. July 1936.

Conservation

This degradation of Wisconsin's forests did not go unnoticed. An era of forest conservation was about to begin. One of the most persistent advocates of conservation was E. M. Griffith, appointed the first state forester in 1904. With the help of people as disparate as Senator Robert LaFollette, Sr., lumber baron Frederick Weyerhaeuser, and University of Wisconsin President Charles R. Van Hise, Griffith pieced together land into state-owned forest preserves. He also oversaw construction of the first state nursery at Trout Lake near Minoqua, implemented new fire control strategies, and was influential in locating the U.S. Forest Products Laboratory in Madison.

Unfortunately, neither the public nor the Wisconsin Supreme Court was ready for such innovations. County governments were concerned about the loss of land from the tax rolls and also contended that Griffith and his cohorts were trying to turn northern Wisconsin into a 'playground' for the rich at the expense of the farmers becoming established in the area.

The Supreme Court found that the land was purchased for the forest preserves under the authority of an improper amendment to the state constitution. Griffith resigned in 1915, and the reforms that he tried to promote were not implemented for another decade.

Finally, in the late '20s and 30s, some of Griffith's goals were realized. A new concern for conservation and an understanding that the forest resource is indeed finite informed new decisions regarding Wisconsin's forests. Farmers in the north realized that the land and climate were not well-suited to agriculture. Many of them abandoned the land, bankrupt. This land reverted to forest.

The State Constitution was amended in 1924 to allow state funds to go to acquisition, development, and preservation of forest resources. The Northern Highland State Forest, still the largest state forest, was the first created under the new amendment. The Forest Crop Law, a precursor to the current Managed Forest Law, was passed in 1927, making it easier for private landowners and counties to conserve forest resources for future use. County forests were created from much of the tax delinquent land of failed farms. In 1928, the first national

Jim Escalante

Early succession species like these paper birch and aspen became very common after the Cutover. Door County.

forest land was purchased in Wisconsin, creating what is now known as the Chequamegon-Nicolet National Forest.

After 50 years of pervasive forest fires, made worse because of the ready availability of fast-burning slash from the extensive harvesting, the public began to value fire control. Human life, farms, buildings, and forests were protected with new fire prevention and control measures. With Smokey Bear's advent in 1944, the public embraced a commitment to fire prevention and forest conservation in Wisconsin.

In the '30s and early '40s, a notable influence on Wisconsin's forests was the Civilian Conservation Corps (CCC). As in other areas, the "CCC boys" fought fires, planted trees, built park buildings, and worked on other conservation projects. Reforestation efforts commenced across the state, with the goal being to renew the forests. Many of Wisconsin's older pine plantations originated with CCC efforts.

The Cutover era had dramatically changed the composition, structure, and function of Wisconsin's forests. The extensive logging and large fires allowed species like quaking aspen and paper birch to become prevalent, encouraging large populations of whitetail deer and other wildlife that thrive in early successional habitat.

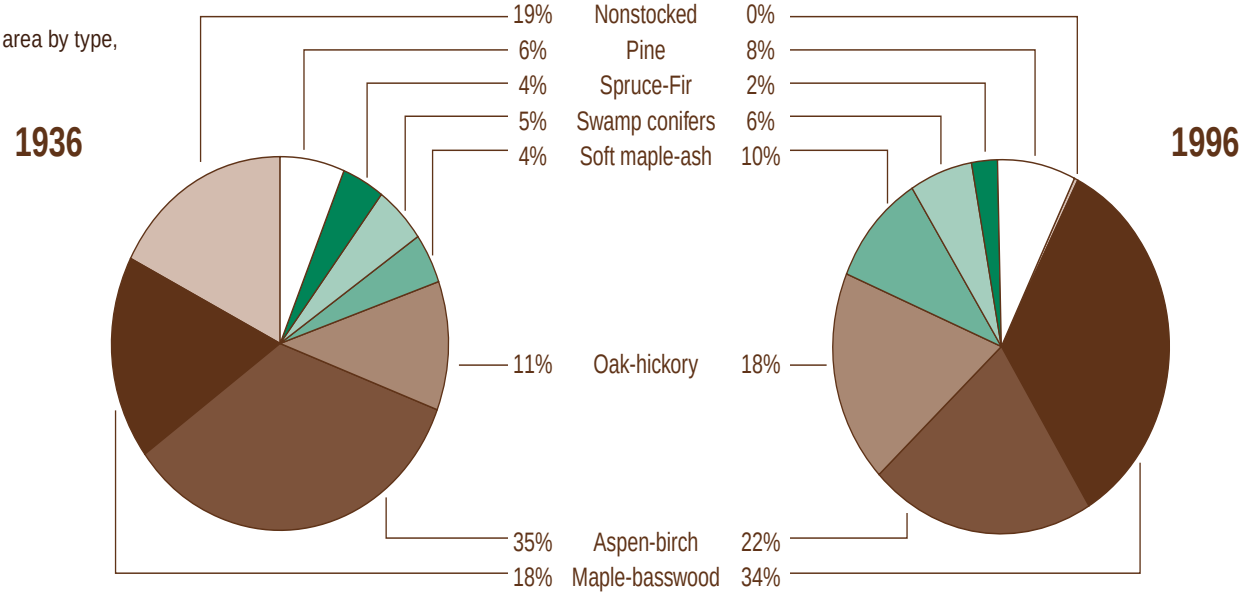
A forest inventory of Wisconsin was conducted in 1936. It revealed a very young forest, with aspen-birch being by far the most prevalent forest type.

Many years passed before the cutover forests recovered sufficiently for harvest. Fortunately, by this time there was a better understanding of the need to conserve forest resources and employ sound forest management. In many instances, professional foresters from forest products companies and government agencies worked together to bolster the growing forests.

Since the Cutover era, Wisconsin's forests have recovered dramatically. The state now supports a wide array of healthy forest ecosystems. Ecological, economic, and social benefits have grown with the growing forest. There are also challenges that face Wisconsin's forests including environmental issues, economic demands, and changing expectations among people who use and own the forests. This assessment will discuss the current state of Wisconsin's forest resources as well as issues and trends that will affect the forests' future.

Figure 5

Wisconsin forest area by type, 1936 and 1996



Assessing Wisconsin's Forests from Various Points of View

Northern Mixed Forest

Ecological Capability

Glacial activity dramatically influenced the ecology of much of Wisconsin, and the entire Northern Mixed Forest region. The most recent glaciers receded from northern Wisconsin about 10,000 years ago, leaving glacial deposits covering much of the northeastern three fifths of the state.

Much of the surface hydrology of the Northern Mixed Forest results from glacial activity. Northern Wisconsin has one of the highest concentrations of freshwater lakes in the world. The Ojibwe word "wisconsin" actually means "gathering place of waters."

Most of the northern area of Wisconsin is a gently rolling plain, punctuated by steeper glacial features and a few ancient pre-glacial escarpments. Tim's Hill and Rib Mountain, the highest points in the state, occur in the northern region.

Most of the soils of the north developed from glacial till and loess (wind deposited material). They developed under forest vegetation, and tend to be lighter colored than soils further south. Most are loams or silts, fairly fertile, and supported complex, well-developed maple-hemlock forests.

Jim Escalante

The Northern Mixed Forest is composed of both conifer and broadleaf trees, and helps to protect the abundant water and soil resources of northern Wisconsin. Copper Falls State Park.

Figure 6

Map of Wisconsin's Northern Forest (below, left)

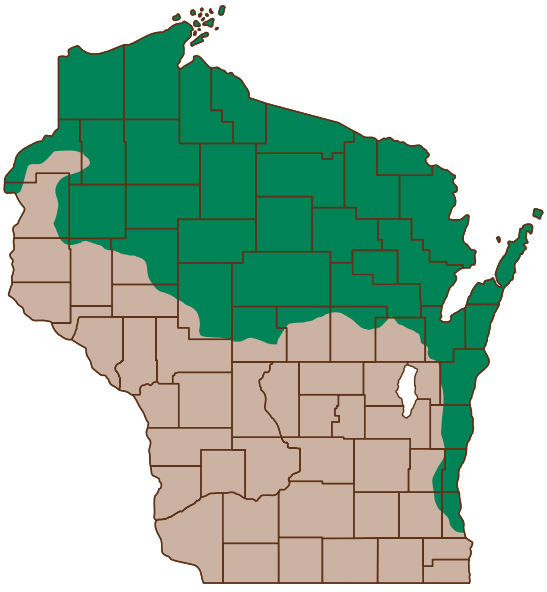
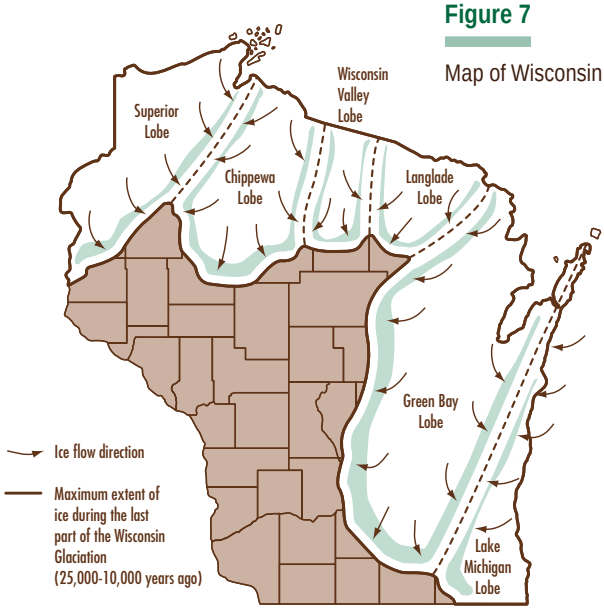


Figure 7

Map of Wisconsin glaciation (below, right)



Dorothy Ferguson

Over half of the northern region of Wisconsin is currently forested. This is a typical young pine forest in northern Wisconsin.

Areas of sandy, infertile, and droughty soils originated as glacial outwash. They supported pine barrens, pine forests, and some broadleaf forests (primarily oak, aspen, and white birch). These soils developed in the extreme northwest area of the state, as well as a limited area in northcentral Wisconsin, a small area in northeast Wisconsin, and a larger area extending into central Wisconsin. These areas tend to be more susceptible to fire as there is less moisture contained in both the soil and vegetation. The pine and hardwood species that grow in these areas are adapted to these unique conditions, namely droughty conditions and fire.

Along Lakes Michigan and Superior, clay soils developed. These areas tend to be fertile and moist due to the lakes' influence, and support a variety of forest vegetation.

The northern area of Wisconsin is well known for it's snowfall and extreme cold. Some areas receive well over 100 inches of snow per winter. This snow serves as both a moisture source and insulation for the soil and plants it covers. Total precipitation in the north ranges from 26 to 36 inches per year. Rain is generally consistent through the growing season, without any pronounced dry periods. This reliable moisture encourages complex forests, supporting many genera and species of both plants and animals.

Average annual temperatures in the Northern Mixed Forest region range from about 37 degrees to 45 degrees Fahrenheit. The usual high average daily temperatures in August are in the low 80s, and common low average daily temperatures in January are near zero. The average high daily temperature varies on a southwest to northeast gradient throughout the state, the southwest being significantly warmer. Growing degree days follow the same trend.

Climate, landform, soil and vegetation interact to result in a wide variety of site conditions in northern Wisconsin. This ecological capability influences what forest types and communities can develop across the landscape.

Current Status of Wisconsin's Northern Mixed Forest

Fewer people live in northern than southern Wisconsin. Consequently, because there is less pressure for urban development and a climate less suitable for agriculture, much of the north remains forested. Over 70% of Wisconsin's forests occur in the north, on only a little over 50% of the total land area. Over half of the Northern Mixed Forest region is forested.

Wisconsin's Northern Mixed Forest is owned by a wide array of individuals and organizations. Although there is significant public ownership in the

Figure 8

Map of Wisconsin's growing degree days. (A growing degree day is an index that combines factors of moisture and temperature to express vegetation growth.) (below, left)

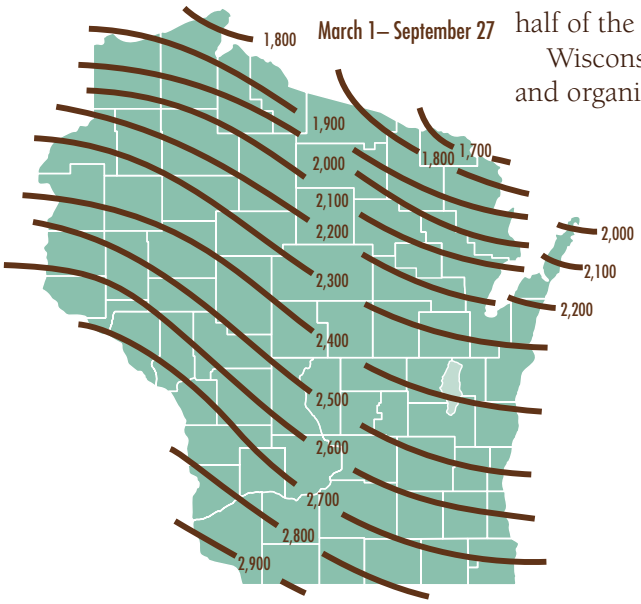
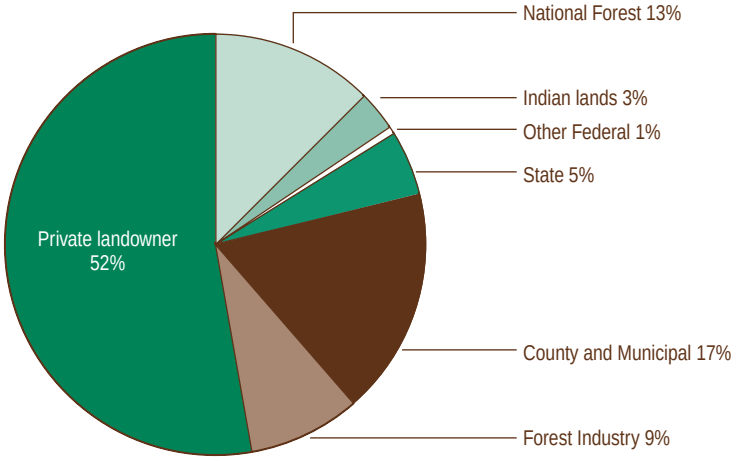


Figure 9

Northern mixed forest ownership, 1996 (below, right)



Robert Queen

Snow is abundant in northern Wisconsin. Snow serves both as a source of moisture and insulation against the bitter cold temperatures common in northern Wisconsin.

northern forests, the most common ownership class is non-industrial private owners. County and municipal ownership is also important in the Northern Mixed Forest. Many of these forests were once bankrupt farms that returned to county ownership after the Cutover. Third largest, in terms of acreage, is national forest land. The Chequamegon-Nicolet National Forest is composed of a number of large tracts located across Wisconsin's northern regions. Forest industry owns 9% of the northern forest, providing wood primarily for the paper industry. Wisconsin is the number one papermaking state in the nation. The State of Wisconsin owns about 5% of the northern forestland—mostly in the state forest system. Indian lands account for about 3% of the total forestland in the north.

The presence of both conifer and broadleaf species characterizes the Northern Mixed Forest. About 30 fairly common, native tree species can be found in the region. However, there are usually only a few primary species in any given locale. These primary species determine the *forest type* of an area.

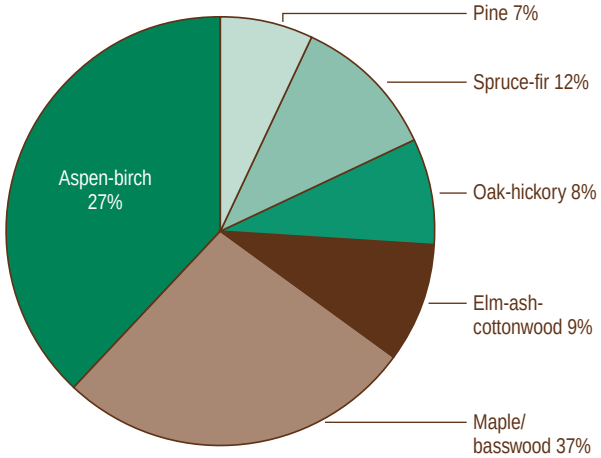


Figure 10

Northern forest types, by acreage, 1996

Common wildlife in Wisconsin's Northern Mixed Forest

Mammals

- white-tailed deer
- beaver
- black bear
- snowshoe hare
- raccoon
- red squirrel
- chipmunk
- other small rodents

Birds

- broad-winged and sharp-shinned hawks
- barred and saw-whet owls
- downy and pileated woodpeckers
- veery
- least flycatcher
- chickadee
- chestnut-sided warbler
- blue jay
- red-eyed vireo
- hermit thrush

Reptiles/amphibians (herptiles)

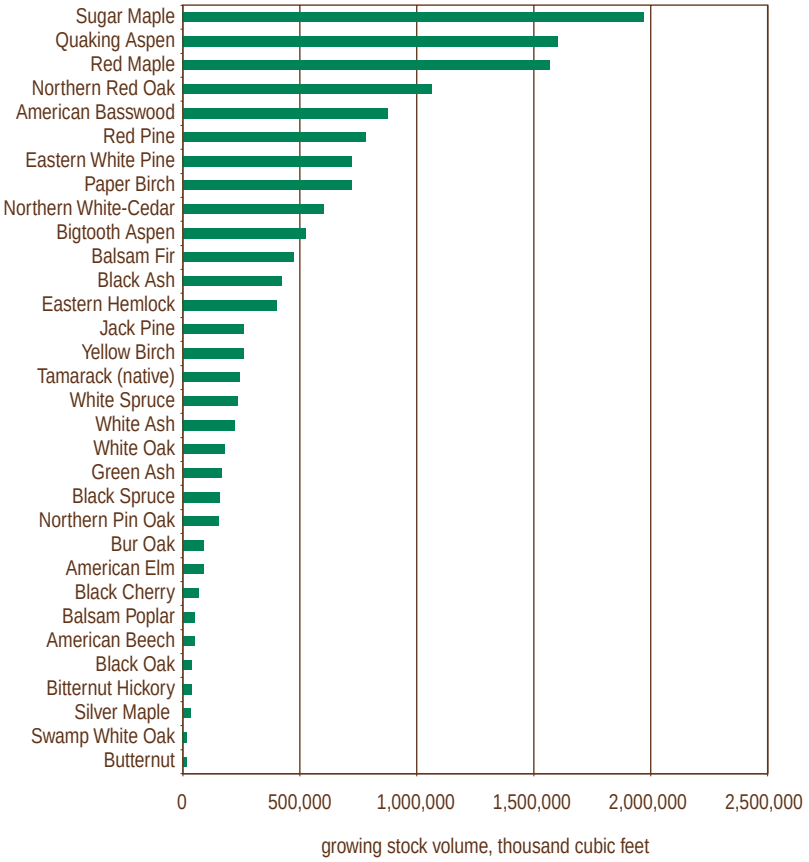
- American toad
- eastern garter snake
- leopard frog

Robert Queen

State land accounts for only about 5% of forestland in northern Wisconsin.

Figure 11

Northern Wisconsin growing stock volume by species, 1996



Common plants in maple-basswood forests

Woody shrubs

- beaked hazelnut *(Corylus cornuta)*
- leatherwood *(Dirca palustris)*
- elderberry *(Sambucus pubens)*
- alternate-leaf dogwood *(Cornus alternifolia)*
- bush-honeysuckle *(Diervilla lonicera)*
- raspberries *(Rubus* spp.)

Non-woody plants

- springbeauty *(Claytonia caroliniana)*
- large-flowered trillium *(Trillium grandiflorum)*
- wood anemone *(Anemone cinquefolia)*
- marsh blue violet *(Viola cucullata)*
- downy yellow violat *(V. pubescens)*
- Solomon's seal *(Polygonatum pubescens)*
- false Solomon's seal *(Smilacina stellata)*
- sweet cicely *(Osmorhiza* spp.)
- Jack-in-the-pulpit *(Arisaema atrorubens)*
- clubmosses *(Lycopodium* spp.)
- largeleaf aster *(Aster macrophyllus)*
- Canada mayflower *(Mianthemum canadensis)*

Maple-basswood forest type

The maple-basswood forest type is the most common forest type in the northern forest region, as well as the entire state. Over 4.2 million acres of the Northern Mixed Forest are maple-basswood forest type. A predominance of sugar maple and basswood characterize this type. Quaking aspen, paper birch, red maple, northern red oak, hemlock, yellow birch, and white pine are also common. Maple-basswood supports a variety of understory plants and animals.

The most important species, by volume, in the maple-basswood forest type are sugar maple, red maple, basswood, quaking aspen, northern red oak, and hemlock. Sugar maple, basswood, eastern hemlock, and yellow birch will be discussed in this section. Red maple will be discussed in the elm-ash-soft maple forest type discussion; quaking aspen will be discussed under the aspen-birch forest type, and northern red oak under the oak-hickory forest type.

Sugar Maple: Maple-basswood is the most common forest type in the northern region of Wisconsin (as well as statewide), and sugar maple *(Acer saccharum)* ranks first in volume in the northern forests. As succession proceeds, sugar maple probably will become even more common. In older forests sugar maple usually has a competitive advantage over other species due to its ability to regenerate and compete in shaded conditions [Curtis, 1959].

Between 1983 and 1996, sugar maple volume in the north increased by almost 62 million cubic feet. In 1996, there were about 1.97 billion cubic feet of sugar maple growing stock north of the tension zone.

Table 1: Forest types of Northern Wisconsin

Forest Type	% of Northern Forest	Characteristic tree species
Maple-basswood	38%	sugar maple *(Acer saccharum)* red maple *(Acer rubrum)* American basswood *(Tilia americana)* eastern hemlock *(Tsuga canadensis)* yellow birch *(Betula allegheniensis)* northern red oak *(Quercus rubra)* quaking aspen *(Populus tremuloides)* white ash *(Fraxinus americana)*
Aspen-birch	27%	quaking aspen *(Pupulus tremuloides)* bigtooth aspen *(Populus grandidentata)* paper birch *(Betula papyrifera)* red maple *(Acer rubrum)* balsam fir *(Abies balsamae)*
Elm-ash-soft maple	9%	red maple *(Acer sacchurum)* black ash *(Fraxinus nigra)* white ash *(Fraxinus americana)* American elm *(Ulmus americana)*
Oak-hickory	8%	northern red oak *(Quercus rubra)* northern pin oak *(Quercus ellipsoidalis)* white oak *(Quercus alba)* red maple *(Acer rubrum)* bigtooth aspen *(Populus tremuloides)* eastern white pine *(Pinus strobus)*
Spruce-fir	11%	white spruce *(Picea glauca)* black spruce *(Picea mariana)* balsam fir *(Abies balsamae)* northern white cedar *(Thuja occidentalis)* tamarack *(Larix laricina)* quaking aspen *(Populus tremuloides)*
Pine	7%	eastern white pine *(Pinus strobus)* red pine *(Pinus resinosa)* jack pine *(Pinus banksiana)*
Other northern species		mountain ash balsam poplar

Sugar maple follows quaking and bigtooth aspen as the most common species harvested in the northern region of Wisconsin. Between 1983 and 1996, an annual average of 21.1 million cubic feet of sugar maple were harvested from Wisconsin's northern forests. However, during the same period, sugar maple net average annual growth was 55.5 million cubic feet. In other words, over 60% of sugar maple growth was retained, adding to the net growth of the forest.

DNR Photo Archives

Since the last assessment, sugar maple volume increased 62 million cubic feet.

Sanborn

Maple-basswood forests, like this one in Rusk County, are the most common forest type in Wisconsin.

Robert Queen

Sugar maple provides many benefits, not least of which is the delicious maple syrup northern Wisconsin is famous for. This photo shows people tapping maple trees in late winter.

Basswood: American basswood (*Tilia americana*) is another primary species in the maple-basswood forests of northern Wisconsin. In 1996, there were 874.5 million cubic feet of basswood growing stock in Wisconsin's northern forests. This was a 28% increase over the 683.7 million cubic feet in the northern forests in 1983.

Like sugar maple, basswood volume is increasing as the forests mature. A fast growing tree, basswood is a common lumber species. Other important uses of basswood include hand carving, local crafts like basketry and rope making, and as a honey tree. Bees find the basswood's fragrant flowers very attractive as a nectar source [USDA Forest Service, 1990].

Basswood is harvested extensively in the north. An annual average of 10.6 million cubic feet of basswood was harvested in northern Wisconsin between 1983 and 1996. This was about two-thirds of the 15.9 million cubic feet of average net annual growth between 1983 and 1996. This resulted in 5.3 million cubic feet of basswood growth in northern Wisconsin.

An important pest for basswood is the basswood thrips. Rabbits may also feed on seedlings. Basswood is also very susceptible to fire [USFS, 1990].

Eastern Hemlock: Eastern hemlock *(Tsuga canadensis)* was historically a very important component of what is now the maple-basswood forest. At one time, hemlock was one of the two dominant species in the northern forests. With sugar maple, it composed a significant portion of forest vegetation before the Cutover, especially on wet-mesic and mesic sites.

Today hemlock is much less prevalent. For the most part, this is due to the Cutover beginning at the turn of the century. During the Cutover, Wisconsin's hemlock was cut for the tanning industry. The tannins in hemlock bark were used for tanning leather.

Robert Queen

Although hemlock was mostly removed from the northern forests during the Cutover, small patches are found throughout the range of hemlock in northern Wisconsin.

Hemlock is a long-lived, shade-tolerant, slow-growing tree. Individual trees can live up to 500 years, and may not bear seeds until they are 150 years old [USFS, 1990]. Harvest during the Cutover removed the mature trees that provide the seed source for future trees. Because of the scarcity of hemlock, recovery time for hemlock may take much longer than for other species like maple or pine. After the Cutover, few areas had sufficient hemlock composition to offer enough seed source to adequately regenerate hemlock.

For a long time, ecologists were concerned that hemlock would never make a comeback in Wisconsin's forests. However, new inventory data indicates that

DNR Photo Archives

Red-eyed vireos are common woodland birds in northern Wisconsin.

Figure 12

Hemlock size classes

Robert Queen

Trillium are common on the forest floor throughout Wisconsin. Their large, three-petaled flowers are easily identified in spring.

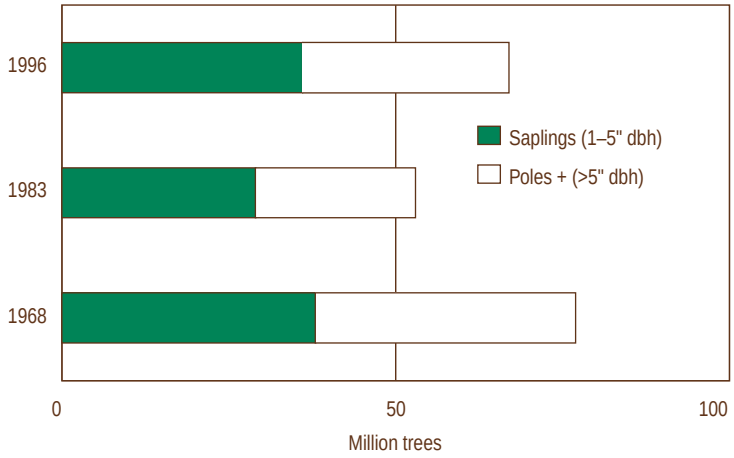
Common plants on aspen-birch forests

Woody plants

- beaked hazelnut *(Corylus cornuta)*
- American hazelnut *(C. americana)*
- mountain maple *(Acer spicatum)*
- speckled alder *(Alnus rugosa)*
- dwarf bush-honeysuckle *(Diervilla lonicera)*
- raspberries *(Rubus* spp.)
- gooseberry *(Ribes* spp.)
- willow *(Salix* spp.)
- sweetfern *(Comptonia perigrina)*

Non-woody plants

- largeleaf aster *(Aster macrophylla)*
- wild sarsaparilla *(Aralia nudicaulis)*
- Canada mayflower *(Mianthemum canadensis)*
- bunchberry *(Cornus canadensis)*
- yellow bead lily *(Clintonie borealis)*
- roughleaf ricegrass *(Oryzopsis asperifolia)*
- sweet-scented bedstraw *(Galium triflorum)*
- lady fern *(Athyrium felix-feminina)*
- bracken fern *(Pteridium aquilinum)*
- sedges *(Carex* spp.)
- goldenrods *(Solidago* spp.)



hemlock may be recovering in Wisconsin's northern forests. In 1983, there were about 284 million cubic feet of growing stock in the northern forests. In 1996, that figure had increased to 401 million cubic feet. The majority of this growth is on existing large hemlock. Currently, only about half of hemlock's growth is being harvested.

Despite browsing by the large Wisconsin deer population, numbers of hemlock trees also increased between 1983 and 1996, including 1–3 inch diameter trees [Schmidt, 1997].

Yellow Birch: Yellow birch *(Betula alleghaniensis)* is a relatively common species in maple-basswood forests. Like its associate, eastern hemlock, yellow birch is a long-lived, shade-tolerant, slow-growing species [USDA Forest Service, 1990]. Over the last inventory period, from 1983 to 1996, yellow birch volume has increased a little over 4%, from 233.4 million cubic feet to 260.6 million cubic feet. Between 1983 and 1996, an annual average of 2.3 times as much yellow birch timber was harvested—about 3.2 million cubic feet—than grew—about 1.5 million cubic feet. Sources of natural yellow birch mortality are the birch leaf miner, bronze birch borer, injury, and windthrow.

Aspen-Birch Forest Type

Second to maple-basswood in total area is the aspen-birch forest type. Just less than 3.1 million acres of the Northern Mixed Forest region are aspen-birch. Important tree species in this forest type include quaking aspen, bigtooth aspen, and paper birch. Wildlife in aspen-birch forest type is abundant—many of the state's most important game animals favor this type of forest. The most important species, by volume, in the aspen-birch forest type are quaking aspen, paper birch, and bigtooth aspen.

Quaking aspen removals are the highest of any species in the state. It is very important in the Wisconsin pulp and paper industries, which produce 11% of the United States' paper supply [Wisconsin Paper Council, 1999].

DNR Photo Archives

The American toad is found in all of Wisconsin's forest types.

Aspen: There are two species of aspen in Wisconsin—quaking and bigtooth. Quaking aspen *(Populus tremuloides)*, distinguished from bigtooth *(Populus grandidentata)* by its smaller-toothed leaf margins, has a range that stretches all the way across North America, and probably is the most widely distributed tree on the continent [USDA Forest Service, 1990]. Bigtooth aspen is also quite common in northern Wisconsin.

In 1996, there were 1.6 billion cubic feet of quaking aspen growing stock in northern Wisconsin. This figure had decreased from just less than 1.7 billion cubic feet in 1983. Bigtooth growing stock volume also decreased slightly between 1983 and 1996, from 526 million cubic feet to 522 million cubic feet. This decrease in growing stock is due to the predictable aging of the northern forests, which are succeeding from early successional species like aspen to more shade-tolerant species like sugar maple and basswood.

Between 1983 and 1996, more aspen was harvested and died from natural causes than grew in Wisconsin's northern forests. Quaking aspen average net annual growth between 1983 and 1996 was 50 million cubic feet; removals were 52 million cubic feet. Bigtooth aspen average net annual growth was 15 million cubic feet; removals were 23 million cubic feet. As has been the trend for many years, quaking aspen and bigtooth aspen were the most harvested species between 1983 and 1996.

Aspen are short-lived, prolific species. Aspen regenerates well after severe disturbances, either by sprouting after clearcutting or seeding after fire, which open up the forest canopy and allow sufficient light to penetrate for these sun-loving species. They are susceptible to many diseases and other mortality factors. In Wisconsin, aspen is used for fiberboard, pulpwood, flakeboard, and some sawtimber.

Many kinds of wildlife feed on aspen, sometimes damaging individual trees, or, in the case of beavers, entire stands. Deer, snowshoe hare, sapsuckers, porcupines, and beaver are some of the primary animals impacting aspen [USFS, 1990].

Staber W. Reese

Almost 3.1 million acres of the northern forest is aspen-birch forest type. Vilas County.

DNR Photo Archives

Bunchberry is a common flowering plant in aspen-birch forests. In the fall, the plant produces bright red edible berries.

Robert Queen

Paper birch is quite distinctive, easily identified by it's characteristic papery, peeling white bark.

Robert Queen

Black spruce swamps are fairly common in the northern forests of Wisconsin. They are a good example of spruce-fir forests. Northern Highland American Legion State Forest.

Allen Haukom

Balsam fir is declining throughout northern Wisconsin. This open-grown balsam fir was photographed in Price County.

Paper Birch: The beautiful paper birch *(Betula papyrifera)*, sometimes called white birch, is perhaps the most identifiable tree in Wisconsin's northern forests. Its distinctive papery bark distinguishes it from all other hardwoods. Like its associates, the aspens, paper birch is a short-lived, early successional species.

In 1996, northern Wisconsin's paper birch growing stock volume was 719 million cubic feet. This was a 20% decrease from the 900 million cubic feet of growing stock in 1983. Paper birch average net annual growth between 1983 and 1996 was 6.7 million cubic feet; average annual removals were over three times average net annual growth at 20.5 million cubic feet.

Like aspen, paper birch is susceptible to many damaging agents. Since white birch is less prolific than aspen, these impacts are greater. Particularly important are two insects, the birch leaf-miner and the bronze birch borer. Animals impacting paper birch are similar to those affecting aspen—deer, hare, small mammals, and sapsuckers. Most of these animals feed on seedlings, decreasing long-term regeneration. Sapsuckers, while drilling into the bark for insects, make entry wounds that are susceptible to insect invasion or infection [USDA Forest Service, 1990]. Severe weather, especially drought and windstorms, has also been an important factor in birch decline. The severe drought of 1988 and 1989, in combination with defoliation caused by the birch leaf miner and infestations of the bronze birch borer contributed significantly to the decline and mortality of paper birch between 1983 and 1996 [USDA Forest Service, 1998].

Spruce-Fir Forest Type

The Northern Mixed Forest is distinguished primarily by the prevalence of conifers. The most common conifer forest type is spruce-fir with 1.3 million acres in the northern region. Spruce-fir forests are fairly diverse and can occur in many moisture regimes. They are the most common wet forests in the north, and often surround and blend into bogs.

Important tree species in spruce-fir forests include white spruce, black spruce, balsam fir, tamarack, quaking aspen, and white pine. White and black spruce, balsam fir, and tamarack will be discussed under the spruce-fir forest type. See the preceding aspen-birch forest type discussion for more information on aspen in northern Wisconsin. White pine will be discussed in the next forest type, pine.

White Spruce: White spruce *(Picea glauca)* is an important component of spruce-fir forests of northern Wisconsin. White spruce grows in a variety of soil and moisture conditions. It generally grows on more mesic sites than black spruce.

In 1996, there were over 233 million cubic feet of white spruce growing stock in Wisconsin's northern forests, a 17% increase over 1983. A net annual average of over 11.2 million cubic feet of new growth was added between 1983 and 1996, while an average of 2 million cubic feet as harvested.

Many birds and animals find shelter in spruce stands. Red squirrels feed on white spruce. Many species of wood warblers nest in white spruce.

Windthrow, fire, and flooding are primary white spruce mortality factors. The spruce budworm is the most important insect pest of white spruce [USFS, 1990].

Black Spruce: Black spruce *(Picea mariana)* is primarily a bog species. It is very common on northern Wisconsin's wet, low-nutrient soils. Black spruce is used for timber, boxes, and sometimes pulpwood [USFS, 1990].

In 1996, there were almost 156 million cubic feet of black spruce growing stock in northern Wisconsin. This was up from 123 million cubic feet in 1983. Black spruce grew a net annual average of 2.2 million cubic feet between 1983 and 1996, an annual average of .6 million cubic feet were harvested.

Windthrow and breakage is the primary cause of mortality of black spruce in northern Wisconsin. Fire, herbivory by snowshoe hare, and spruce budworm infestation also cause mortality in black spruce [USFS, 1990].

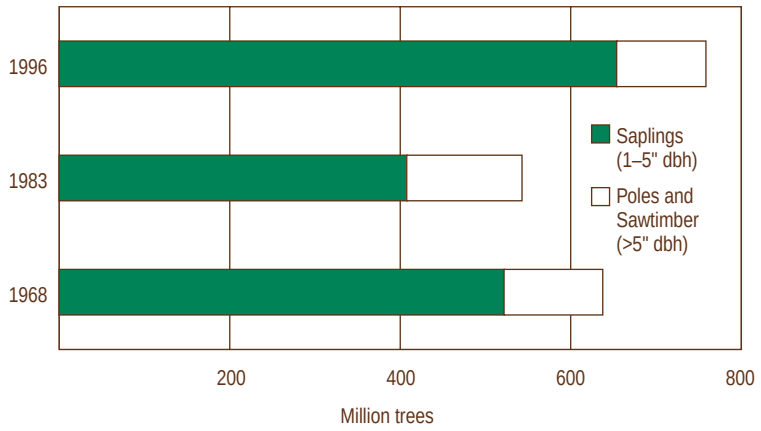
Balsam Fir: Balsam fir *(Abies balsamae)* is a common species in the northern forests. It grows on a wide variety of site types. In recent decades, balsam fir has been experiencing a decline. Forest inventory information from 1983 and 1996 shows that balsam fir growing stock volume in northern Wisconsin decreased 15%—from 552.8 million cubic feet in 1983 to 470.8 million cubic feet in 1996.

However, young trees—seedlings and saplings—are increasing and are likely to continue to increase. It is believed that balsam fir volume and forest type acreage will increase in coming decades.

Between 1983 and 1996, balsam fir in northern Wisconsin grew at a net average annual rate of almost 7.7 million cubic feet. Of that, an annual average of 5.8 million cubic feet was harvested.

Insects and disease are important mortality factors. The larger size class of large balsam fir is maturing and experiencing high mortality. Spruce budworm, windthrow, fire, and some animals (deer, snowshoe hares, red squirrels, and black bear) damage balsam fir.

Balsam fir is used for pulpwood and lumber. It is also an important species for wildlife shelter.



Common plants in spruce-fir forests

Woody plants

- beaked hazelnut *(Coryluc cornuta)*
- mountain maple *(Acer spicatum)*
- Labrador-tea *(Ledum groenllandicum)*
- Canada yew *(Taxus canadensis)*
- raspberry *(Rubus* spp.)
- sheep-laurel *(Kalmia angustifolia)*
- speckled alder *(Alnus rugosa)*
- red-osier dogwood *(Cornus stolonifera)*
- bog-rosemary *(Andromeda glaucophylla)*
- leatherleaf *(Chamaedaphne calyculata)*
- bog-laurel *(Kalmia polifolia)*

Non-woody plants

- twinflower *(Linnaea borealis)*
- bunchberry *(Cornus canadensis)*
- starflower *(Trientalis borealis)*
- creeping snowberry *(Gaultheria hispidula)*
- sedges *(Carex* spp.)
- common wood sorrel *(Oxalis montana)*
- yellow bead lily *(Clintonia borealis)*
- cinnamon fern *(Osmunda cinnamomea)*
- sweet-scented bedstraw *(Galium triflorum)*
- Canada mayflower *(Mianthemum canadensis)*
- spinulose wood fern *(Dryopteris spinulosa)*
- feathermosses *(Hylocomium splendens, Pleurozium scheribi, and Ptilium cristscastrensis)*
- sphagnum moss *(Sphagnum* spp.)

Figure 13

Balsam fir size classes

Robert Queen

Tamarack is an important wetland species in northern Wisconsin. Unlike other conifers, in autumn tamarack lo ses it's needles.

Tamarack: This distinctive conifer, turning a blazing gold in autumn and dropping its needles, is common in wet areas in northern Wisconsin. Tamarack *(Larix laricina)* is not an important timber species, although there is some use made of it for pulpwood. It is, however, an important wildlife species. Porcupines, hares, sparrows, warblers, and osprey live in tamarack bogs [USFS, 1990]

Tamarack growing stock volume has almost doubled over the last inventory period. In 1983, there were about 118 million cubic feet of tamarack growing stock in northern Wisconsin. In 1996, that figure increased to 243.46 million cubic feet.

Between 1983 and 1996, a net average annual growth of 5.4 million cubic feet was added to tamarack volume growing in northern Wisconsin. On average, less than .4 million cubic feet were harvested annually.

Tamarack is susceptible to fire, flooding, and windthrow. Porcupines and other animals may damage tamaracks by feeding.

Darrell Zastrow & David Schultz

Northern white cedar is having problems regenerating due to whitetail deer and snowshoe hare herbivory. Animals eat seedlings like this one.

Northern White Cedar: Northern white cedar, or arbor vitae—tree of life—is a common northern Wisconsin species. It is especially found around northern lakes in peatland bogs, usually alkaline. Northern white cedar *(Thuja occidentalis)* is not an important timber species, but it is used for posts and craft products. It is very important to wildlife, especially deer and elk in winter [Johnston, 1990]. Cedar forests also support many rare plants and animals.

In 1996, there were 600 million cubic feet of northern white cedar growing stock in northern Wisconsin. This was an increase over the 465 million cubic feet growing stock volume measured in 1983. Average net annual growth between 1983 and 1996 was over 10 million cubic feet; average annual removals were .8 million cubic feet.

Northern white cedar is susceptible to flooding, fire, windthrow, winter cold damage, and road salt damage. Whitetail deer and snowshoe hare herbivory can also impact northern white cedar, limiting regeneration [USFS, 1990]. There are few insect or disease problems with northern white cedar.

Pine Forest Type

Seven percent (802,000 acres) of the Northern Mixed Forest in Wisconsin is pine forest type. Red pine, eastern white pine, and jack pine are the common pine species that occur in Wisconsin. Forest character can vary from jack pine barrens, to red pine plantations, to thick stands of young white pine, to old growth stands with pines hundreds of years old. Other than pines, common associates of pine forests are quaking aspen, paper birch, balsam fir, red maple, white spruce, northern pin oak, and northern red oak. Only pine species will be discussed in this section.

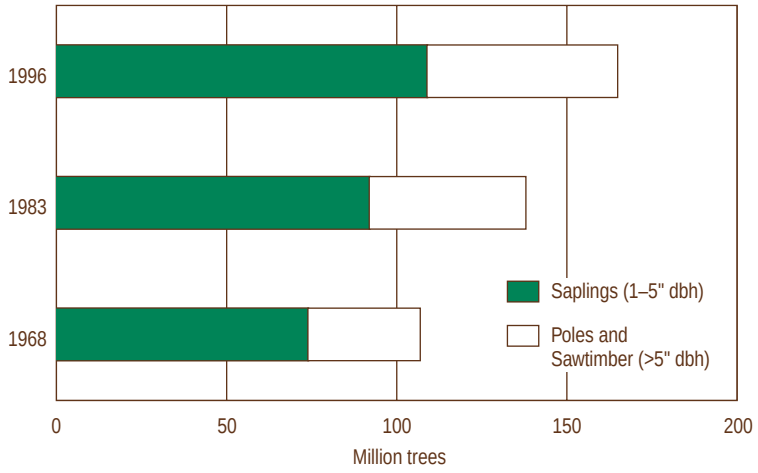
Robert Queen

Eastern white pine is making a come-back in the northern forests. Along with the bald eagle, it is once again an important part of Wisconsin's landscape.

Eastern White Pine: One of the largest and longest lived of Wisconsin's tree species, eastern white pine *(Pinus strobus)* historically played an important role in the northern forests. During the Cutover, almost all large white pine in Wisconsin was harvested. Since then natural regeneration as well as planting has resulted in white pine's resurgence.

Eastern white pine is used for many products, including furniture, pulp and paper. Many species of wildlife use white pine for food and or shelter. White pine makes a good urban tree, and is widely planted. It can also make attractive Christmas trees [USDA Forest Service, 1990].

In 1996, there were 722 million cubic feet of eastern white pine growing stock in Wisconsin's northern forests. This was up from 457 million cubic feet in 1983.



Common plants in pine forests

Woody plants

- blueberries *(Vaccinium* spp.)
- sweetfern *(Comptonia perigrina)*
- bearberry *(Arctostaphylos uva-ursi)*
- American hazelnut *(Corylus cornuta)*
- beaked hazelnut *(Corylus americana)*
- dwarf bush-honey-suckle *(Diervilla lonicera)*
- New Jersey tea *(Ceanothus americanus)*
- Fly honeysuckle *(Lonicera canadensis)*
- serviceberries *(Amelanchier spp.)*
- raspberries *(Rubus* spp.)
- trailing arbutus *(Epigaea repens)*
- wintergreen *(Gaultheria procumbens)*
- partridgeberry *(Mitchella repens)*
- dogwoods *(Cornus* spp.)

Non-woody plants

- bracken fern *(Pteridium aquilinum)*
- clubmoss *(Lycopodium* spp.)
- wild sarsaparilla *(Aralia nudicaulis)*
- Jack-in-the-pulpit *(Arisaems atrorubens)*
- Canada mayflower *(Mianthemum canadensis)*
- cow wheat *(Melampyrum linaere)*

Common wildlife in pine forests

- Yellow-bellied sapsucker
- Black-capped chickadee
- White-breasted nuthatch
- Pine warbler
- Pine grosbeak
- Red crossbill
- Beaver
- Snowshoe hares
- Porcupine
- Red and gray squirrels
- Mice
- White-tailed deer

Figure 14

White pine size classes

Robert Queen

Red pine volume increased over 250 million cubic feet between 1983 and 1996. Red pine bark.

Robert Queen

Pine forests account for 7% of northern Wisconsin's forests. White pine, Northern Highland-American Legion State Forest.

Between 1983 and 1996, there was a net annual average of 19.9 cubic feet of growth of eastern white pine in Wisconsin's northern forests. During the same period, an average of 8.6 million cubic feet were harvested annually.

Damaging agents of white pine include fire, herbivory, air pollution (ozone and sulfur dioxide), white pine blister rust, white pine weevil, and Armillaria root disease. There are other insects and diseases that affect white pine, as well, although most others have negligible impact [USFS, 1990].

Red Pine: Red pine *(Pinus resinosa)* is an ecologically and economically important species. Red pine is important to the pulp and paper industry, and mature stands with good structure often provide valuable wildlife and aesthetic benefits. Red pine is used for lumber, poles, railway ties, boxes, pulpwood, fuel, erosion control, and Christmas trees [USDA Forest Service, 1990].

Red pine is most common in dry to very dry forests [Spencer, et. al., 1988].

Between 1983 and 1996, red pine growing stock in northern Wisconsin increased from 511 million cubic feet to 779 million cubic feet.

Red pine plantations statewide increased by 150,300 acres over the inventory period. Of all red pine forest type in the state, 88% is in plantations, an increase from 79% in 1983. Although there has been an increase in red pine forest type, naturally regenerated red pine forests have decreased 26% since 1983.

Between 1983 and 1996, red pine grew at a net average annual rate 33.7 million cubic feet in northern Wisconsin. On average, about 20% of this growth, or 6.6 million cubic feet, was harvested annually.

Red pine is less susceptible to damaging agents than its associates. However, severe weather, fire, herbivory, insects, disease and road salt can injure red pine and cause mortality [USDA Forest Service, 1990].

Jack Pine: Jack pine *(Pinus banksiana)* grows most often in dry to very dry forests and in barrens.

During the last inventory period, between 1983 and 1996, jack pine growing stock volume in northern Wisconsin decreased by 38% to 98.5 million cubic feet. In 1983, there were 359 million cubic feet of jack pine growing stock in the Northern Mixed Forest. In 1996, that figure was 260 million cubic feet.

Between 1983 and 1996, jack pine grew at a net annual rate of 5.7 million cubic feet. During the same period, almost 10 million cubic feet—1.75 times the amount of growth—were harvested annually from northern Wisconsin.

Jack pine's decrease in acreage and volume is primarily a result of aging coupled with forest pest infestations, particularly jack pine bud worm, and limited natural regeneration, in part due to the absence of fire. There has also been a decrease due to the loss and conversion of the pine barrens and forests in the northwest and central parts of Wisconsin to red pine plantations or farmland. Jack pine forest type acreage between 1 and 20 years old is down from 117,000 acres in 1983 to 60,000 acres in 1996 statewide.

Jack pine also appears to be more dispersed among forest types than in 1983, impacting resource availability and operability of harvest.

Jack pine is a short-lived, early successional species. It is susceptible to many damaging agents including fire, drought, flooding, herbivory, insect damage, and disease. Fire, or similar disturbance such as clear-cutting combined with soil disturbance, is also required for its successful regeneration.

Jack pine can be important for wildlife like deer and hares. Jack pine forests often provide the best opportunity for wild blueberry picking in the Northern Mixed Forest [USDA Forest Service, 1990]. Although decreasing, jack pine is an important Wisconsin species for wildlife.

Eric Epstein

Jack pine barrens are a rare ecosystem in Wisconsin's northern and central regions. Adams County.

DNR Photo Archives

Black-capped chickadees are common in pine forests.

Robert Queen

Blueberries are especially common in sandy soiled pine forests.

Robert Queen

Jack-in-the-pulpits are found in many forests, on mesic and wet-mesic sites.

Robert Queen

Prickly pear, an unexpected sight for many in Wisconsin, occurs in pine barrens on sandy, well-drained soils.

Common plants in pine and oak barrens

Trees

- jack pine *(Pinus banksiana)*
- northern pin oak *(Quercus ellipsoidalis)*
- red pine *(Pinus resinosa)*
- quaking aspen *(Polulus tremuloides)*
- bigtooth aspen *(Populus grandidentata)*
- white oak *(Quercus alba)*

Other plants (woody and non-woody)

- sweetfern *(Comptonia perigrina)*
- New jersey tea *(Ceanothus americanus)*
- bearberry *(Arctostaphylos uva-ursi)*
- lead plant *(Amorpha canescens Pursh)*
- grasses (many genus)
- sedges *(Carex* spp.)

Wildlife in pine and oak barrens

- rufous-sided towhee
- northern flicker
- vesper sparrow
- lark sparrow
- orchard oriole
- Brewer's blackbird
- eastern hognose snake
- prairie skink
- northern brown snake
- eastern mole
- thirteen-lined ground squirrel
- prairie deer mouse

Pine and Oak Barrens

In past assessments, pine and oak barrens were not discussed. However, today they are receiving increased attention as unique ecosystems. Barrens are plant communities that occur on sandy soils and are dominated by grasses, low shrubs, small trees, and scattered large trees. Oak and pine barrens occur in northwestern and northeastern Wisconsin, and also in the Central Sands area, within and south of the tension zone. Wisconsin's Natural Heritage Inventory lists barrens communities as globally imperiled [DNR, 1999]. Most barrens exist in isolated fragments on protected state or federal land.

Changes in Tree Composition and Abundance

The northern forests have experienced many changes in composition and relative distribution over the last 150 years. In the 1850s much of the land north of the tension zone was forested with primary, old forests [Finley, 1976]. Sixty years later, nearly all had been cut over [WCD, 1955]. By the 1950s, much of Wisconsin's forests had been re-established but were still quite young. In 1996, although forests in the northern part of the state had reached a similar coverage as in the 1850s, notable compositional, functional and structural changes had occurred.

One of the most notable differences between today's forest and that of the 1850s is diminished importance of conifers. At the time of European settlement, sugar maple shared its dominance of the Northwoods with eastern hemlock. Although eastern hemlock is occasionally found in association with sugar maple, it has been reduced to an estimated 1% of its historical abundance [Eckstein, 1999].

White pine was a fairly common, and occasionally dominant, forest tree in the 1850s. Today in many areas it is nearly absent as a dominant overstory species. However, since the 1983 inventory, there is evidence of white pine recovery with abundant seedlings and saplings on many sites.

Red pine communities (vs. plantations), northern white cedar, and tamarack are also less common today. However, since 1968, red pine and tamarack volume has been increasing. Snowshoe hare and whitetail deer herbivory prevents similar recovery of northern white cedar [USFS, 1990].

Forest succession has continued since the Cutover. In the 1930s, aspen-birch was by far the most common forest type. Since then, as aspen-birch acreage has decreased, maple-beech-birch has increased. In 1996, the relative status of the two forest types was nearly opposite to that in the 30s

Barrens have experienced a decrease since European-American settlement began. This is due to decreased incidence of fire. Significant portions of the central and northwest sands areas of the state were once periodically covered in jack pine forest and barrens. These tree-dominated communities intermingled and alternated with grass- and forb-dominated openings. Openings succeeded to jack pine dominated communities, lasted for a few decades, only to be subjected again to the regressive effects of insects and fire.

With increased human population it became important to suppress fire to protect human safety and property. Since efforts at fire suppression have been successful, perhaps since the 1940s, areas that were historically jack pine forests and barrens communities have succeeded to mixed forest communities. Other areas have been converted to red pine plantations. This has led to a

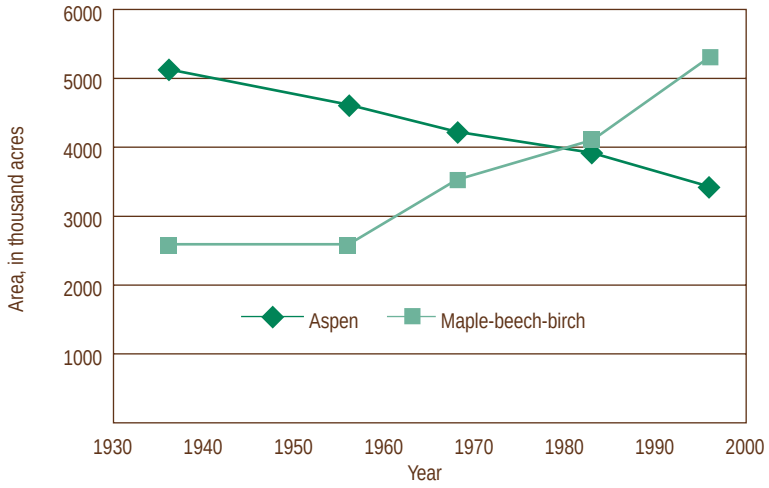


Figure 15

Aspen-birch and Maple-basswood over time

significant decrease in the barrens type community and a corresponding decline in the plants and animals associated with them [Epstein, 1998]. Jack pine forests have reached maturity and have been harvested or become senescent and susceptible to various pests and diseases. The jack pine budworm has been especially important in the recent decline and mortality of this species in Wisconsin [USDA, 1997]. Without fire or similar disturbance, many jack pine forests are being replaced by hardwood species or being converted to red pine plantations.

Biodiversity

Note: Most of the information in this section is derived from an ecological assessment of the northern forests prepared to support northern State Forest master planning [Wisconsin Department of Natural Resources, 1999]. No similar assessment has yet been conducted for the southern part of the state.

The Northern Mixed Forests—those forests north of the tension zone—have retained much of the diversity present before the Cutover. The concerns regarding biodiversity in the northern region of the state focus on community composition, structure, and function, and on specific species of concern. The overall species richness is present, although the relative abundance of many species has been greatly altered. As development of land progresses, fragmentation is a growing concern. Some ecosystems and many individual species in the Northern Mixed Forest will require management attention to protect them into the future.

Robert Queen

Since the cutover, coniferous trees are less common in Wisconsin's Northern Mixed Forests.

Robert Queen

Maple-basswood forest types, like this young maple forest, are replacing aspen-birch forest types as Wisconsin's forests age.

Ridges

Sundew is an interesting plant occurring in northern wetlands. Plant diversity in the Northern Mixed Forest is abundant, with about 1,800 vascular plants.

Ecosystem Diversity

Presettlement forest composition, structure, and function have been greatly altered by humans. The composition is the variety of tree species that occurred in the forest at the time of presettlement. The structure refers to the physical arrangement of trees, other vegetation, and the now-living components of the forest, including coarse weedy debris in the form of dead snags or fallen trees and limbs. The function of forests refers to the various interactions between living organisms and non-living components. These interactions affect ecological processes such as the decomposition of vegetation, the forming of soil, the flow of water through the system, and the filtration of air and water.

An example of these interactions is found in the changes in the mixed coniferous-deciduous forests, which show a significant reduction in coniferous component. Early logging in the north focused on pine. The white pine seed source was dramatically reduced, and the slash left on the ground after logging fueled intense fires, typically eliminating the present advanced regeneration of pine. Most of the area that was white pine forest before the intense harvests of the late 19th century is today covered in oak, red maple, white birch, and/or aspen. The replacement of a mixed coniferous forest with primarily hardwoods greatly changes composition and structure. Until recently, white pine regeneration was severely limited. However, there is currently evidence to suggest that white pine may be recovering to some extent. This regeneration process reflects a change in function.

Eastern hemlock was harvested in a second wave of logging to provide the tanning industry with bark for processing hides. Much of the hemlock component was removed from the northern forests, and now only occurs sporadically in second growth hardwood stands.

In addition to the pine and hemlock, hardwoods were also removed during the Cutover. Although clearcutting and high grading were practiced, many

hardwood species had competitive advantages over conifers. For example, sugar maple seeds' germination requirements are less demanding (colder germination temperature) than conifers', and they were able to regenerate more successfully. Many hardwood species also have the ability to sprout new growth from their roots, unlike the conifers.

The relative importance of hardwood species has also changed significantly in many stands. While sugar maple has retained or increased its dominant position, yellow birch is much less common than it once was. On the other hand, basswood and white ash are now the most important associates of sugar maple, although they were seldom listed as such by early surveyors.

The distribution of forest types, representing different seral stages of the forest, has also been significantly altered by human impact. Seral stage refers to the stages of development of an ecosystem, from very early pioneer plant and animals communities to older, later successional communities. For example, aspen, a pioneer species and an early successional forest type, is well represented and currently covers over 18% of the forestland in the state, most of which is in the north. In early surveyors' work, aspen was regularly mentioned with a variety of forest types, but rarely as a dominant so widely represented in the landscape.

In comparison, barrens, another early successional community type, is very rare. The advent of agriculture and the removal of fire from the landscape combined to convert this ecosystem to other forest types and land uses.

In contrast to these early successional forests, many hardwood mid-successional to late-successional stages are well represented in Wisconsin's northern forest. Diverse structural attributes, such as larger heights and diameters or coarse dead woody debris are still developing in these mid- to late-successional forests.

Plant Diversity

The vegetation of northern Wisconsin is a primary source of the state's biodiversity. Of the state's 2,300 vascular plants, about 1,800 occur in the northern forest region. Statewide, approximately 22% of plant species are introduced exotics. Thus, there are about 1,400 native plant species that occur in the northern forest region [DNR, 1995].

Trees, being the dominant vegetations of any forest, are crucial to the forest's biodiversity. There are approximately 30 tree species that occur in the northern forests of Wisconsin, although no more than about 10 are found together in any given ecological community.

There are 59 plants in the northern forest region that are endangered, threatened or species of concern (see Appendix 2). These plants will likely require some management attention in order to preserve them within Wisconsin.

Animal Diversity

Of the 327 vertebrate species present in Northern Wisconsin, 273 are believed to have secure futures in the state. Fifty-four are believed to require management to protect and preserve them into the future [DNR, 2000].

The richness, distribution and abundance of animals in the northern forests have changed significantly. Among mammals, historically unregulated commer-

Northern Wisconsin forest and barrens species requiring management attention

Mammals

- star-nosed mole
- fisher
- Franklin's ground squirrel
- woodland jumping mouse
- black bear
- arctic shrew
- plains packet gopher
- gray wolf

Birds

- cerulean warbler
- black-throated blue warbler
- wood thrush
- Connecticut warbler
- veery
- blue-winged warbler
- rose-breasted grosbeak
- Canada warbler
- chestnut-sided warbler
- blackburnian warbler
- bay-breasted warbler
- American woodcock
- eastern wood pewee
- Louisiana waterthrush
- mourning warbler
- black-billed cuckoo
- least flycatcher

Herptiles

- four-toed salamander
- bull snake
- copes gray tree frog
- smooth green snake

DNR Photo Archives

Fishers were once extirpated from Wisconsin. They have returned to the state and are now fairly common forest predators.

Robert Queen

Wolves are important predators in our forests. Wolf populations in the state are increasing.

cial hunting and trapping as well as dramatic habitat changes resulted in extirpation of some formerly important game species. Unregulated hunting was also responsible for the loss of large carnivores in the northern forests as well as a number of grazers. Eastern timber wolf, wolverine, fisher, pine marten, and eastern cougar were the most severely affected carnivores. Affected herbivores include elk and moose [DNR, 1995]. Recovery of some of these species is underway. Over-hunting also contributed to the demise of some bird species. Perhaps the most renowned example was the extinction of the passenger pigeon.

The second important factor in many species' change in abundance was, and continues to be, loss of habitat. Currently, for most animals, this is a more severe threat than hunting. Permanent habitat loss caused by urban encroachment, road building, and lakeshore/rural development is a very serious issue. Generally, forest habitats need to be maintained as forests to remain viable habitat for forest-dwelling species. The compositional and structural characteristics of the forest provide the habitat niches for species that are forest-dependent. Some of these species are very specialized in their habitat requirements. A variety of bird species, for example, typically prefer discrete nesting sites in a particular part of a tree, or in the shrub layer in an understory, or on the ground. Another example would be the many species of frogs and salamanders requiring forest ponds, or decaying logs on the forest floor, or a thick litter layer to provide habitat for their different life stages.

Kuesehke

There are many organisms living in our forests that we have yet to understand well. Lichens (pictured), fungi, bacteria and invertebrates, for example, are fundamental components of forest ecology and require further study.

Other Life

Although there is near universal acknowledgment of their importance, invertebrates, non-vascular plants, fungi, bacteria, and other small species have been largely overlooked in most of the research and planning regarding biodiversity. It is estimated that fungi alone may account for 12–30 thousand species in Wisconsin, few of which have been described. Fungi are extremely important in nutrient cycling and ecosystem functioning.

Except for pest species, little research has been directed at forest invertebrates. Lack of knowledge in this area is a concern since invertebrates are a very diverse group and perform important ecosystem functions, such as the breakdown of dead vegetation, the soil formation process, and predator-prey interactions. There has been even less research directed toward non-vascular plants and protozoa.

It is hoped that by sustaining a full array of community compositional and structural attributes, plants, and animal species, these associated organisms will also be sustained. However, it is clear that more research is needed to better understand the diversity and function of these organisms in Wisconsin's forests.

Dorothy Ferguson

Savanna, prairie, and forest are all important ecosystems in the Southern Broadleaf Forest region of Wisconsin. Savanna, Devil's Lake State Park.

Southern Broadleaf Forests

Ecological Capability

The southern region is located in the area south of the tension zone. Glaciers covered about half of the Southern Broadleaf Forest region of Wisconsin. Extensive glacial features like steep moraines, deep kettles, droughty outwash plains, and layered glacial lake deposits blanket the glaciated area. The well-known Kettle Moraine in the southeast is one of the more pronounced moraine systems found in the area. Because this steep terrain limits urban and agricultural development, forests are more common on the Kettle Moraine than on the surrounding landscape.

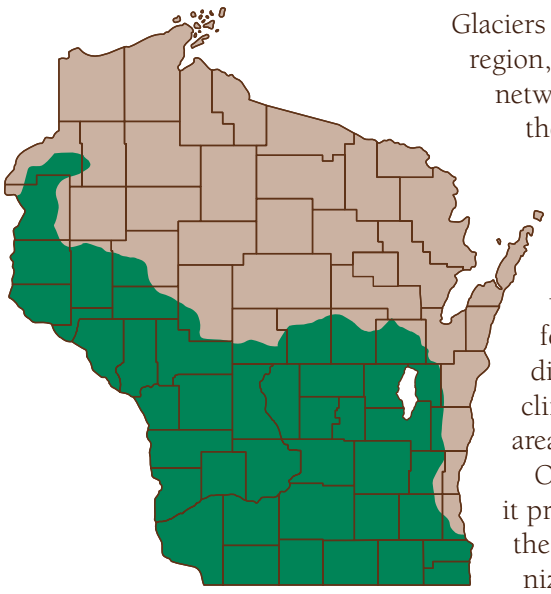
As in the north, many lakes and ponds formed by means of glacial activity. Glaciers scoured the beds of Lake Winnebago and other larger lakes in the region, as well as Lake Michigan. In addition, there is an extensive riparian network in the Southern Broadleaf Forest. Streams, creeks, and rivers drain the southern region into Lake Michigan and the Mississippi River. Lowland elm, oak, maple, birch, cottonwood and ash forests grow along the rivers and streams.

The other half of the Southern Broadleaf Forest region remained unglaciated, and is therefore called the Driftless Area. *Drift* is a term used to describe the material moved by a glacier that becomes the base for subsequent soil development. The coulee topography here is much different from the other half of the Southern Broadleaf Forest. Ancient cliffs, deep winding valleys, and the steep Baraboo Hills characterize this area.

One of the reasons the Driftless Area is significant ecologically is because it provided plant and animal habitat throughout the glacial period. During the glacial period, this area sheltered many species that eventually colonized the glaciated areas of Wisconsin after the glaciers receded.

Figure 16

Wisconsin's Southern Broadleaf Forest.



The climate of the Southern Broadleaf Forest is warmer than in the north. Average temperature in the Southern Broadleaf forest is between 43 to 52 degrees Fahrenheit. Average high daily temperature in August is generally in the low 80s, and average daily low temperatures in January are in the single digits. Areas near Lake Michigan experience a distinct moderation, with their average variance between August and January temperatures as much as 15 degrees less than inland areas.

Precipitation ranges from 25 to 35 inches. In the glaciated area, about two-thirds of the precipitation falls during the growing season. In the Driftless Area only about 40% falls during the same frost-free period. Although snow is abundant, it is not as plentiful as in the Northern Mixed Forest area. In Beloit, the average snowfall per winter averages 30 inches. In Wisconsin, average annual snowfall tends to increase moving north, at higher elevations, and near the Great Lakes. Snow provides valuable insulation to plants and animals.

Soils in the Southern Broadleaf Forest were formed under prairie, savanna, or forest—or all three, as there was often a dynamic progression between the three vegetation types at a site. For the most part fertile and tillable, much of Wisconsin's southern region has been converted to agriculture. Soils in the Driftless Area tend to vary more than in areas where glacial till is the parent material. The varied topography in the Driftless Area influences the soils, vegetation, and even climate at local scales. Soils on steep slopes tend to be less developed and thinner than bottomland soils—less fertile and more challenging for vegetation. Loess deposits are frequently found on ridgetops. A large area of sandy soils in central Wisconsin—called the Central Sands—is included in the Southern Broadleaf Forest. These soils originated from the glacial outwash from the north. These soils tend to be droughty and infertile. The areas tend to be susceptible to fire due to less moisture and vegetation associated with fire disturbances.

DNR Photo Archives

Raccoons are very common throughout southern Wisconsin's forests.

Robert Queen

The Baraboo Hills is one of the few large forest tracts remaining in Wisconsin's Southern Broadleaf Forest. The steep slopes prevented these hills from being converted to agriculture.

Common wildlife species in Wisconsin's Southern Broadleaf Forest

Mammals

- white-tailed deer
- beaver
- muskrat
- raccoon
- skunk
- coyote
- red fox
- red and gray squirrels

Birds

- various hawks
- sandhill cranes
- quail
- grouse
- wild turkey
- Canada geese
- many songbirds

Reptiles and amphibians (herptiles)

- American toad
- tiger salamander
- fox snake
- garter snake

DNR Photo Archives

Wildlife like the ever-present gray squirrel thrive on the nuts provided by oak-hickory forests

The Southern Broadleaf Forest region is very urbanized, especially in the eastern area. Much of the remaining area in the region supports agriculture. The southern region of Wisconsin is more attractive for settlement and agriculture because it is more fertile and experiences less severe winters than the northern area of the state. Forests are mostly limited to steeper slopes, shallow poor sites, and very dry or wet sites.

Current Status of Wisconsin's Southern Broadleaf Forest

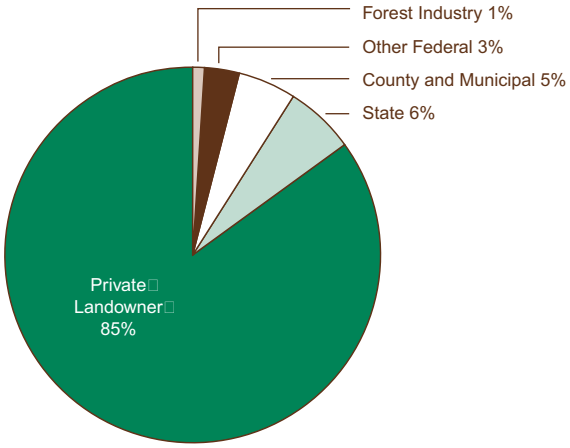
About 27% of the Southern Broadleaf Forest region is actually forestland. Most of the remaining land-use is agriculture or developed urban areas. A little less than 30% of Wisconsin's forests occur in the southern region, although the region contains almost 50% of the total land area in the state. This is primarily due to potential forestland in southern Wisconsin currently used for agriculture or urban development.

Private individual owners own almost 85% of the Southern Broadleaf Forest. The state owns just 6% of the forestland in southern Wisconsin. County and municipal forests account for 5% and federal lands account for just 3% of the total forestland in southern Wisconsin. Ownership differences between the southern and the northern forest regions are dramatic. The primary difference is the lack of public ownership of forests in the south. Another major difference is that, in the southern region, forestland is held in much smaller parcels. The average forest parcel size in southern Wisconsin is less than 40 acres.

Most of the Southern Broadleaf Forests of Wisconsin are located in the central and southwest areas of the state. Due to agricultural and urban development, the southeast contains little forestland. The largest blocks of forest occur in the Central Sands region as well as in the Driftless Area of the southwest. Large

Figure 17

Wisconsin's Southern Broadleaf Forest ownership



blocks include the Central Sands, the Baraboo Hills, the northern unit of Kettle Moraine State Forest, and forest along the Wisconsin, Chippewa, Black and Kickapoo Rivers.

The most common forest type in the Southern Broadleaf Forest is oak-hickory. It represents about 46% of the forests in the southern part of Wisconsin. Primary tree species in oak-hickory forests include northern red oak, white oak, burr oak, northern pin oak, black oak, red maple, aspen, shagbark hickory, basswood, white pine and black cherry.

About a quarter of the forests in the Southern Broadleaf Forest are maple-basswood forest type. Species composition is similar to the northern maple-basswood forest, with sugar maple and basswood being the dominant species. However, there is decreased importance of hemlock, yellow birch and aspen and the increased importance of oaks as compared to the northern maple-basswood forests.

The elm-ash-cottonwood forest type generally is a lowland type that makes up a higher percentage of the southern than northern forests. However, the Northern Mixed Forest contains a larger net acreage of elm-ash-cottonwood forest type. Important species in this forest type are black ash, white ash, silver maple, and red maple. Other forest types of note are aspen-birch, red pine, white pine, and jack pine.

The Southern Broadleaf Forest can be distinguished from the Northern Mixed Forest by the predominance of oak species, as well as by the presence of other species whose range is restricted to areas south of the tension zone such as shagbark hickory, hackberry, and black walnut. For the most part, barring the Central Sands' pine forests and barrens, the forests of the southern region lack a coniferous component (eastern red cedar being an exception). However, microsites containing white and red pine and even hemlock are found in parts of the Driftless Area.

Although not a tree-dominated ecosystem, oak savanna will also be discussed within the context of the southern forest region.

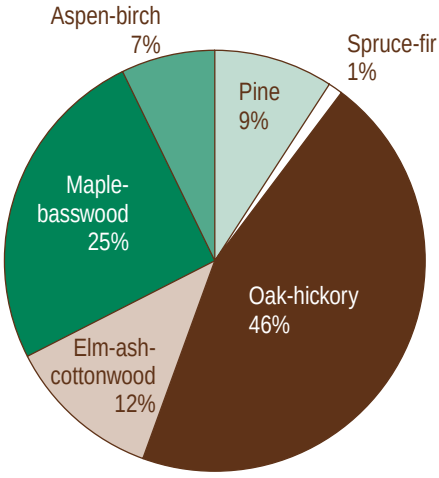


Figure 18

Southern Broadleaf Forest types

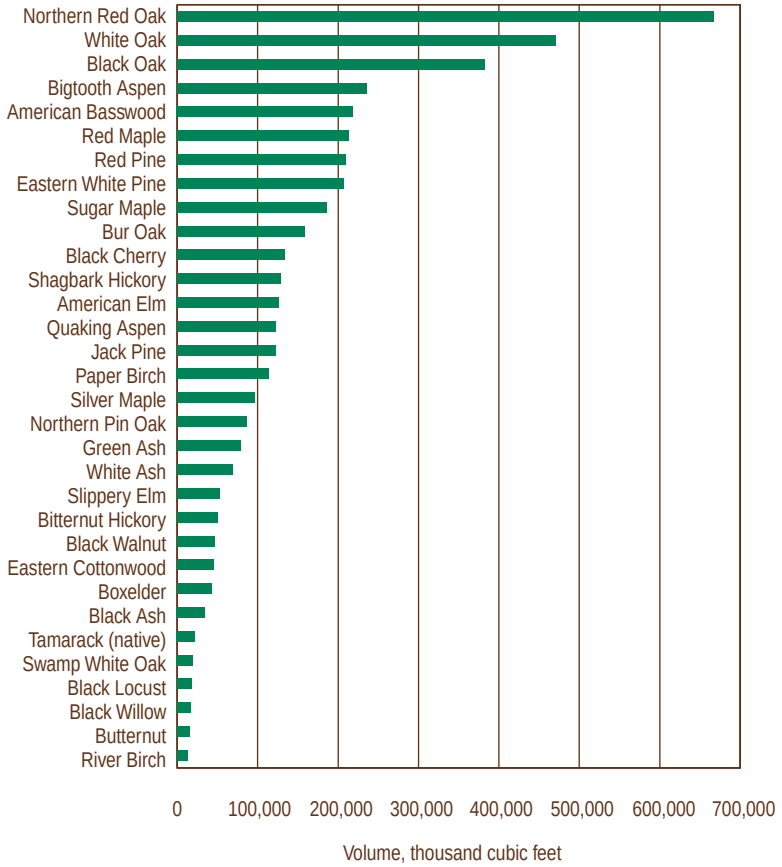


Figure 19

Volume of Wisconsin's Southern Broadleaf Forest, by species

Table 2: Forest types of Wisconsin's Southern Broadleaf Forest

Forest Type	% of Wisconsin's Southern Broadleaf Forest	Characteristic tree species
Oak-hickory	46%	northern red oak *(Quercus rubra)* white oak *(Quercus alba)* northern pin oak *(Quercus ellipsoidalis)* bur oak *(Quercus macrocarpa)* black oak *(Quercus velutina)* shagbark hickory *(Carya ovata)* quaking aspen *(Populus tremuloides)* basswood *(Tilia americana)* white pine *(Pinus strobus)* bitternut hickory *(Carya cordiformis)* red maple *(Acer rubrum)* black cherry *(Prunus serotina)*
Maple-basswood	25%	red maple *(Acer rubrum)* sugar maple *(Acer saccharum)* American basswood *(Tilia americana)* northern red oak *(Quercus rubra)* black cherry *(Prunus serotina)* white ash *(Fraxnus americana)* white oak *(Quercus alba)* shagbark hickory *(Carya ovata)*
Elm-ash-soft maple	12%	American elm *(Ulmus americana)* red maple *(Acer rubrum)* black ash *(Fraxinus nigra)* white ash *(Fraxinus americana)* cottonwood *(Populus deltoides)* willow *(Salix* spp.*)* green ash *(Fraxinus pennsylvanicum)* swamp white oak *(Quercus bicolor)* silver maple *(Acer rubrum)* riverbirch *(Betula nigra)* quaking aspen *(Populus tremuloides)*

Common plants in oak-hickory forests

Woody plants

- American hazelnut *(Corylus cornuta)*
- common blackberry *(Rubus* spp.)
- gray dogwood *(Cornus racemosa)*

Non-woody plants

- blue marsh violet *(Viola cucullata)*
- lady fern *(Athyrium felix-feminina)*
- false Solomon's seal *(Smilacina racemosa)*
- hog-peanut *(Amphicarpaea bracteata)*
- wild geranium *(Geranium maculatum)*
- wild strawberry *(Fragraria virginiana)*
- interrupted fern *(Osmunda claytonia)*

Oak-Hickory Forest Type

Oak-hickory forests are havens for "nut-loving" wildlife. These forests produce valuable timber, provide much of the southern region of Wisconsin with recreational opportunities ranging from hiking to hunting, and perform essential ecological functions.

Many of the state's current oak forests are a result of land management practices following European-American settlement, including clearing, short-term intense fires, and farming. The frequent fires and resultant open conditions after the Cutover favored oaks over more shade-tolerant species. Since then, these areas have matured and become dense oak forests. For the most part, fire has been removed from the oak forests of southern Wisconsin. Since

oak-hickory forests prefer relatively open conditions for regeneration and are tolerant of fire, the absence of fire has resulted in less oak regeneration in these forests in recent decades.

There are almost 2 million acres of oak-hickory in the southern region—46% of the total regional forest cover. Important species in the oak-hickory forest type include northern red oak, northern pin oak, white oak, burr oak, black oak, aspen, basswood, white pine, shagbark hickory, bitternut hickory, red maple, black cherry, and black walnut. This discussion will cover the oaks, hickories, black cherry, and black walnut.

Robert Queen

This open-grown burr oak is typical of the trees that grew in savannas.

Oaks: Oaks are very important commercially, ecologically, and aesthetically. There are seven species of oak that occur in the Southern Broadleaf Forest region of Wisconsin—northern red oak *(Quercus rubra)*, northern pin oak *(Quercus ellipsoidalis)*, black oak *(Quercus velutina)*, white oak *(Quercus alba)*, burr oak *(Quercus macrocarpa)*, swamp white oak *(Quercus bicolor)*, and chinkapin oak *(Quercus muehlenbergii)*. Chinkapin oak is limited to the very southern edge of Wisconsin, and has minimal volume and little harvest.

In 1996, there was 666.6 million cubic feet of northern red oak growing stock in the Southern Broadleaf Forest. During the same year, there was 469.5 cubic feet of white oak growing stock. Black oak accounted for 382.1 million cubic feet, burr oak for 157.5 million cubic feet, northern pin oak for 85.8 cubic feet, swamp white oak for 19 million cubic feet growing stock volume.

Northern red and white oak are the most harvested species in Wisconsin's southern forests. For most oak species, and especially these more common ones, harvest is far exceeding growth in southern Wisconsin.

There has also been less oak regeneration than in the past. As people harvest the maturing oaks, some are choosing to harvest only the best quality trees and to leave the smaller, undesirable trees, a practice called *high-grading*. The shady and shrubby growing conditions in these high-graded forests favor shade-tolerant species like maples, ash, hickory, cherry, elm, ironwood and basswood rather than oaks. Another associated problem is that in high-graded stands there may not be enough viable seed source for regeneration because all the commercially desirable species, like oaks, have been removed. This situation often results in a forest of poor-quality mixed hardwoods. With the lack of fire, these hardwoods quickly capture the site. Lots of sunlight and limited plant competition are required for good oak regeneration and establishment.

Size class data can illuminate the oak regeneration situation somewhat. The data here is statewide data, however, the following are applicable to the

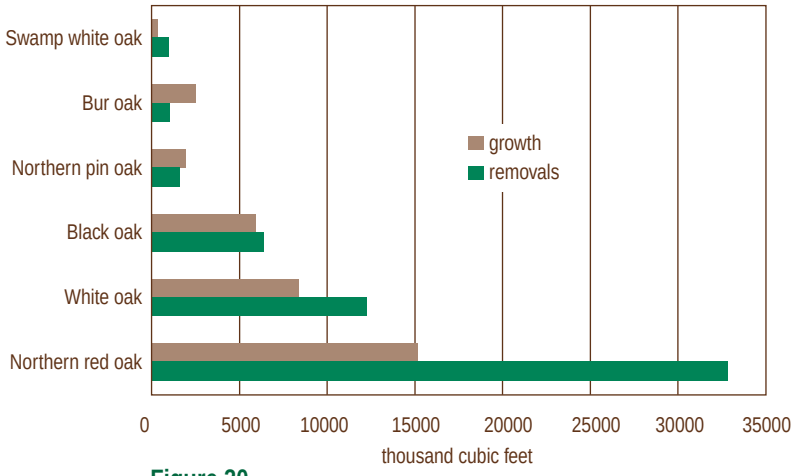


Figure 20

Growth and removals of southern Wisconsin oaks, 1996

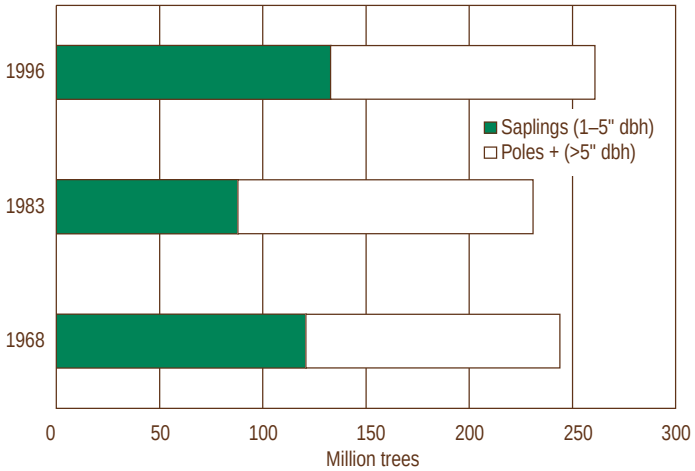


Figure 21

Red oak size classes

DNR Photo Archives

Northern red oak is the most common oak species in Wisconsin.

DNR Photo Archives

Northern red and white oaks are the most harvested of Wisconsin's southern species. Harvest exceeds growth in these species in southern Wisconsin.

DNR Photo Archives

The future of oak regeneration is unclear in Wisconsin's southern forests.

southern oak population. With the exception of northern pin oak, all species of oak have increased their volume in Wisconsin's Southern Broadleaf Forest over the last inventory period (1983–1996). However, combining this information with southern Wisconsin's large harvest:growth ratio, the future of oak in Wisconsin's Southern Broadleaf Forest is unclear. Stand-age class information for oak-hickory forests shows that over the last 15 years there has been a decline in acreage of the 1–20 year-old age class in all but the northwestern part of the state. As oak-hickory stands represent the future oak resource, in southern Wisconsin there is a concern that oak may decrease as a component in Wisconsin's southern forests.

Hickory: Wisconsin's hickories—shagbark, bitternut, mockernut, pignut, and shellbark—provide the hardest, most resilient wood of all the state's timber species. Shagbark *(Carya ovata)* and bitternut *(Carya cordiformis)* are the more common hickories in the state, the others occur only rarely. They are very valuable for wildlife. Squirrels, chipmunks, black bear, gray and red foxes, rabbits, white-footed mice, mallards, wood ducks, bobwhites, and wild turkey all eat hickory nuts. Hickory is used for products requiring strength and resilience—tools, furniture, gym equipment, etc. Shagbark hickory nuts, unlike the aptly named bitternut, are sweet, and eaten and sold by many Wisconsinites [USDA Forest Service, 1990].

In 1996, there were 49 million cubic feet of bitternut hickory, and 128 million cubic feet of shagbark hickory growing stock in southern Wisconsin. The other three species of hickory—shellbark *(Carya laciniosa)*, pignut *(Carya glabra)*, and mockernut *(Carya tomentosa)*—combined accounted for about 1.6 million cubic feet of growing stock in southern Wisconsin. Shagbark and bitternut both increased their growing stock over the 1983 figures of 112 million cubic feet and 48 million cubic feet, respectively [Schmidt, 1997].

Between 1983 and 1996, shagbark hickory grew a net annual average of 3 million cubic feet in Wisconsin's Southern Broadleaf Forest. About 14% of that growth was harvested, 442 thousand cubic feet annually. During the same time period, bitternut hickory grew a net annual average of 1.7 million cubic feet, 56%—948,000 cubic feet—of which was harvested annually [Schmidt, 1997].

Hickory is very susceptible to fire. Even low intensity fires can kill mature hickories. Hickory timber is often damaged by sap-sucker feeding which can stain the wood. The most common damaging disease of hickories is white-heart rot, although it is not a significant mortality factor for Wisconsin's hickories [USDA Forest Service, 1990].

Robert Queen

The aptly named shagbark hickory is an important species in the Southern Broadleaf Forest, and its wood is some of the strongest growing in Wisconsin's forests.

Black Walnut: Black walnut *(Juglans nigra)* is one of the most prized of Wisconsin's timber species. Its beautiful, straight-grained, strong wood is used for furniture, gun stocks, and veneer.

Black walnut nuts are eaten by a wide array of wildlife. The shells have been used for any number of interesting products, including abrasive cleaners and media for pesticide application. [USDA Forest Service, 1990].

In 1996, there were 45.7 million cubic feet of black walnut growing stock in southern Wisconsin. This was up from 22.6 million cubic feet in 1983. Between 1983 and 1996, just 12% of the 1.5 million cubic feet of average net annual growth were harvested.

Black walnut is susceptible to a number of insects. Two diseases that can impact black walnut are root rot disease, and anthracnose. Animals can cause

physical damage by browsing on young plants, or by gnawing bark. Late freezes in the spring can also damage the opening buds of black walnut [USDA Forest Service, 1990].

Because of its economic value, back walnut is growing in popularity as a plantation tree.

Black Cherry: Black cherry *(Prunus serotina)*, known for its lovely reddish wood, occurs in most of Wisconsin's mixed or deciduous upland forests. It is harvested and used for furniture or veneer. Black cherry is also important to wildlife. Songbirds, squirrels, deer, turkey, mice, moles, and other species eat the cherries in the fall. Humans also eat the fruit—generally made into jelly or wine. The bark is used for cough medicines [USDA Forest Service, 1990].

In 1996 there were 133 million cubic feet of black cherry growing stock in the Southern Broadleaf Forest, a 50% increase over the figure for 1983. Between 1983 and 1996, black cherry grew at an average net annual rate of 4.1 million cubic feet in southern Wisconsin. About half of that was harvested.

Black cherry is susceptible to a number of mortality factors. Fire will kill it, but unless it is a very hot fire, black cherry is likely to sprout from its surviving root stock. Porcupines and deer can cause damage by feeding. The eastern tent caterpillar and the cherry scallop moth are both insects that can damage black cherry trees.

Often, black cherry can be identified by the black knot fungus that causes elongated black swellings several times the diameter of an infected twig and large swellings of the trunk. Although still useful for wildlife and ecosystem functioning, black knot can make the tree unusable for commercial projects [Marquis, 1990].

Elm-Ash-Cottonwood

There are a half million acres of elm-ash-cottonwood forests in Wisconsin's southern forests. Characteristic tree species in the elm-ash-cottonwood forest type include red maple, silver maple, black ash, green ash, American elm,

John Kotar

Elm-ash-cottonwood is a lowland forest type occurring along rivers and streams in southern Wisconsin. This type includes bottomland forest types, as shown in this picture, which flood periodically

Common plants in elm-ash-cottonwood forests

Woody plants

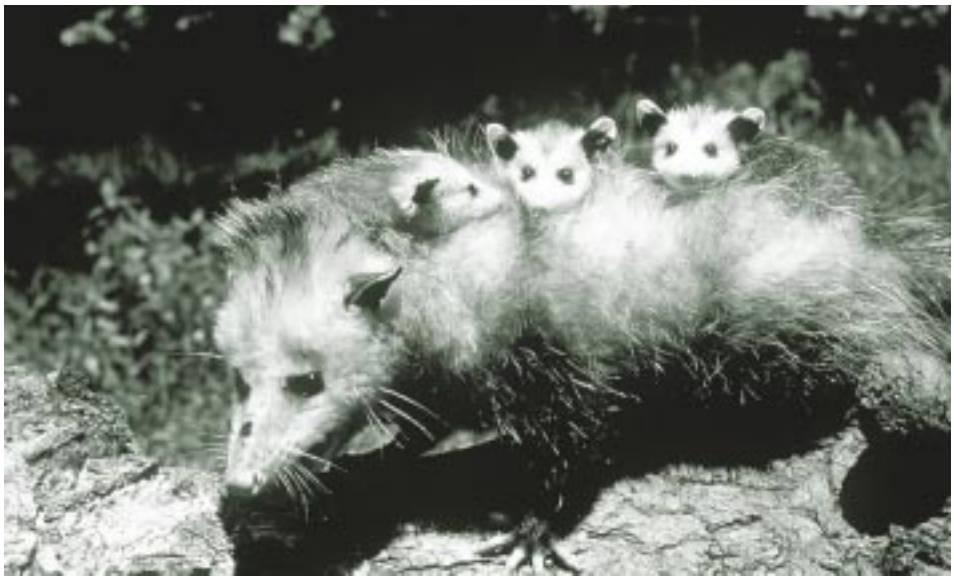
- red osier dogwood *(Cornus stolonifera)*
- buttonbush *(Cephalanthus occidentalis)*
- wild grape *(Vitis riparia)*
- Virginia creeper *(Parthenocissus quinquefolia)*
- moon seed *(Menispermum canadense)*
- wahoo *(Euonymus atropurpurea)*

Non-woody plants

- false nettle *(Boehmeria cylindrica)*
- fringed loosestrife *(Boehmeria cylindrica)*
- orange jewelweed *(Impatiens capensis)*
- wood-nettle *(Laportea canadensis)*
- green dragon *(Arisaema dracontium)*
- clearweed *(Pilea pumila)*
- sedges *(Carex* spp.)
- grasses (many genus)

Common wildlife in elm-ash-cottonwood forests

- white-tailed deer
- gray squirrel
- great blue heron
- barred owl
- red-bellied woodpecker
- red-shouldered hawk
- blue-gray gnatcatcher



DNR Photo Archives

Opossums, nocturnal marsupials, are common throughout Wisconsin, especially in the elm-ash-cottonwood forests.

quaking aspen, river birch, swamp white oak, black willow, eastern cottonwood, and boxelder. American elm—once a primary indicator of these moist, riverine forests—has been greatly reduced in Wisconsin (and the rest of the eastern United States) by Dutch elm disease.

Statewide, cottonwood, willow, balsam poplar, river birch, and black ash all have their greatest volume in the elm-ash-cottonwood forest. By volume, the most important species in the elm-ash-cottonwood forest of Wisconsin are red maple, black ash, green ash, silver maple, quaking aspen, northern white cedar, balsam fir, and American elm. Quaking aspen is discussed under the aspen-birch forest type in the Northern Mixed Forest section. Northern white cedar and balsam fir are discussed under the spruce-fir forest type heading in the Northern Mixed Forest section. Cottonwood, willow and balsam poplar contribute only small volume to Wisconsin's forests; they will not be discussed separately. The rest—red maple, the ashs, and American elm—will be discussed in this elm-ash-cottonwood forest type section.

Elm: The American elm *(Ulmus americana)* has had one of the most dismal recent histories of all of Wisconsin's tree species. Dutch elm disease was introduced to the United States in the 1930s. It is a fungus, and can be transmitted either through insects or through the roots of a neighboring tree. Although isolated large individuals and trees under 25 years old are still found in Wisconsin, there is significantly less elm in the state's forests than there once was. It is hoped that the remaining elms may have some resistance to the Dutch elm disease fungus.

In addition to the American elm, there are two other elm species in Wisconsin—the slippery elm *(Ulmus rubra)* and the rock elm *(Ulmus thomasii)*. Both are susceptible to Dutch elm disease and have experienced much the same fate as the American elm.

In 1996, there were 126 million cubic feet of American elm growing stock in the state. This was a significant increase over the 75.7 million cubic feet present in 1983. However, most elm are in very young forests as Dutch elm disease doesn't usually manifest until trees are older.

Between 1983 and 1996, American elm average net annual growth was about 6.3 million cubic feet. About 1.8 million cubic feet were harvested annually.

Ash: The three ashes—black, white, and green—vary considerably in their preferred sites and uses. White *(Fraxinnus americana)* and green *(Fraxinus pennsylvanicum)* both prefer well-drained soils, with a neutral to alkaline pH, whereas black ash *(Fraxinus nigra)* is very tolerant of a wide range of pH conditions and found with pH anywhere from 4.4 to 8.4, most often in northern Wisconsin [USFS, 1990].

White and green ash wood, resilient and strong, is used for tool handles and baseball bats [Kennedy, 1990], furniture and flooring, and is one of the most popular street trees in Wisconsin. Black ash is not generally used for lumber or other products, although some specialty products like baskets may utilize black ash [USFS, 1990]. White-tailed deer feed on twigs and seedlings of all three ash species.

In 1996, there were 34 million cubic feet of black ash growing stock in southern Wisconsin. This was a decrease of 4 million from the 38 million present in 1983. Between 1983 and 1996, white and green ash increased from 75.3 million cubic feet of growing stock to 146.6 million cubic feet.

Average net annual growth of black ash between 1983 and 1996 was about 1 million cubic feet, about half of which was harvested. During the same period, white and green ash grew a net annual average of 5.9 million cubic feet, of which 3.6 million was harvested.

Red Maple: Red maple *(Acer rubrum)* is more common now than it once was. The virtual elimination of American elm due to Dutch elm disease, and American chestnut by chestnut blight, the control of fire, combined with the selective harvest of yellow birch and sugar maple, has allowed red maple to become a dominant or common associate in many areas where it historically was not.

Although not as valued as sugar maple for timber, red maple is important to the pulp industry and is also used for furniture. It can be tapped like sugar maple, and its sap boiled into sweet, amber-colored syrup. Because of its beautiful fall leaf color and pleasant shape, red maple is often used as a landscaping tree [USDA Forest Service, 1990].

In 1996, there were 212 million cubic feet of red maple growing stock in Wisconsin's southern forests. This was an increase from the 1983 figure of 120 million. Between 1983 and 1996, about 25% of the 8 million cubic feet of net average annual growth was harvested, leaving 6 million cubic feet to add to the forest's overall volume.

Many species of wildlife use red maple for food or shelter. White-tailed deer especially browse on twigs and seedlings.

Savanna

A *savanna* is an ecosystem that is transitional between the eastern forests and the western prairies, having a mosaic of plant communities that represent a continuum from prairie to forest. Grasses and other forbs share dominance with scattered trees and shrubs. Historically, savannas were maintained by periodic fire. A number of understory species are more frequent in savannas than in either prairie or forests. Wisconsin savannas have been called, among

other names, oak openings, oak barrens and oak woodland. Currently there are approximately 500 acres of good quality oak savanna remaining in the state, with some other areas having potential for restoration [Hoffman, in press]. According to the Wisconsin's Natural Heritage Inventory, oak savanna is among the most threatened ecosystems in the world [Noss, LaRoe and Scott, 1997].

Important tree species in oak savanna are burr, black, red and white oak [Curtis, 1959].

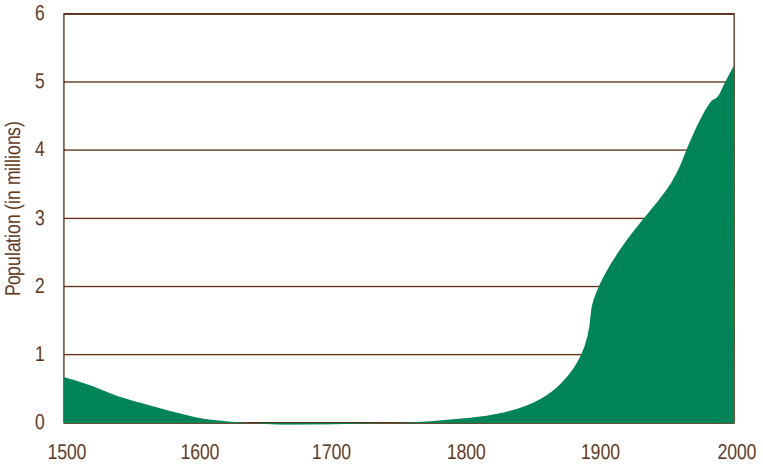


Figure 22

Wisconsin population over time

Changes in Tree Composition and Abundance

Like their northern counterparts, Wisconsin's southern forests have experienced steady change in composition, structure, and function since European settlement. Throughout that time, the area has experienced ever-increasing human population growth combined with increasing demands for resources. Meeting those demands has required converting forestland to agricultural and urban development.

Unlike the Northern Mixed Forest that was cutover in the late 1800s and early 1900s for timber, in general, the Southern Broadleaf Forest was cleared for agriculture. This distinction is important when looking at the events following the Cutover. In the north, although agriculture was attempted after the timber harvest in some areas, the land was not well-suited to most crops and the effort was abandoned. Thus, the forests were able to regenerate, and today northern Wisconsin has approximately the same area of forestland as before the Cutover. However, with the exception of marginal cropland and pastureland, southern agricultural land has been retained for crop production and has not converted back to forest, savanna, or prairie.

The most striking change that has occurred in the Southern Broadleaf Forests of Wisconsin over the last 150 years is the dramatic fragmentation of the forest. The average size of forest parcels in southern Wisconsin is only 47 acres [DNR, 1995]. The average size of privately held forest parcels is just slightly over 30 acres in southern Wisconsin [USFS, 1997]. The remaining larger areas of forest

DNR Photo Archives

The average size of a forest parcel in southern Wisconsin is 47 acres. Fragmentation is a major concern in the Southern Broadleaf Forest.

DNR Photo Archives

There are now only 500 acres of savanna remaining in Wisconsin. Historically, there were as many as 5.5 million acres.

were not converted to farms or cities by virtue of their dry, nutrient-poor soils in the Central Sands or their steep slope and resulting inaccessibility [DNR, 1995].

It is not likely that the extent of southern forested land will undergo any dramatic increase in the near future. However, the composition and distribution may well be altered. Forestland in southern Wisconsin has increased somewhat from 1968 to 1996. However, this trend may change as the population increases and there is more development pressure.

Savanna communities have experienced even more significant change than the southern region's forests. In acreage, Wisconsin's savannas have decreased

DNR Photo Archives

When fire suppression began, areas that were savanna or prairie converted to dense oak woodlands like this one.

to just one tenth of 1% of what was present in the 1850s. There was once 5.5 million acres of savanna in southern Wisconsin. There are now only about 500 acres.

In presettlement times, savannas were maintained by frequent fires and large, grazing herbivores such as bison. The climate of southern Wisconsin receives much more rain than other areas where there was historically savanna. That is one reason researchers now believe that Native Americans were responsible for fire management that maintained the savannas of southern Wisconsin. Both fire and the presence of large grazing ungulates prevented most trees from growing large and provided opportunity for grass species to flourish between scattered oak trees. When these forces were removed, the areas that were savanna were either plowed under for agriculture (the majority) or became denser oak forests (limited to old pastureland or steep hillsides), many of which have succeeded to a mixed hardwood forest.

Biodiversity

Note: Due to the lack of a regional ecological assessment for southern forests (see note on page 37), less information is available on biodiversity of southern forests than northern forests.

Southern forests and savannas have been impacted enormously by fragmentation. Those forested areas that have survived intact did so mainly because they are on dry nutrient-poor sites or on steep hillsides. Intact savanna areas are limited to protected lands. Biodiversity concerns in the southern region of Wisconsin focus on loss of habitat and ecological communities and on a number of species of concern.

Ecosystem Diversity

Almost all of the forest communities of the Southern Broadleaf Forest have experienced significant change in diversity since European-American settlement. Much of the land that is now forested in the southern region was savanna before people began to suppress fire.

One of the major differences in today's Southern Broadleaf Forests in Wisconsin and those of the 1850s is the importance of oak species. The clearing and fires of European-American settlement encouraged oaks to colonize disturbed areas. Subsequently, people removed fire from the southern region to protect lives and property. Dense oak forest grew. Currently, as forests age the shade-intolerant oaks are beginning to be replaced by more shade-loving species like sugar maple on more mesic, nutrient-rich sites.

Some areas that were formerly savanna converted to dense oak forests after the beginning of fire suppression activity. In the short-term, these areas, without a shade-tolerant hardwood seed source, will likely convert to other southern hardwoods.

A great deal of current agricultural land and the forests that remain in the southern region of Wisconsin occur on land that was formerly savanna. Savanna was first cleared for agriculture. Usually because fertility was lacking, a small portion of this land was allowed to go fallow. Without fire or grazing of large herbivores like bison, instead of reverting to its former savanna cover type a dense oak forest grew. Most of the areas that were forest before European-American settlement were more fertile and remained agricultural land [DNR, 1995].

Plant Diversity

The southern region of Wisconsin has lost a number of individual species. Many others are endangered, threatened or of special concern (see Appendix 2). Many forest and savanna plants in the southern region are threatened.

Many plant species that were probably savanna specialists are now uncommon and are found only on the fringes and openings of oak woods, brushy areas, and lightly grazed pastures. Some examples are yellow pimpernel, pale Indian plantain, woodland thistle, downy wild rye, elm-leaved goldenrod, New Jersey tea, sessile-leaved eupatorium, and horse gentian.

Animal Diversity

Almost the entire forest habitat in the southern region is in patches of less than 125 acres. However, this limited habitat seems to be supporting most of the species found at the time of European-American settlement. Some notable exceptions are the extirpation of most large carnivores and grazing herbivores (coyote and white-tailed deer being excepted). Bison, elk, cougar, and bobcat are no longer present in southern Wisconsin. Some large carnivores, such as wolves, are returning [DNR, 1995].

There have been relatively few population surveys or other studies regarding mammals in the southern forests. However, it appears that, in general, small mammals have weathered the changes in the forest community fairly well. Small mammals like mice and voles have increased, and their associated predators also seem to be doing well. Various bats and fox squirrels are some species of concern.

Although most species of birds native to Wisconsin are still present, bird populations have been impacted by the same human forces mentioned earlier—namely habitat fragmentation and loss. There are many birds that require

Dean Tvedt

Most animals, like this cottontail rabbit, have a secure future in Wisconsin's Southern Broadleaf Forest.

DNR Photo Archives

A savanna species, the ornate box turtle is endangered in Wisconsin.

large areas of forest for their habitat—at least a dozen species that require more than 40 acres, and at least five requiring over 200 acres [Ambuel and Temple, 1982]. The average size of southern Wisconsin woodlot is now about 47 acres. Consequently, many of these area-sensitive, interior-dependent songbird species are decreasing and undergoing population declines.

Change in structure in southern forests caused by over-grazing, logging, cutting and gathering firewood can also impact bird populations. Insect and foliage feeders that rely on the understory in forests for their sustenance may be deprived of a food source. Nesting sites for cavity-nesting birds may also be removed through logging and fire-wood gathering [DNR, 1995].

Amphibians and reptiles, as in the northern forests, have not been thoroughly studied. Denning snakes, like the endangered massasauga rattlesnake, are threatened by encroachment on hibernating sites (hibernaculums) and fragmented and altered habitat. Many amphibians are reliant on vernal ponds for breeding habitat and are very sensitive to changes in forest structure.

Although work has been done on invertebrates of non-forested communities in southern Wisconsin, there is little information about the diversity of these species in the Southern Broadleaf Forest region of the state.

Richard Rideout

The urban forest consists of the trees, other vegetation, buildings and people that make up an urban landscape. Kilbourn Ave., Milwaukee.

Urban Forests

The urban forest is all of the trees and other vegetation in and around a city, village, or development. Traditionally, it has meant tree-lined streets, but an urban forest also includes trees in home landscapes, school yards, parks, riverbanks, cemeteries, vacant lots, utility rights-of-way, adjacent woodlots and anywhere else trees grow in and around a community. It is important to remember that this forest is a complex network of green space, extending beyond property lines and involving many, many different landowners.

The trees in an urban forest may be native remnants preserved during development, but more often, they are deliberately planted. Species range from naturally occurring Wisconsin natives, to cultivated varieties, *cultivars*, of native species, to exotic species from other parts of the country and world. For example, the most common tree in the city of Milwaukee is green ash, a Wisconsin native, though many are cultivars such as 'Marshall's Seedless', 'Summit', or 'Patmore'. The most common street tree in Milwaukee, however, is Norway maple, a European native.

Like other forests, the urban forest is not merely composed of trees. Other vegetation, wildlife, and humans are also a part of the urban forest complex. Gardens, shrubs, natural forbs, and lawns all contribute to the larger forest. Songbirds, small mammals, herptiles, insects, fungi, and other microorganisms also play a role.

However, in an urban forest the most influential organisms are humans. Humans plant trees. We build roads, office complexes, strip malls, houses, and parking lots. We prune shrubs and mow lawns. We compact soil and release pollutants into the air and water, apply pesticides to our yard and trees. We salt the roads, sidewalks, and driveways during the icy winter months. All of these activities have a profound effect on the urban forest.

Benefits of Urban Forests

Urban forests serve many of the same functions as other forests. They affect natural systems, like the water cycle and nutrient cycle. Urban forests are markedly important when considering phenomena like storm water run-off and the urban heat-island effect. A large tree canopy softens the blow from a downpour, allowing rain to soak gradually into the ground reducing flooding, pollution, and sedimentation in rivers and lakes, and recharging local aquifers. Trees and green space affect energy usage by converting sunlight into stored energy instead of heat, providing direct cooling through transpiration and evaporation, and by shading and insulating buildings. This reduces the need both for heating and air conditioning which in turn reduces pollution from burning fossil fuels.

In addition to ecological value, urban forests provide resources for people who live among them. Trees contribute to a sense of community. They muffle noise and provide places to rest, meet, and socialize. Trees increase property values by 5 to 20% [Dwyer, 1995]. People linger and shop longer along tree-

Robert Queen

Urban trees muffle noise, increase property values, and enhance urban dwellers' quality of life.

lined streets. Apartments and offices in wooded areas rent more quickly, and have higher and longer occupancy rates. Businesses leasing office space in wooded areas find their workers are more productive and absenteeism is reduced [USDA, 1990]. Tourism is likely impacted by the "greenness" of a community. Studies have even shown that a "relaxation response" evoked by treed landscapes have a positive correlation to physical health and may even reduce incidences of violent behavior [Ulrich 1991; Sullivan and Kuo, 1996].

Urban Forest Assessment

Defining precisely the boundaries of the urban forest is difficult however, because the change between urban and rural land is gradual. In addition, there are urban developments in otherwise rural townships, along rivers, and particularly around lakes.

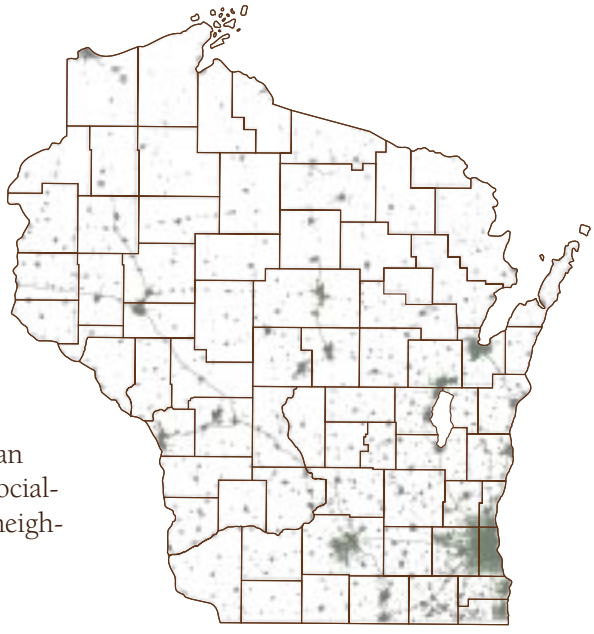
In an effort to define the extent of the urban forest and assess its composition, the DNR, in conjunction with the University of Wisconsin-Stevens Point (UWSP), did an analysis of Wisconsin's communities and developed areas.

According to the DNR/UWSP analysis, Wisconsin has about 875,000 acres of developed land. Cities and villages have an additional 840,000 acres of undeveloped land within their boundaries, giving a total urban forest area of about 1.7 million acres or 4.7% of the total land area in Wisconsin.

Urban forests are more difficult to assess than other types of forests. Many of the functions and resources of the urban forest are intangible and therefore difficult to quantify. What is the value of urban wildlife habitat, for example, or of having a green space in which to socialize? Additionally, people are not used to considering their backyard, neighborhood boulevards and parks, a forest system.

Figure 23

Map of Wisconsin's urban forests (cities, villages, and developed land)



Richard Rideout

The average percent canopy cover in Wisconsin's urban forests is 29%.

Until recently, urban forest assessment was limited to public tree inventories which typically measure tree number, species, size, location and condition of trees in community rights-of-way and green space. Many Wisconsin communities have performed such inventories and used the information to develop and implement urban forest strategic and management plans. As a result, management has steadily improved since 1991 when the DNR began assisting communities in building sustainable tree care programs. During that time, the number of Wisconsin communities providing management for their community trees has more than doubled from 106 to 266.

Richard Rideout

In 1996, Milwaukee's urban forest saved the community over 17 million dollars in flood control, reduced energy, and carbon sequestration. Hyatt Regency, Milwaukee.

Sometimes a monetary value of the trees can be calculated. However, this value is based on casualty loss of the individual trees and does not consider the collective value of the forest. Public tree inventories are an important start, but with public land making up only 10 to 15% of a community's land area and with developed land outside community boundaries being ignored completely, the usefulness of such inventories is severely limited.

The fundamental characteristic now used to assess the entire urban forest is canopy cover. This is a measure of the combined expanse of tree crowns within a community. Increased canopy cover results in greater cooling, greater storm-water mitigation, greater air cleansing, and higher property values. It is also useful as a broad planning tool, showing landscape scale features, and allowing a community to set long-term management goals.

Within a community, canopy cover varies from nearly zero in high-density business or industrial land-use types to more than 75% in low density residential development in mature woodlands. The average canopy cover also varies among regions of the state. In southern Wisconsin, there is less canopy cover since most of the urban development has been in formerly agricultural lands, previously cleared of trees. In northern Wisconsin however, development has expanded into forested land resulting in more urban tree canopy.

In Wisconsin, the average percent canopy cover for developed areas statewide is 29%. Wisconsin's northern region averages 38% canopy cover for its developed areas, while the south central region averages 26% [Miller & Olig, 1999]. The amount of canopy also varies within a community and that variation differs among the state's regions as well. In most communities, the majority of the land area has 25% or less tree canopy cover and very little area with greater than 75% cover. However, as you move generally from southeast to northwest in the state, the percent of the community with little canopy decreases and the percent of the community with heavy canopy increases.

Richard Rideout

As Wisconsin becomes more urbanized, urban forests and green space will become ever more important.

Table 3: Distribution of canopy cover within Wisconsin communities

Region	<26%	26-50%	51-75%	>75%	Average
Northeast	63%	23%	10%	4%	26%
South Central	62%	27%	8%	3%	26%
Southeast	60%	27%	8%	5%	27%
West Central	51%	26%	14%	9%	33%
Northern	42%	29%	18%	11%	38%
Statewide	58%	26%	11%	6%	29%

In addition to assessing canopy cover, new modeling techniques are allowing resource managers and community leaders to estimate some of the economic benefits of the urban forest community. Current models measure the benefits realized in reduced flood control devices, energy savings by reduced need for both air conditioning and heating, and pollution control. In 1996, an ecological analysis of the city of Milwaukee showed that its urban forest reduced the need for flood control devices, saving the city an estimated $15.4 million. Reduced energy needs annually saves $650,000 and carbon sequestration (air pollution mitigation) saves $1.5 million per year [American Forests, 1996].

The DNR/UWSP study was the first statewide study of its kind on such a detailed level, but it's only a beginning. Future assessment models for the urban forest will focus on additional landscape scale ecological characteristics and on urban forest sustainability. Research is currently under way to establish state and local goals for canopy cover, species diversity, age structure, location distribution, and overall health of Wisconsin's urban forests. The intent of this work is to provide urban natural resource managers with tools to assess their community and to develop a strategic plan to achieve sustainability.

The Ever-Changing Forest

Wisconsin's forests—in the north and the south—are changing all the time due to growth of the forest, natural succession as forests mature, and disturbance from human actions, fire, weather, insects, diseases, and wildlife impacts. These are some of the dynamic forces at work in forests, and they have been part of forest ecology for many thousands of years. Disturbance changes the forest's composition, structure and function. Different types, intensity, and frequencies of disturbance influence and change forest diversity at the genetic, species, ecosystem and landscape scales.

DNR Photo Archives

Fire is an important disturbance factor in forest systems. Protecting lives and property from fire has changed fire's impact on Wisconsin's forests.

Fire

Historically, fire was an important natural disturbance factor in Wisconsin's forests, both north and south. However, in the last 50 years, fire has been largely eliminated from the forest. In addition to protecting human lives and property from the effects of fire, this has also resulted in many significant changes in forest ecosystem composition, structure and function. Fire protection remains very important to people owning or living near forests. However, there is increasing awareness of the ecological importance of fire and more planned, managed fires are occurring in restoration areas.

Some ecosystems—such as oak savannas, barrens, and prairies—require fire to regenerate and maintain their species composition.

In the southern region of Wisconsin, fire was considered the most significant disturbance factor in pre-European settlement times. In the north, fire shared dominance with wind as significant disturbance factors. The aspen, pine, oak and birch forests in Wisconsin before the 1850s were a result of fire [USFS, 2000].

Although forest fires are now much less frequent than in the early 20th century, there are still many fires each year. Between 1992 and 1996 about 1,528 wildfires occurred each year, burning approximately 2,658 acres/year. Most fires are started by humans. The most common cause of wildfire is debris burning, followed by equipment use, and arson. Lightening causes just 1% of all of Wisconsin's wildfires. Wildfires are most likely to occur in the spring and early summer, from March to July, with April being the most likely month for wildfires [WDNR, 1998].

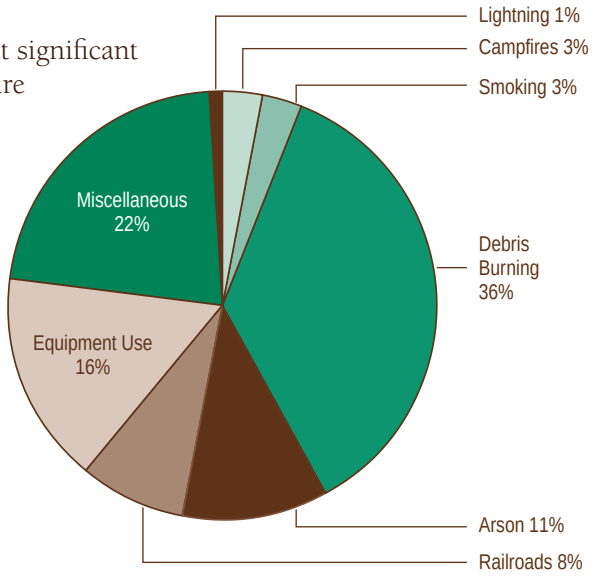


Figure 24

Causes of forest fires in Wisconsin in an average year

Paul DeLong

Forests help maintain water quality by preventing erosion. Use of Best Management practices ensures that forestry activities do not contribute to nonpoint source pollution.

Hydrology

The state of Wisconsin has over 30,000 miles of rivers and streams and over 15,000 lakes. The glaciation of northern Wisconsin is responsible for creating the rich legacy of waterbodies and wetlands in our present landscape. Differential erosion of bedrock, irregular deposition of sands, gravels, silts, and clays, and the melting of ice blocks stranded by the retreating glacial ice left a landscape containing numerous lakes and streams. Covering an area missed by the glaciers in southwest Wisconsin is the Driftless Area, distinguished by classic dendritic stream patterns, few natural lakes, and sharper, more eroded terrain.

In general, forests help maintain water quality by holding soil and preventing erosion. Most of the highest quality streams and lakes in the state are in forests. However, there is the potential for nonpoint source pollution from forestry practices affecting the state's water resources [WDNR, 1995]. Nonpoint source pollution, which accounts for about half of all pollutants entering our nation's waters, occurs when water from rainfall or snowmelt moves across the ground, transporting pollutants into streams, lakes, wetlands, or groundwater. For example, soil becomes a nonpoint source pollutant when water erodes the soil and carries it to a stream. Eroded soil is the primary pollutant associated with forestry activities. Many uses can cause nonpoint pollution, including agriculture, mining, construction, urban and rural development, and forestry. In Wisconsin, it is estimated that only 3% of nonpoint pollution come from forestry practices. While forestry's contribution sounds small, localized impacts can be significant, such as logging road erosion into a trout stream.

Wisconsin's forestry best management practices (BMP's) for water quality are voluntary guidelines to help loggers, landowners and natural resource managers minimize nonpoint source pollution during forestry operations. The use of BMP's is a practical and cost-effective way to ensure that forestry activities do not harm water quality.

Severe weather

Weather has a profound impact on Wisconsin's forests. Over long periods of time, weather forms the climate of an area. Climate is a primary determinant of the type of ecosystem developed in an area. Climate has changed and will continue to change over time. Warming or cooling will impact the composition and distribution of the forest. Since these changes usually occur over longer periods of time, this report will only discuss severe weather events. In forests, severe winters, drought, and windstorms perpetuate dynamic cycles.

Wind events, which cause phenomena aptly called forest blowdowns, are very significant sources of disturbance. For example, on May 31, 1998, a "derecho," a widespread, straight-line wind event, moved through parts of southcentral and southeast Wisconsin—the most damaging straight-line wind event to hit Wisconsin in 100 years. Hurricane-like winds, with gusts up to 100 mph, ripped through 12 counties in that part of the state. Thousands of large trees were uprooted, twisted, broken off, and downed by the winds. Usually, wind events are less dramatic, however they do account for much of the disturbance in Wisconsin's forests. Ice storms, hail storms and tornadoes also influence forests. Severe weather events can occur on a statewide scale, like

Robert Queen

Wind can cause damage to individual trees, or to large areas of forest. Wind storms are common damaging agents in Wisconsin.

those mentioned above, but they are more common on local scales and impact Wisconsin forests on a regular basis.

Severe or unseasonable cold can also impact trees and forests. Hundreds of maples (sugar, red and Norway) died because of an extreme cold snap—as low as minus 56 degrees Fahrenheit—in February of 1996. Unseasonable cold during the spring also affects trees. It is believed that cool temperatures combined with high winds result in oak tatters, a condition resulting in oaks producing small, "chewed up" leaves in the spring. This can result in decreased vigor.

Drought can also have a significant impact on forests. The drought of 1988 and 1989 is responsible for much of the mortality of paper birch seen in the last decade. Drought-stressed trees were not able to survive the ensuing insect stress.

Herbivory

Whitetail deer and snowshoe hare are important species in Wisconsin's forests. Like most forest animals, they are herbivores—they eat plants. Usually herbivores help to maintain natural ecosystem functioning and enhance the health and quality of Wisconsin's forests. However, in especially snowy winters, or when populations are very high, deer and hares can cause damage to the forest.

Whitetail deer

White-tailed deer is a keystone species in Wisconsin's forests. Deer are a generalist species, living in almost all of Wisconsin's terrestrial ecosystems, although they are more common in open areas and early successional forests. They eat a wide array of plant species, both woody and herbaceous. Favorite woody species include northern white cedar, eastern hemlock, basswood, white pine, yellow birch, sugar maple, red maple, aspen, oaks, white ash, and shrubs such as Canada yew, brambles, mountain maples, dogwood, viburnums, and hazel. Those which are known to be very sensitive to deer browse include northern white cedar, eastern hemlock, yellow birch and Canada yew. Deer also eat many herbs. In addition to grasses and sedges, deer eat at least 70 plant genera. [Christoffel, 1998 and Vander Zouwen et. al., 1995].

Darrell Zastrow & David Schultz

This northern white cedar enclosed in the fence was protected from whitetail deer and snowshoe hare. The area adjacent to the fence was browsed clean of cedar.

Keith McCaffery

High concentrations of deer can severely damage forest vegetation. In severe winters, many deer starve after eating all available vegetation, except when they are fed by humans. Ashland.

Deer have been shown to have significant impact on rare, threatened and endangered plant species. Rare orchid and lily populations have been documented casualties of deer herbivory [Waller et. al., 1997].

Deer have a direct effect on individual plants, but their effects on an entire ecosystem can also be significant. They can influence the future fertility of the soil by selecting for certain species against others, and the long-term reproductive capacity of various plants can also be affected. Once changes in the vegetation have occurred, changes in animal species may follow, as do changes in ecosystem function. For example, by over-browsing understory, deer can

remove cover and food sources for songbirds. When songbird populations decrease, predator populations are also likely to decline [Vander Zouwen et. al., 1995].

Snowshoe hare

Like deer, snowshoe hare is a generalist species. Hares thrive in many different types of habitat, especially edge habitat. Snowshoe hares have a 10-year population cycle, reaching a peak and then tapering off every decade. Bobcat and other predators hunt and feed on hare, and along with winter hardship are the primary check on hare populations.

In summer, snowshoe hares are a soft brown and feed on a wide variety of grasses and understory plants. Grasses, clover, dandelions, raspberries, and blackberries are favorite hare fare. When snow covers their usual summer browse, the winter white hares turn to trees for sustenance. They eat a variety of buds, twigs, and bark of broadleaf trees. Aspen, willow, birch, maple, sumac and alder are frequently eaten by hares. However, their preferred winter forage is conifers. Balsam fir, northern white cedar, eastern hemlock, spruces, and white pine are sought out by hungry hares.

In the forest, hares maintain open understory conditions. They can help renew the soil, and their nibbling can even encourage new growth, especially on undergrowth species. However, if local hare populations are very high, or if it's an especially hard season, hares can do significant damage to the forest. Hares are so voracious and prolific that they can chew away conifer regeneration, especially in nurseries or plantations where young trees are concentrated. Hare herbivory can prevent regeneration of these conifer forests after harvest, or disrupt other reforestation efforts.

DNR Photo Archives

Snowshoe hares are found in all forest types in northern Wisconsin.

Exotic species

Exotic species are those that have been introduced from beyond Wisconsin's borders. Often these exotic species are brought from other areas of the world. Wisconsin's forests have been assailed by a variety of introduced exotic species that have caused major disturbance in the forests. Exotic species can overwhelm the ecological capability of an area because they have not developed in conjunction with the natural ecosystem and there are frequently no checks on their populations. Exotic species can sometimes out-compete and crowd out native species, or infest local trees. Dutch elm disease, chestnut blight, the European gypsy moth, and the Asian long-horned beetle are some of the major exotic threats to Wisconsin's forests. In addition, plants such as garlic mustard and multiflora rose can completely take over a forest understory, effectively eliminating native plants from the area.

Biodiversity

Biodiversity has also changed over time and will continue to change. It is important to recognize this change from the past in order to provide stewardship to Wisconsin's biodiversity. The following information provides a summary of changes that have occurred and the general status of our knowledge.

Robert Queen

Forest biodiversity encompasses a wide array of species—plants, animals, and the less familiar fungi, bacteria, and protozoa. Shaggy mane mushroom.

DNR Photo Archives

The Karner blue butterfly is an endangered species that depends on wild lupine growing in young forests, barrens, savanna, and prairie. Management techniques focusing on maintaining disturbance-dependance habitat will help this species.

About 40 distinct Wisconsin terrestrial communities were described by John Curtis in the 1950s [Curtis, 1959]. Most of these are intact. However, savanna and barrens have experienced striking decline. Both savanna and barrens communities are listed on the globally recognized Natural Heritage Inventory's list of most threatened ecosystems (see Appendix 1).

Forests that have never been disturbed are also increasingly uncommon. In 1995, Frelich estimated that 58,500 acres—less than .4%—of Wisconsin's forests had not experienced severe human disturbance since European settlement. Seventy-nine percent of this area is white cedar forests; another 10% are black spruce-tamarack forest [Frelich, 1995].

There are estimated to be about 2,300 species of vascular plants in the state of Wisconsin. About 1,800 of these are native to the state, 22% are believed to be introduced exotics.

Six hundred fifty-seven species of vertebrates live in the state. In addition to these fairly conspicuous species, there are also thousands of species of non-vascular plants and invertebrates, as well as fungi, bacteria, and protozoa—most of which have not yet been adequately described or researched.

Human activities since European-American settlement have dramatically altered the distribution and abundance of many species. As of 1998, there were 241 species listed on the state's endangered or threatened list, and 15 Wisconsin species are on the federal endangered or threatened list (11 species appear on both lists). Of the plant species listed, 28% are forest species, all of the listed mammals are forest species, 50% of listed bird species are forest species, and 40% of listed reptiles and amphibians are forest species.

Two species were hunted to extinction—the passenger pigeon and the Carolina parakeet. Other species were extirpated from the state. Some remain extirpated—bison, wolverine, woodland caribou, Eskimo curlew, and whooping crane. Six have been reintroduced with varying degrees of success—elk, fisher, American marten, trumpeter swan, peregrine falcon, and wild turkey. Two species, moose and timber wolf, have returned to Wisconsin of their own volition. There have also been a few sitings of cougar in northern Wisconsin, although it is thought these animals are probably escapees from domestication.

Robert Queen

Agriculture and urban development have caused severe fragmentation of the state's forests, especially in the southern region.

Ecological Simplification, Fragmentation and Environmental Pollution

Many of the impacts to the forests that have been described so far are naturally occurring events that are part of the ever-changing composition, structure, and function of the forest which do not permanently harm the overall balance of the system. Generally, sustainable forestry practices protect the fundamental vitality of the forest system by safeguarding water quality and ensuring robust regeneration. However, human pressures can fundamentally alter the composition, structure, and function of the forest ecosystem. For example, permanent changes in land-use can result in ecological simplification and fragmentation, while levels of environmental pollution have been increasing in quantities or at rates that may harm organisms, habitats, communities, ecosystems, or human health [DNR, 1995].

Economic and Social Values and Benefits

Debbie Proctor

Forest-based tourism is a powerful economic force in Wisconsin. Newport State Park, Door County.

Economic Values and Benefits

Note: the information for this section comes from Marcoullier and Mace, 1998.

In many parts of the state, forests are essential to economic activity. Tourism and timber production contribute significantly to the state's overall economy. Other, less quantifiable, economic returns of forests include environmental benefits like carbon sequestration, erosion control, and heat mitigation. Forests also have an impact on land values and business recruitment.

Estimating the economic impacts of forest use raises a complex set of issues that are only partially addressed through traditional means. The reasons for this are many. Two primary difficulties specific to forest resources include the simple facts that: 1) forests provide the raw material for a substantial amount of economic activity but they are not the sole input into the production process; and 2) many of the values we associate with forests are of a non-market nature.

In analyzing the contributions of forest resources and activities to economic growth, it has been argued that a more accurate view of the situation could be achieved through a more 'green' accounting structure that integrates the level

Robert Queen

Wood-based industry is very important to the Wisconsin economy, especially in the Northern Mixed Forest. Northern Highland American Legion State Forest.

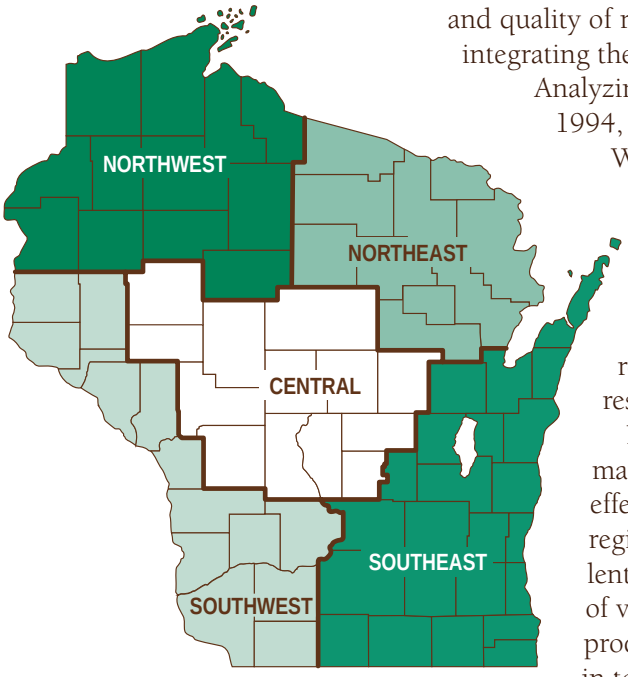


Figure 25

Regional delineations used by Marcoullier and Mace (1998) for their study

and quality of resource stocks into regional economic models. However, models integrating these ideas have not yet been developed.

Analyzing two clearly forest-based economic activities showed that, in 1994, roughly 12% of the Gross State Product and 18% of the jobs in Wisconsin are tied to either wood-based industries or tourism sensitive sectors.

A simple measure of the resource stock can be inferred from the ratio of growth to removals of timber. A value greater than one indicates a growing resource base, less than one indicates a shrinking base. Statewide, Wisconsin's growth to removals ratio is above one. Therefore, we know that the forest resource base is expanding in the state as a whole.

It is clear that forests provide the primary means of support for many families in Wisconsin. Forest-based activities have a dramatic effect on the viability of regional households in both rural forested regions and in regions where wood-based manufacturing is prevalent. The employee compensation (wages paid to workers) portion of value added accounted for approximately 25% of total wood products output and 35% of tourism-sensitive output. Average jobs in tourism-sensitive sectors earned almost $11,000 per year while wood-based industries paid approximately $36,800 per year. These figures are compared to average statewide earnings per job of just under $25,000 per year.

The forest that these economic activities rely on is extremely varied in extent and character throughout the state. It follows that there are significant regional differences in the extent and character of timber-related activity and tourism, as well.

For example, even though much of the reconstituted wood products sector (paper-making) is focused in the southeastern region, wood-products and tourism sensitive sectors account for only about 10% of this region's output. In northeast Wisconsin, on the other hand, almost 30% of the regional output is tied to wood products and tourism. Indeed, the central and northern parts of the state are much more reliant upon wood products and tourism sensitive firms for regional economic activity when compared to the southeastern portion of the state.

Wood-based Industries

Traditionally, forest-based economics has referred to the wood-based industries. Logging and paper-making are intertwined with the state's economic and cultural history. What is now termed the "wood-based industries"—timber production, primary and secondary wood processing and reconstituted wood products production—is still a very important portion of Wisconsin's economy.

Timber production is the growth of trees, the annual output of which is reflected in the stumpage values of removals. Stumpage value is a measure of the pre-harvest value of standing timber. It is the value of the timber to the owner. Primary wood processing begins with timber harvesting (logging) and includes sawmills and other primary log processors. Secondary wood processing includes the value-added sectors of turning dimensional timber into final use products such as wooden cabinets or furniture. Finally, reconstituted wood products include those industries that reconstitute wood fibers into final products, examples of which include fiberboard manufacturing and the pulp/paper industry.

Greatwood Log Homes

The wood products sector that provides products like this log home accounts for 30% of northeast Wisconsin's regional output. Elkhart Lake.

Table 4: Selected characteristics for wood-based sectors in Wisconsin, in millions of dollars *(State of Wisconsin, 1994)*

Industry output	MM$	Employee compensation (MM$)	Employment (# of jobs)
Wood-based sectors			
Timber production	209.001	34.303	3,152
Primary wood processing	956.862	152.635	7,346
Secondary wood processing	3,412.918	954.96	37,925
Reconstituted wood products	10,346.688	2,510.89	50,895
Total in wood based sectors	14,925.469	3,652.788	99,318
Total (all sectors)	242,514.17	76,201.309	3,070,532

In 1994, timber production provided a partial basis for primary, secondary and reconstituted wood products sector activity that accounted for approximately 6% of Wisconsin's gross state product—roughly $15 billion of $242 billion. The bulk of timber production occurs on non-industrial private forest lands with a surprising amount of sawtimber value being realized in the southwestern part of the state.

Over 1,800 companies in the timber industry employ over 99,000 people in Wisconsin, with a total payroll of more than $3.6 billion.

The market value of timber is influenced by the species or type of tree harvested, the size or product class, and the harvest costs. In general, hardwood species are more valuable than softwoods. Some of the more valuable

Table 5: Value of annual timber removals in Wisconsin in millions of 1996 dollars

Ownership type and product class	NW	NE	CTRL	SW	SE	Total
Public forests, federal						
sawtimber	3.063	10.829	0.459	0.0	0.0	14.351
pulpwood	2.216	2.426	0.38	0.0	0.059	5.081
Public forests, state						
sawtimber	0.974	0.648	1.539	0.548	0.0	3.709
pulpwood	0.225	0.406	0.528	0.009	0.0	1.168
Public forests, county						
sawtimber	3.707	1.666	2.376	0.004	0.0	7.753
pulpwood	1.829	2.436	1.715	0.06	0.0	6.04
Private forests, industrial						
sawtimber	2.76	8.481	0.195	0.0	0.0	11.436
pulpwood	1.435	1.5	0.144	0.0	0.0	3.079
Private forests, non-industrial						
sawtimber	11.754	18.828	50.226	51.21	8.369	140.385
pulpwood	4.847	4.457	5.239	1.745	0.701	16.989
Total	32.81	51.677	62.801	53.57	9.129	209.991

Terry Mace

Wood-based industries are an important contributor to Wisconsin's economy.

species include red and white oak, walnut and hard maple. Less valuable hardwoods include aspens, birch, and soft maples. Softwood species (conifers) tend not to vary as much in value from species to species.

Size of harvested trees is another important feature as it determines what uses the timber is suited for. The larger and more valuable size class is called sawtimber, and timber that meets the sawtimber size requirements is used for veneer and dimensional uses. Pulpwood, or poletimber, is the other, less valuable, size class. Pulpwood is used in reconstituted wood products and paper-making.

The cost associated with harvest and marketing is the third element determining timber's value. Generally, transportation cost is the largest determinant in the cost of harvest. This is directly influenced by how far away the timber is harvested from its destination.

Across Wisconsin, there is a wide range of forest management activity and harvesting intensity. The stumpage value of timber harvesting in Wisconsin during 1996 is shown in Table 5. This is shown by product class, land ownership, and region. As can be seen from Table 5, there was roughly $210 million worth of timber harvested during 1996, the bulk (roughly 82%) of which originated from privately owned forestlands.

More specifically, most (91% of the privately owned timber) harvest value in 1996 took place on lands owned by non-industrial private forestland owners. Of the harvest value originating from publicly owned forest lands, federal lands—namely lands managed by the USDA Forest Service—accounted for roughly 50%, county-owned timber harvests made up about 36% and state lands accounted for 14%. For public lands, the highest value from sawtimber came from federal lands, while the highest value from pulpwood came from county lands.

Regional differences were also an interesting feature of removals. Most of the timber stumpage value in Wisconsin during 1996 was removed from lands located in the central and southwestern parts of the state. Certainly, this speaks to the simple fact that value reflects species type and product class. While the forests of the northern part of the state produced the highest volumes, much of what was harvested was of relatively lower value. A good example simply compares the value of aspen and birch (two of the important species of the north) with the value of walnut and oak (two of the important species of the southwest).

Beyond the timber harvest, the value-added wood industries are also important economic contributors to the state. The reconstituted wood products—specifically pulp and paper—dominate with over $10 billion of output and just over 50,000 jobs across Wisconsin. Indeed, Wisconsin is a national leader in the production of tissue products. Timber production and primary wood processing are dwarfed when compared to this highly capital intensive set of industries.

Wisconsin ranks first in the nation in paper production, forest industry value of shipments, and employee compensation. As a result, the United States Forest Service considers Wisconsin the number one state in forest industries.

Tourism

In addition to timber related activities, tourism is the other major forest-based economic activity. The value of forest-based recreation to regional economies focuses on the additional demand for local businesses that occurs when people

DNR Photo Archives

Wisconsin's forests provide opportunities to experience nature personally.

from outside the region visit with the expressed intent of undertaking forest-based recreation. The dollars they spend provide additional opportunities for local businesses. Unfortunately, delineating the specific contributions of forest-based tourism to the overall transportation, retail, and service sectors is difficult. The primary difficulty lies in the fact that these are the same businesses that serve the local population. However, it is generally accepted that certain types of businesses are sensitive to tourism demands, such as transportation, restaurants, gift shops, and hotels, motels and recreational/amusement firms.

Wisconsin households spend over $5.5 billion per year on goods and services associated with forest-based recreation. Of this total spending, roughly $2.5 billion are spent in local regions within close proximity of the recreational site. This provided a significant portion of the receipts of tourism-sensitive sectors in Wisconsin. These sectors accounted for another 6% of gross state product, roughly $14 billion of $242 billion.

With respect to tourism sensitive sectors, tourism retail sectors dominate with almost $10 billion of output and roughly 350,000 jobs. To be sure, the jobs in tourism retail are not the same types of jobs offered by the reconstituted wood products sector. In general, tourism retail jobs are more apt to be seasonal, part-time and pay substantially lower wages than manufacturing jobs.

Table 6: Selected economic characteristics for tourism industry in Wisconsin, in millions dollars *(State of Wisconsin, 1994)*

	Industry output (MM$)	Employee compensation (MM$)	Employment (#of jobs)
Tourism sensitive sectors			
Tourist transport	1,364.252	391.437	27,215
Tourism retail	9,622.395	3,581.742	346,804
Tourism services	2,764.316	876.312	73,240
Total for tourism sensitive sectors	13,750.963	4,849.491	447,259
Total (all sectors)	242,514.170	76,201.309	3,070,532

Recognizing the connectedness of forest-based tourism and the wood-based industries can help managers and planners understand more fully the many economic benefits of the forests.

Social Values and Benefits

Note: The information for this section was taken from Marcouiller, et. al., 1998 and the DNR Draft Statewide Comprehensive Outdoor Recreation Plan, 2000–2005.

In the social and cultural arena, we encounter some of the most deeply felt and complex values related to the forest. These values are difficult to quantify, but not the less significant for their intangible nature. We walk in the crisp autumn air, kicking up sweet wet aspen leaves as we go. We sit silently in tree stands, watching squirrels play tag in an oak, awaiting the arrival of an elusive white-tail. We gather together as families to camp along sparkling streams. We feel pride in knowing that Wisconsin harbors some of the most beautiful forests in the world. We are happy to contemplate our children and grandchildren enjoying the same forests that we cherish today.

Whether through recreation, aesthetic enjoyment, ethnic activities, or knowledge of its existence, countless Wisconsinites value the forests for social and cultural reasons. In surveys conducted by the Wisconsin Department of Natural Resources, our citizens rank the importance of conservation of natural resources and recreation a 9 on a scale of 1 to 10, in front of many other issues on the state's list of priorities. Most of us believe that everyone benefits from conserving our natural resources [WDNR, 1998].

Recreation

Wisconsin forests provide a vast array of recreational opportunities. Some, like hunting and wildlife study, have had a place in Wisconsin since the very first humans arrived. Others, like mountain biking and snowmobiling, are relatively recent phenomena. A large majority of Wisconsin residents participate in outdoor recreation. Wisconsin is a state of hardy outdoor enthusiasts, active throughout the year.

DNR Photo Archives

Hunting has long been one of the most important forest-based recreational activities in Wisconsin.

Activities and People

The most important forest-based recreational activities in Wisconsin are hunting, camping, snowmobiling, hiking, fishing, all terrain motor vehicle (ATMV) use, watching wildlife, off-road biking, cross country skiing, horseback riding, plant collecting, and pack animal use. The people who participate in each activity are referred to as *user groups*. User groups have various characteristics that we can use to help us understand their patterns of use and likely future needs.

What are the people like who use Wisconsin's forests for recreation? Through surveys and other studies, recreation planners have come up with some general ideas about the characteristics of people who use the forests for recreation. Some of these numbers are based on information from DNR's State Comprehensive Outdoor Recreation Plan and refer to characteristics of outdoor recreationists as a whole, including but not limited to forest-based recreationists.

Edwin E. Proutor

Cross country skiing is a popular winter sport in Wisconsin's snow-covered forests.

In general, male outdoor recreationists tend to out-number female 2 to 1.

About 65% of recreationists have some college education.

In general, most people using the forest for recreation are satisfied about issues like rules and regulations and access to public lands.

Recreationists tend to be concerned about issues like trespass, crowding and appearance of timber harvest.

Summer is the most popular season to be out in the forest, followed by fall, spring, and winter.

A person's satisfaction level about their chosen recreation activity is related to accessibility to the activity. If people who like to camp are able to get to a nice campground when they want to, they tend to be satisfied with their experience. If a snowmobiler needs to travel two hours to get to an appropriate trail, they are likely to be unsatisfied with their experience.

Table 7 indicates the most popular, wholly forest-based, recreational activities.

Figure 26

Wisconsin forest recreation by season, 1996

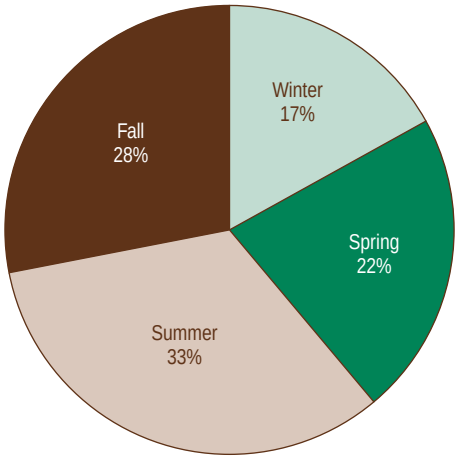


Table 7: Wisconsin forest-based recreation by activity and percent participation, 1998

Activity	Percent	Activity	Percent
Fishing	34.26	Own recreation vehicles	9.21
Wildlife viewing	27.61	Canoeing	8.56
Camping (tent)	26.93	Camping (RV)	5.91
Picnicking	26.69	ATV	5.82
Nature study/Bird watching	21.17	Backpacking, wilderness camping	5.52
Hunting with firearm	19.21	Cross country skiing	5.37
Bird watching	18.41	Mt. biking, off road	4.76
Nature photography	17.03	Horseback riding	4.61
Hiking	13.22	Snowshoeing	1.41
Own a vacation home	12.78	Off-highway vehicle—trucks	0.92
Snowmobiling	10.47	Off-highway vehicle—motorcycles	0.52

Robert Queen

Summer is Wisconsin's most popular season for forest-based recreation like camping.

In addition to those listed on the table, other activities often take place in or are enhanced by, forests. For many people, much of the appeal of pleasure driving, exercise walking, and jogging comes from being in or near forests.

There are some aspects of Wisconsin forest recreation that are changing. People are participating in many new activities—in part due to new products, in part to revival or expansion of existing activities. The following is a list of the forest-based recreational activities enjoying the largest growth.

Robert Queen

Trails offer new opportunities for forest recreation. Biking, hiking, jogging and cross-country skiing are popular trail activities. Bear Skin Trail, Minoqua.

DNR Photo Archives

Forest trails offer opportunities for people of varying abilities to participate in forest-based recreation. Whitefish Dunes State Park.

Trail-Based Activities: One of the most notable recreation phenomena of the 1990s was the growth in the popularity of trails. A number of factors have contributed to this growth, including the conversion of abandoned rail lines to recreation trails and the recognition of trails as a means to connect dispersed recreation sites. The various activities that take place on trails are often vying for the same resource, placing pressure on the trail to provide for multiple uses. Trail activities include exercise walking, bicycling, hiking, in-line skating, running/jogging, roller-skating, mountain biking, all terrain vehicles (ATVs), cross country skiing, horseback riding, snowshoeing, off highway vehicle (OHV) truck driving, and OHV motorcycle driving.

Motorized Users: A trend that is having a major effect on forest recreation is the increasing use of motorized vehicles. Snowmobiles, ATVs, 4x4 trucks, and motorbikes are seen in Wisconsin forests increasingly often. For example, from 1990 to 1997, snowmobile licenses in the state increased 33%, and ATV licenses increased 50%.

Mountain Biking: Another growing activity in Wisconsin and throughout the U.S. is mountain biking. Before the early 1990s, the vast majority of bicycles bought were traditional road bikes. Now, mountain bikes account for 90% of bikes purchased in the United States. The number of cyclists who ride in forests is correspondingly increasing.

Hiking and Backpacking: Hiking and backpacking are perennial forest recreational activities. Participation hit a peak in the early '90s. Since then, they have decreased slightly, but are expected to remain important uses of the forests.

RV Camping: Camping with use of recreational vehicles is increasing. Sixteen percent of Wisconsin adults have expressed interest in purchasing an RV in the next 5 years, and many families with children prefer the amenities of RV camping.

Robert Queen

Snowmobiling and other motorized uses are becoming more popular activities in Wisconsin's forests. Brule River State Forest.

Bonnie Gruber

Horseback riding has experienced a surge in participants. Governor Dodge State Park.

Horseback riding: Percentage-wise, horseback riding has grown phenomenally in the last 5 years. The number of user days increased by 290% from 1992 to 1996. Much of this use is forest trail-based.

Snowshoeing: Snowshoeing is experiencing a revival in Wisconsin's forests. It appeals to summer athletes trying to stay in shape, families that want to recreate in the winter, and people interested in trying "new" activities. Although still a small percentage of total users, this activity has grown significantly.

Kayaking: Another activity undergoing renovation is kayaking. New variations on an old theme, like sea kayaking, boogie boards, and river kayaking, have contributed to explosive growth in this activity. Kayaking, while not an inherently forest-based activity, takes place on rivers that rely on forests for their aesthetic beauty as well as water quality.

User Conflicts

Unfortunately, the wide variety of activities enjoyed by Wisconsin residents sometimes results in user conflicts. Conflicts between motorized and non-motorized users are becoming more important. The interface between passive uses like hiking and wildlife viewing and motorized activities like snowmobiling or ATV use often results in debate.

In addition, various groups have different perceptions about what is compatible with their own recreation style. Usually groups are more tolerant of recreationists enjoying activities similar to their own. For example, a cyclist feels less crowded by other cyclists than the same number of people riding ATVs, and vice versa.

E. Vlack

Conflicts between motorized and non-motorized recreationists are becoming more common, especially where they share trails. Black River State Forest.

Dean Tvedt

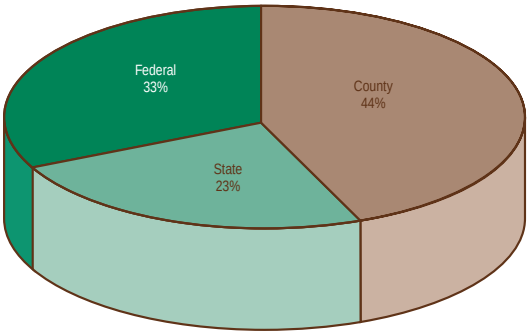
Bow-hunters as well as gun hunters tend to use private land.

Recreational Land and Facilities

Just as the activities that Wisconsin forest recreationists choose to participate in are wide in range, so too is the land and facilities that are used. All classes of ownership, region, and amenity level are represented in the land used for recreation.

Figure 27

Public conservation and recreation land, Wisconsin, 1998



Land ownership

Ownership of recreational land varies from small county parks to the national forests, from large tracts of forest industry land to small private woodlots. Ownership often determines the accessibility of the land for recreation.

The land people use for recreation varies by recreational activity. Non-consumptive users tend to recreate on state land, and overall, state parks are the most popular recreation sites. Hunters tend to hunt on non-industrial private land. Motorized users are also more likely to use private land. However, all groups use a variety of land, and many individuals use more than one site for recreation.

Region

Some regions of the state are preferred over others for recreation sites. This may be due to population, natural features, or built improvements. Often preferences are based on the availability of facilities for particular recreation type.

Southeast: most popular region for recreation; many campers and wildlife watchers; few horseback riders

Southwest: many campers and wildlife watchers; few snowmobilers; very few anglers

Central: popular with almost all groups; many campers and wildlife watchers

Northeast: popular with almost all groups; many snowmobilers, anglers, campers and wildlife watchers; few horseback riders

Northwest: many campers and wildlife watchers; few hikers, off-road bikes, horseback riders, ATV users

State Forests

The northern state forests—the Brule River, the Flambeau River, the Black River, Governor Knowles, and the Northern Highland-American Legion State Forests—provide some of the best opportunities for forest recreation in the state. Many recreationists throughout the year visit these forests. A look at the participation rates for various activities provides a more concentrated look at the state's forest recreation patterns.

Wisconsin forests offer a stunning array of recreational opportunities and provide enjoyment and leisure to millions of people each year. The variety of forest types, ownership, seasons and interests found in this state work in concert to provide quality recreational opportunities for Wisconsin's people.

Table 8: Number of participants in selected activities, northern Wisconsin state forests

Activity	Number of participants in 1997
Family camping	238, 230
Outdoor group camping	6,572
Indoor group camping	1,903
Canoe	32,969
Other camping (hunt, wilderness camp, backpack)	14,318
Swimmers, picnickers	227,110
Canoeists	118,339
Boaters, anglers	481,741
Hunters	226,697
Hikers	62,504
Snowmobilers, ATV	264,456
Skiers	63,093
Mountain bikers	54,724
Horses	3,131
Other users	996,774

DNR Photo Archives

Wisconsin provides opportunities for wildlife watching throughout the state.

Debbie Proctor

Families enjoy a naturalist's presentation in the fall.

Compatibility of Forest Uses

Note: This information comes from Marcouiller and Mace, 1998.

There is a general perception that timber production and recreational use are mutually exclusive; specifically, that forest planners and community development practitioners must recognize a trade-off between the two and plan accordingly. Regional analysis often pits the two alternative forest uses (timber production and recreation) against each other and fails to address the core issues of compatibility between uses. A certain level of land-use compatibility could serve as an important driver of local economic policy prescriptions.

Although most forest managers understand this general concept, it is often difficult to adequately measure the success of multiple-use management. The variety of demands and the limited resources of public agencies create difficulties in this sort of assessment. Performance measures used to assess the effectiveness of this comprehensive provision, all too often, are reactive and deteriorate into an assessment of the level and extent of stakeholder complaints. Perceived conflicts in management of forests include both inter-use conflict (between two different uses like timber production and recreation) and intra-use conflict (conflict within a broad use category, for example between birdwatchers and motorized recreationists). Both of these types of conflicts should be addressed and minimized for successful multi-use management. Inter-use conflict will be discussed in this section.

Inter-use conflicts

Timber production and recreation are the base of the wood-based industries and the tourism-sensitive sectors, respectively.

Some forest-based recreationists exhibit skepticism about timber harvesting; much of this focuses in the appearance of on-site environmental effects. Basically, recreationists think that some harvests are ugly, and they also worry about the environmental effects of timber production.

Forest openings are one by-product of harvest. In addition to affecting the biological forest growth, these openings have an impact on the values and benefits that recreationists derive from forest land. When asked, recreationists indicated that encountering large forest openings on forestland bothered them and detracted from their recreational experience.

However, when asked to agree or disagree with a statement that said that intermittent clearings have important wildlife benefits most recreationists generally agreed, especially hunters. Moreover, in general respondents agreed with the statement that forest-based recreation is generally compatible with timber harvesting activities. Response to this statement differed among recreationists. Hunters were more apt to agree with this than quiet recreationists were.

Although quiet recreationists (hikers, bikers, bird watchers, photographers, etc.) may indicate a concern about compatibility, most did agree that timber production and harvest is a legitimate use of the forest.

Local Land-use Regulation and Economic Development

Note: This information comes from Marcouiller and Mace, 1998.

Another issue affecting forest management is land-use regulation. Land-use regulation is a public policy issue that has been a rallying cry for both property rights advocates and environmentalists. Results point out that clear consensus on these issues is elusive. However, there does seem to be a general understanding that property rights to manage forest lands begin with the owner of the land. Furthermore, recreational users reveal a stronger feeling that land-use should be locally determined.

It has been the prevailing belief that recreational users' attitudes are shaped by their outsiders' view of the forest as primarily a recreational resource. However, outsiders are more sensitive to local needs than has been thought. In general, forest-based recreationists appear to understand the need to develop economic activities in local regions where they recreate.

In general, recreational users felt that important strategies for improving local conditions included the growing and harvesting of trees and strategies that help existing businesses remain viable. Of less importance were strategies that target wood processing industries and general tourism development. Respondents were much less interested in Native American casino development, mining and the processing of minerals, and the general attraction of manufacturing firms as important strategies for rural community quality of life.

Timber production and recreation both provide value-added opportunities and represent equally important directions in forest use. More importantly, however, both also rely on the health, productivity, and management of the same raw material—Wisconsin's forest and natural resource base.

Robert Queen

Many water-based recreation activities exist within forests, including fishing.

Sanborn

Trends and Issues Affecting Wisconsin's Forests Now and Into the Future

This report provides an assessment of Wisconsin's forest resources from ecological, social, and economic perspectives. This information provides DNR Forestry with the basis for the next step: planning—along with our partners and public—for the sustainable management of our forest resources now and into the future. During 2000–2001, we will work with others who care about Wisconsin's forest resources to develop a statewide forest plan. Because those participating in this planning process will no doubt be focusing on trends and issues, we provide the following overview of some trends and issues that will likely play a part in planning discussions. This is by no means an exhaustive list—and it offers no position on issues or solutions to problems. Rather, we hope that by briefly describing some of these trends and issues, we can begin to create the bridge between assessing our forest resources and planning for their future management.

Ecological

There are a number of trends and issues regarding species composition, age-structure, and other ways that foresters and other resource managers analyze forest resources.

Trend: Wisconsin's forests are aging and forest succession is occurring.

Wisconsin's forests are aging. Most of the state's forestland is a result of regeneration or planting in the early to mid-1900s. Mid- to late-succession maple-basswood forests are replacing the early succession aspen-birch and oak forests of the '40s–'70s. The forest inventory of 1996 was the first Wisconsin inventory to show more maple-basswood acres than aspen-birch. Aging forests—and the associated species composition, structure and function changes—impact economic and recreational opportunities, as well as biodiversity.

Trend: Forestland is increasing.

Between 1983 and 1996, Wisconsin's forestland increased by 640,000 acres. This trend of increasing forestland began in the 1960s and is mostly the result of marginal agricultural land converting back to forests.

Issue: Some species are declining.

Some tree species have declined or effectively been removed from Wisconsin's forests. American elm and butternut have declined in recent years. American chestnut has effectively been removed from Wisconsin's forests. Dutch elm disease, butternut canker, and chestnut blight have seriously impacted these beautiful and valuable tree species. Some individual trees show resistance to the various diseases, but not enough to hope for recovery in the near future. Jack pine and the jack pine forest type acreage is also decreasing. Much of the acreage is being replaced with other pine or oak species. The oak in particular reflects a later successional type due to a management choice or lack of disturbance, primarily fire.

Trend: There is limited oak regeneration in southern Wisconsin.

On a statewide basis, oak-hickory acreage increased slightly between 1983 and 1996 (primarily on very sandy sites); however, acreage decreased in southern Wisconsin. This trend is most likely a result of aging, concentrated oak-hickory forests in southwestern Wisconsin with continued heavy selection harvests, which increase the rate of succession to elm-ash-soft maple and maple-basswood types. This, in conjunction with the difficulty in regenerating the mid-tolerant northern red oak on good sites in southwestern Wisconsin and the resulting large decrease in seedling-sapling acreage, provides support for a continued decline in oak-hickory acres and the red oak species in southern Wisconsin.

Issue: information about biodiversity is scarce.

We are still exploring and learning about biodiversity and what it means to human beings and to the forest. There are clearly holes in our knowledge. For example:

- We do not have a good understanding of the diversity of Wisconsin's non-vascular plants, invertebrates, or herptiles.
- Genetic diversity within species is something we're just beginning to examine.
- The relationship of forest composition and structure to ecosystem function—a critical piece of the puzzle—is not well understood beyond some basic knowledge of nutrient and energy cycles.
- An understanding of the different scales at which biodiversity is important is also just emerging.
- The positive and negative impacts of forest succession on species diversity are not well known.
- The role of reserves, buffers, and corridors need further study to clarify the relationship with conserving biodiversity.
- The importance of coarse woody debris within forest is a stand attribute that can be managed for; however, guidelines need to be developed for various forest types and sites.
- Monitoring management activities and developing feedback mechanisms need to be refined in order to understand forest changes and subsequent adaptive management.

DNR Photo Archives

The wood turtle is a threatened reptile.

Issue: It is a challenge to make scientific information relevant to decision-making.

Forests are complex. Describing even what we do know about forests in ways that can be readily understood and used by people who want to participate in planning for future forest management is an increasing challenge for natural resources professionals. The good news is that with tools such as Geographic Information Systems (GIS), we can provide very useful visual aids to help people think about multiple layers and scales of information.

Trend: The list of threatened and endangered species is growing.

Currently there are 33 threatened and 34 endangered Forest species listed on either the Wisconsin or federal endangered and threatened lists. These numbers are up from 1985, the time of the last assessment. These latest listings are concentrated in the invertebrate and plant categories. The increase in listed species is largely due to our increasing knowledge about a wider variety of species and their habitat needs.

Issue: Invasive exotic species are an increasing threat.

Human activities—trade, travel, gardening, and recreation—have resulted in many species not native to Wisconsin being introduced to the state. Some of these new species cause problems in native ecosystems. Exotic species often have few if any competitors or predators, making it easy for them to take over an ecosystem, significantly altering the structure and diversity of the system. The gypsy moth, Asian long-horned beetle, Dutch elm disease, garlic mustard, and Japanese honeysuckle are some of the exotic species that have invaded, are invading, or pose a future threat to Wisconsin's forests.

Dean Tvedt

We are losing some important ecosystems such as savanna. Kettle Moraine State Forest.

Issue: Some ecosystems and important development stages of ecosystems are rare.

Savannas, barrens, and advanced successional stages are ecosystems that have become extremely rare. Savannas, for example, were once common ecosystems that are now very rare. They have been converted to farmland, succeeded to forest, or changed in land use to urban development. Barrens were historically rare and now have become globally imperiled. These forest systems have also been altered in their composition, for example through increased plantations or stocking of trees in barrens and savanna, as well as through fire suppression in systems that are fire-dependent. Hemlock relicts are declining due to deer damage, poor regeneration, and conversion of land to other uses.

Common ecosystems present concerns due to changes in integrity. For example, riparian forests are becoming significantly degraded. Human activities are impacting communities along rivers and streams. Development, agriculture, and pollution have impacted many riparian forests, affecting the native biodiversity [DNR, 1995].

Issue: Forest disturbance patterns are changing.

Forest disturbance patterns have changed dramatically over the past century. This has resulted in significant impacts upon forest composition, structure, and function. Once, the dominant short-term disturbance factors in Wisconsin's forests were windthrow, fire, disease, and severe weather. Today, fire has been widely suppressed in our forests. Human-caused disturbance is now predominant in Wisconsin's forests, while disease, windthrow, and severe weather continue as disturbance factors. Various types, intensities and timing of disturbance have different impacts on forest composition, structure and function.

Issue: Stands of old forest are rare.

Since the Cutover, what people think of as old forest[1] in Wisconsin has been relatively rare, with notable exceptions of stands of old forest in the Menominee Forest (Menominee County), on Goodman Timberland, and in the Connor Forest (Marinette, Forest and Florence Counties). What remains is scattered across the state in very small parcels, mostly in cedar bogs or spruce swamps. Our aging forests provide opportunities to manage for old forest.

Issue: The forest is becoming more fragmented.

Permanent fragmentation is the process of converting large contiguous areas of forest into smaller patches of forest and non-forest land use in ways that do not allow the forest to regenerate. In contrast, habitat fragmentation temporarily decreases the continuous area of a similar-aged or structured forest, which may impact some species. Temporary habitat fragmentation occurs naturally through agents such as fire, windthrow, or severe weather. Humans can also increase the rate of permanent or habitat fragmentation in Wisconsin's forests. Road building, agriculture, and urban development all contribute to permanent fragmentation, whereas timber harvest contributes to habitat fragmentation. However, there are dramatic differences between the impacts of temporary habitat fragmentation, such as timber harvest, which provides for regeneration of the forest, and fragmentation under conditions that create permanent or very long-term alterations to forest systems, such as development and agriculture. Like many of the issues identified in this section, this one is much debated.

Trend: Average acreage burned by forest fires has declined.

Great strides have been made in controlling forest fires since initial efforts to suppress fires over 70 years ago. The annual acreage burned in Wisconsin has declined with improvements in forest fire detection and suppression techniques, saving lives, property and forest resources. However, weather continues to play a critical role in determining the number and extent of fires in any given year. It has been more than a decade since Wisconsin has experienced prolonged severe fire weather.

Issue: Control of fire affects forest composition.

The control of forest fires in Wisconsin is a necessity given the juxtaposition of forests, people and property. The suppression of forest fires affects the composition, structure and function of forests by facilitating the conversion of non-forested land to forest. Controlled fire is increasingly used as a tool to mimic the attributes of fire in maintaining some forest and non-forest ecosystems, including prairie, oak savanna and pine barrens.

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[1] The term "old forest" includes relict forest, old growth reserve, managed old growth, extended rotation, and miscellaneous old forest. From draft report compiled by the DNR's silviculture committee [DNR, 1996].

Economic

Forests and other natural resources have provided the base for human economic activity since the first economic system was developed. In Wisconsin, the forest products industry and forest-based recreation are both very important to our state and local economies. People also place economic value on forest aesthetics and forest ecosystem functions.

Economic trends can be very dynamic. Individuals often have very different ideas about what the economic priorities and needs for a community should be. These reasons, among others, can create contentious issues regarding forest uses. There are a host of important factors coming together to shape Wisconsin's forest uses. The special character of the timber and tourism industries impact how they function, as does the high value that people place on forests and forest activities.

The economic value of the ecological functions that forests provide, although often overlooked, is also important. Erosion control, nutrient cycling, and flood control are examples of important functions performed by forests that have obvious economic worth.

Some important trends and issues in the forest economics arena include:

Trend: Succession is changing forest composition and potential forest products.

As discussed previously, Wisconsin's forests are maturing, succeeding from an aspen-birch dominated composition to maple-basswood and other mid-to late-successional forest types. This change in species composition will have a major impact on the forest industry and the goods it produces.

The transition of Wisconsin's northern forests from early successional to late successional forest types is the key factor that will affect the forest industry in the future. This transition will cause the industry to adapt to use more soft hardwoods, such as red maple, for both pulpwood and sawlogs. Along with this transition to later successional forests comes an increase in tree size in the predominate species, such as maple, which will help supply the sawmills.

The southern forests in Wisconsin are predominately oak-hickory forest type and are transitioning to maple-basswood and elm-ash-soft maple types. In this part of the state there may be a greater dependence on the production of pulpwood and a consolidation of sawmills due to a reduction of sawtimber supply from the southern broadleaf forest.

Trend/Issue: Demand for forest products is increasing.

There is an increasing demand for wood and wood products globally, including the products that Wisconsin's forests provide. Paper, timber, furniture, crates — even syrup and wild mushrooms — are experiencing an increased demand. This increase in demand can be met in a number of ways. Increased importation, increased production through forest management, shifting harvests to other states and/or countries, shifting harvest to other species, increased efficiency in production, recycling, reuse of products, shifting demand to non-forest products, and reducing demand together form the range of alternatives, all of which have environmental, economic, and social consequences.

Pukall Lumber, Inc.

Demand for forest products is increasing all over the world. Wood furniture and flooring, Pukall Lumber, Inc, Woodruff

Robert Queen

More people choose to recreate in Wisconsin's forests each year.

Trend: Demand for forest-based recreation and associated services is increasing.

More people within Wisconsin want to use our forests for recreation. Forest recreation in general is growing in popularity, i.e. a growing percentage of Wisconsin's citizens participate in forest recreation, and there are more people in Wisconsin to participate. A growing population of retirees also increases the interest in all sorts of recreation, including forest-based recreation. The increase in retirees using Wisconsin's forests for recreation also increases the demand for some types of services associated with forest recreation like lodging, restaurants, and retail stores.

Issue: Forests are in demand for a mix of uses.

More forests are being used and managed for multiple economic and other benefits. For example, many forest areas can support both timber removal and recreation. There are, however, trade-offs that are made when choosing what benefits to use a forest for. Some uses—like wilderness—preclude other uses—like timber harvest. Because these activities rely on the same resource base, it will become increasingly important to coordinate activities in a way that will allow many uses of the forest.

Issue: "Green" accounting is a new way of evaluating forest benefits.

There are functions that a forest serves that are not considered in traditional economic accounting. For example, while most people value clean air and water, there has not been an accepted method of calculating the value of the environmental functions a forest provides. The difficulty in accounting for these values can lead to a lack of understanding when assessing the economic value of forests. Likewise there has not been a way to establish the value of forest aesthetics or other societal values. New research is developing ways to assign value to these aspects of forests (a concept called "green" accounting).

Robert Queen

The DNR's Division of Forestry supports sustainable management for Wisconsin's forests.

Issue: Sustainable management certification is emerging.

The forest products economy is a global one. High value veneer timber is likely to be shipped around the world, while wood for lumber and pulpwood is usually processed in the same region in which it grew. An outgrowth of the global marketplace has been the call for "green certification" of forest products. The stamp of certification is meant to assure the buyer that the product came from sustainably managed forestland. There is currently a wide range of certification systems, including Forest Stewardship Council, Sustainable Forestry Initiative, American Tree Farm, and International Standards Organization (ISO) 1400. Several Wisconsin lumber producers are choosing to become certified.

Trend: Recycling is increasing.

Recycling of paper and wood products has increased dramatically over the last inventory period. Nationwide, between 1970 and 2000, recycling has increased from under 7% of total waste to about 30% of total waste [EPA, 2000]. In weight, that increase has been even more dramatic, as our waste production has also increased significantly.

Trend: Efficiency in use of wood has increased.

With improved technology for harvesting and milling, processing wood is now more efficient. More of the tree can be utilized at each step of the process, and new markets are being developed for wastes, such as saw dust, that once were discarded.

Social

As discussed previously in this report, Wisconsin's forests are used by citizens for a wide variety of activities. Both numbers of participants and types of activities are increasing. Following are some trends and issues that represent the social part of the management equation.

Trend: Large blocks of industrial forests are changing hands rapidly.

In recent years we have seen an increase in transfer of large blocks of forested lands between industrial companies, and in some notable cases, out of industrial ownership and into government or non-industrial private ownership. This trend may have important ecological, economic, and social implications for the future as these large forested land holdings are divided and, potentially, converted from forested lands to other land uses.

Trend: More people are purchasing forested lands.

While public ownership of Wisconsin's forests is increasing through state and county acquisitions, the number of non-industrial private owners of forested land is also up, due to the division of forested lands into smaller parcels. Forested land is now highly valued for home sites and recreational areas. Associated with more owners is more fragmentation—more roads, more yards, more houses, more paths, etc.

Issue: Private forestry assistance is needed.

With the increasing number of non-industrial private forest land owners, it is becoming more difficult to provide professional forest management guidance to these landowners. It is estimated that only about 20% of these landowners receive professional assistance prior to having timber harvested from their lands. With over nine million acres of forest land, the management of these non-industrial private lands are critical to ensuring the sustainability of Wisconsin's forests.

Trend: Demographics of forest land owners is changing.

Today, forested parcels are more likely to be purchased by people who have different values than the forest owner of the past. Rather than the farmer who owned forest and used it primarily to supplement his income, many of today's new forest owners are from urban areas who own forest for primarily recreational use or aesthetic values. These newer private owners tend to be more cautious about harvesting their timber, less knowledgeable about rural areas and the forest they've moved to, wealthier than past owners, and more likely to be absentee landowners.

Trend: Less forested land is accessible for public use.

With changes in ownership of industrial lands and demographic changes in non-industrial private land owners, the amount of forested land open for public use is decreasing. This trend has implications for the future of public hunting, fishing, and other forms of recreation.

Trend: Stakeholders are more involved in forest decisions.

For a number of reasons, there is increased participation by a variety of stakeholders in decisions affecting forest policy and management of public lands. Various levels of government, local community groups, concerned industry groups, recreational users, property owners, and environmental groups are often a part of major decisions affecting Wisconsin's forests.

Issue: Conflicting use of forests is a public debate.

Forests are used for recreation, to provide aesthetic beauty, to produce forest products, to maintain water quality, and to preserve wildlife habitat, among many other uses. Not all of these uses are always compatible in the same forest. The debate among people who value the forest for different reasons has grown in recent years. Some forest uses and some forest management techniques are controversial. This debate will continue to inform management decisions made in Wisconsin's communities.

Issue: Clearcutting and even-age management techniques are controversial.

Clearcutting is a timber harvesting process that removes all trees from an area at the same time. This method typically encourages the management of earlier successional species in forest types that have a uniform age. This even-age management technique, along with other techniques (such as seed tree and shelterwood harvests), create aesthetic and ecological changes to a forest. A variety of forest values (both aesthetic and ecological) benefit from this activity while at the same time a variety of values are negatively affected. The trade-offs typically polarize advocates for specific forest values. Forest types that are favored with these techniques are pioneer to mid-successional types. Other disturbances, either natural or human caused disturbance (such as fire), could be used to maintain these types. Fire has historically been suppressed or not used in forest management prescriptions due to public health and safety concerns or the lack of technical experience and resources. The use of even-age techniques and other disturbance oriented management tools (like prescribed fire) will continue to be an issue of conflict.

Issue: Role of Public Forests.

As our growing populace places more extensive and diverse demands on our forests, the conflict is most acutely felt on the public forests. The federal, state, county and local forests have, to varying degrees, been subject to increasing conflicts between various interests and among various users. The role of public forests at different scales needs to be more clearly defined, and the implications of possible decisions made clear.

Trend/Issue: Motorized recreation is becoming more popular.

Snowmobilers, off highway vehicle users, four-wheelers, and dirt-bikers are taking to the forests in ever-increasing numbers. There are a number of issues associated with this trend. There are more complaints of crowding on trails used for motorized recreation and more conflict with other types of recreationists. There are also safety and environmental concerns associated with motorized use of the forests. Ecological impacts on the trails—exhaust fumes, trail erosion and rutting, noise—can cause environmental problems in the immediate area, as well as in habitat off the trail. Motorized recreationists also tend to spend more money recreating than other types of recreationists, thus providing greater financial support for the community in which they recreate.

Trend: More trails are being created and used.

Trails have become very popular throughout the United States, and Wisconsin is no exception. The "rails to trails" program, the national trail system, and the general interest in trail activities has resulted in many new trails being constructed and used in Wisconsin's forests. Trails are used primarily for hiking, running, walking, biking, horseback riding, snowmobiling, and backpacking.

Issue: Development is increasing in fire-prone areas.

As development continues to expand into forested areas of the state, there is an increasing fire risk, particularly in those parts of the state which have high fire potential. The absence of prolonged severe fire weather throughout the 1990s has the potential to embolden those who wish to develop in fire prone areas. The increased human presence in the wildland/urban interface presents a major challenge in protecting life, property and the forest resource from destructive forest fires.

DNR Photo Archives

Trend/Issue: Consumption patterns are not linked to production.

Americans continue to increase their consumption of forest products, while at the same time many are calling for reducing the amount of forest land that is actively managed to produce those products. The disconnect that occurs between resource production and resource consumption is causing ecological, social and economic consequences, including here in Wisconsin. These consequences include the shifting of harvests to different parts of the country and world, consumer decisions about product choices and land use choices.

Urban Forests

Along with increasing understanding of the importance of our urban forests comes a variety of issues centered on economics, planning, environmental justice, quality of life, and personal taste. Here are some of the trends and issues associated with urban forests:

Trend: Urbanization is increasing.

Wisconsin is becoming more urbanized, increasing demand for additional community green space, and putting use pressure on existing urban and nearby recreational green space. Communities are becoming more aware of the need to manage their urban forest and more are doing it; however, the pressure on limited resources to maintain other infrastructure is also increasing.

Trend: Development is increasing.

Development continues to encroach upon forest land in Wisconsin. This trend is expanding the extent of urban forests while decreasing and fragmenting rural forests. People with urban attitudes and expectations are moving into rural areas and lake-front developments. This affects how the forest is used and impacts the ecology of these areas.

Issue: Absentee landowners affect urban canopy.

There is less concern for urban land stewardship from absentee landowners and renters, so trees and other vegetation are not managed and not replaced as they die. This results in declining canopy in lower socioeconomic areas dominated by rental properties.

Issue: Exotic species threaten urban forests.

Invasive, exotic species planted by urbanites may threaten natural areas in and around communities. Urban forests may become a focal point in a conflict between the traditional horticultural industry and ecological preservationists.

Specifically, gypsy moth is making its way westward in Wisconsin. Impacts of the moth on the urban forest can be very distressing for community residents, and stop-the-spread and control measures can be controversial.

Global Issues

Wisconsin's forests are increasingly influenced by global trends. Improved global communication and new global economies present new challenges and opportunities for Wisconsin's forests.

Trend: Warming of the earth may affect forest composition, structure and function.

It is becoming increasingly clear that the earth is warming. However, much is unclear about the long-term effects of this trend. Ecologists speculate that long-term global warming may result in a corresponding response in natural systems that could mean significant changes in forest composition, structure and function.

Trend/Issue: Exotic species threaten ecological balance.

Exotic species are an increasing threat to Wisconsin's forests and other ecosystems. Exotic species make their way into Wisconsin through many avenues. Horticulturists have introduced some, like gypsy moth, buckthorn, and Japanese honeysuckle. Others, like the Asian long-horned beetle and the fungi that cause Dutch elm disease and oak wilt, are the result of global trade, through which forest products from other areas of the world are shipped to the United States. With global trade continuing to increase, the potential for new introductions of exotics is also increasing.

Issue: Forests affect carbon emissions and sinks.

Wisconsin's land-use is resulting in a net greenhouse gas emission (EPA, 1997). The conversion of forest and farms to other uses results in the emission of carbon dioxide and other greenhouse gases. Human-caused greenhouse gas emissions result in global warming. However, Wisconsin's forests are powerful challengers to global warming. A good portion of trees and other living things are made of carbon. As trees and forests grow, they remove carbon dioxide from the air and release oxygen, using the carbon to maintain themselves and grow. Forests provide a very significant carbon sink that helps to combat global warming.

Trend: Global demand for wood products is increasing.

As world populations increase, the demand for wood and wood products continues to increase. Wisconsin will be affected by this trend as the desire for forest product sustainability and national self-sufficiency increases.

Issue: Sustainable forest products may provide a global advantage.

Wisconsin's forests have been increasing in volume for decades. To meet increasing global demand for wood products, sustainable forest management in Wisconsin forests has the potential to take some of the pressure off more at-risk forests in other areas. Forest products sustainably produced in Wisconsin may be a good substitute for products made from wood harvested in tropical or boreal forests, where sustainable harvest is more difficult to maintain.

Issue: Criteria and indicators for sustainable forestry being developed.

Wisconsin forest managers are joining other landowners across the country in meeting the commitment the U.S. made as part of the Earth Summit to practice sustainable forestry. Accomplishing this requires the development of criteria and indicators that we can use to gauge progress. Sustainability criteria are being developed for rural Lake States forests as well as for urban forests (see Appendix 3).

The Next Step: A Statewide Forest Plan

This assessment provides an overview of the state of Wisconsin's forest resources and some of the major trends and issues that face those who are interested in our forested lands, their uses, and their future. Wisconsin DNR Division of Forestry works with partners on an ongoing basis to address many of these trends and issues. However, this report provides the basis for our next step: to work with our partners and others who care about Wisconsin's forests to develop a statewide forest plan. This plan will articulate a commonly held vision for Wisconsin's forest resources and lay out a strategy for achieving that vision. Wisconsin DNR Division of Forestry will host a series of meetings throughout Wisconsin in 2000-2001, in which we will:

- Articulate a vision for Wisconsin's forest resources;
- Identify the issues that affect our ability to achieve that vision. Assess the priority issues that need to be addressed by DNR Division of Forestry and our partners.
- Outline a course of action to address the priority issues during the next 6–10 years.

We invite you to participate in this forthcoming planning process. If you wish to ensure that you are on our mailing list for this effort, please send your name, postal address, and email address to:

Statewide Forest Planning Coordinator
Wisconsin DNR Division of Forestry
Box 7921
Madison, WI 53707-7921

or on web site:
www.dnr.state.wi.us/org/land/forestry

DNR Photo Archives

Appendix 1

Several Ways We Study the Forest: Forest Inventory and Ecological Land Classification

Information Systems That Help Us Understand the Status and Capability of Our Forests

Wisconsin's forests have been studied since people have lived here. Field notes from the original land survey, begun in 1830, were analyzed and compiled by R. W. Finley into his famous map of the presettlement vegetation of Wisconsin [Finley 1976] which is shown juxtaposed with a map of current vegetation on pp. 102–103. The USDA Forest Service has conducted inventories of Wisconsin's forests since the 1930s. It is very helpful to have such a consistent long-term data base on one of the state's primary natural resource systems.

In recent years, much attention has been drawn to the need to recognize ecological relationships and the complexity of these interrelationships in time and space. In making resource management decisions, it is now common to look not only at a given site or area, but also at larger scale areas that share similar structure, function, and composition. Several different systems provide us with a framework for gathering, organizing, analyzing, interpreting, and presenting ecological information. They provide a common language for communication, and they facilitate management based on knowledge of ecological potential of the land.

Following is a brief introduction to some of the systems that we use to study and track the status of Wisconsin's forest ecosystem. Although there are many other informational systems that pertain to forest management, the ones described below are the main systems from which information was derived for this assessment report.

US Forest Service Inventory

To track the basic status and condition of Wisconsin's forests, we conduct an annual forest inventory, which is part of a national inventory conducted by the USDA Forest Service. The Forest Service has conducted the Wisconsin forest inventory on a periodic basis in 1936, 1956, 1968, 1983 and 1996. Forest Service field crews collect inventory data from a random selection of grid plots across the state. For the 1996 inventory, field measurements were taken on about 9,000 forested plots. Inventory data provides information on timberland acres and growing stock; sawtimber volume, growth, mortality, and removals; the status of Wisconsin's forests; and trends in forest composition.

Inventory data historically has been reported in terms of **forest types** and **species groups.** Successional changes, species specific insect and disease problems and mortality, forest product desirability and harvest levels are all well defined by forest type acreage and/or species group volume changes over time.

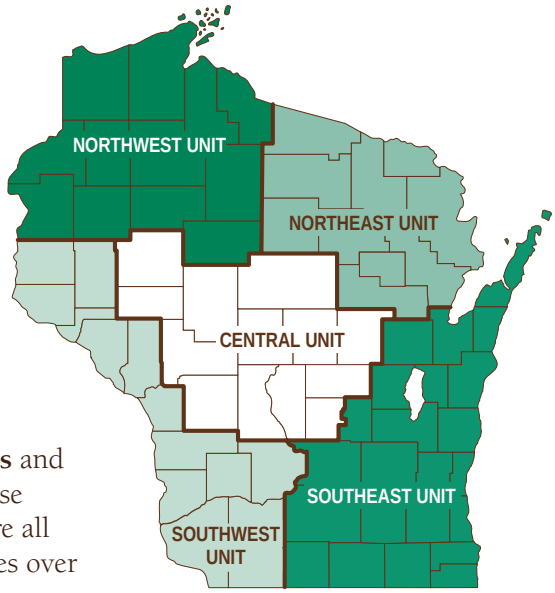


Figure 28

Forest Survey Units in Wisconsin

A forest type is a classification of forest land based on the species forming the best represented majority of all live trees ≥ 1-inch diameter. Most common forest types in Wisconsin are maple-basswood, aspen and oak-hickory. **A species group** is a grouping of individual tree species, such as quaking aspen and bigtooth aspen, into a single family group, in this case aspen.

National Hierarchical Framework of Ecological Units (NHFEU)

The National Hierarchical Framework of Ecological Units (NHFEU) is an ecological classification system that divides landscapes into ecologically significant regions at multiple scales. Ecological types are classified and units are mapped based on associations of biotic and environmental factors which include climate, geology, physiography, soils, hydrology, and potential natural communities. In Wisconsin, the Provinces, Sections, Sub-sections, and Landtype Associations of the NHFEU have been delineated and are being used as large-scale ecological units for resource assessment and planning projects. The development of these important layers of information have supplied a spatially oriented, ecological classification tool that is available to a variety of landowners, land managers, and resource interest groups in Wisconsin and the Lake States. The NHFEU provides a basis for assessing resource conditions at multiple scales – from assessing resource capability at large scales to assessing site specific conditions such as distributions of terrestrial and aquatic biota and forest growth, succession, and health.

Figure 29

Section level of NHFEU for Wisconsin

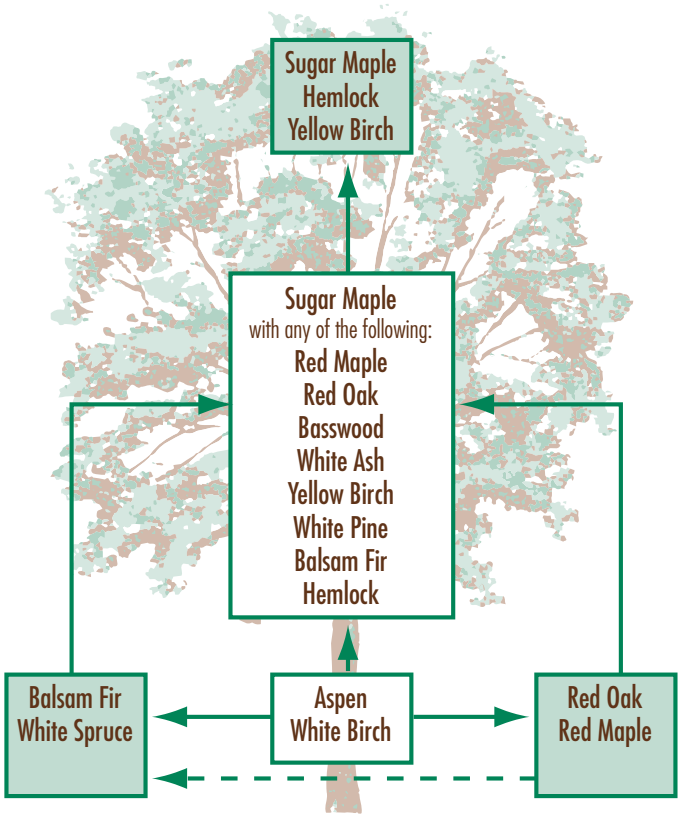


Figure 30

Acer-Tsuga-Maianthemum (sugar maple-hemlock-wild lily of the valley) Habitat Type Successional Diagram

Forest Habitat Type Classification System (FHTCS)

The FHTCS, developed in the 1980s and 1990s, is a natural classification system for forest communities and the sites on which they develop. It is a site classification system based on the composition of plant communities. It groups land units with similar capacity to produce vegetation. The system integrates those environmental factors that affect species reproduction, growth, competition, and community development. Each habitat type represents a segment of environmental variation with a certain potential for vegetation development.

The FHTCS provides a guide to common site types and upland forest plant communities of Wisconsin. It can be applied to research, forest management, and communication. The system provides an ecological framework for the systematic gathering of data for the development of management interpretations, objectives, and prescriptions. It specifies potential community changes over time, with or without disturbance. It describes potential community composition, competition, and development, as well as site and distributional characteristics. Knowledge of ecological potentials can improve forest management decision making.

The Natural Heritage Inventory (NHI)

Wisconsin's Natural Heritage (NHI), established in 1985, is maintained by the DNR Bureau of Endangered Resources. The NHI program is responsible for maintaining data on the locations and status of rare plant and animal species, natural communities, and unique geological features and animal aggregation sites (such as bat hibernacula) in Wisconsin. The Wisconsin NHI program is part of an international network of inventory programs that collect, process, and manage data on the occurrences of natural biological diversity. This network is coordinated by The Nature Conservancy (TNC), an international non-profit organization. NHI provides useful information for developing management plans for specific properties and also for determining landscape-scale patterns and connections that cross property or political boundaries.

How Are These Systems Used Together?

These information systems are used together by foresters, ecologists, and planners for a wide variety of uses. Following are some examples:

The Wisconsin Forest Accord: Classification systems provide managers and scientists with a common language for describing forest sites, communities, and landscapes, as well as management expectations. As a result of a joint effort led by the University of Wisconsin-Madison and the Wisconsin DNR Bureau of Forestry, representatives of public, industrial, and private landowners and land

managers agreed in 1994 to adopt the National Hierarchical Framework of Ecological Units (NHFEU) and the Forest Habitat Type Classification System (FHTCS) as a common language to characterize the ecological potential of forested sites. Called the "Wisconsin Forest Accord," this memorandum of understanding resolves that the variety of landowners involved with the Accord will describe, evaluate, and share critical ecological information concerning the forested landscape.

Northern Forest Master Planning: In preparation for revising existing state forest master plans, the DNR Forestry program initiated a series of assessments of the Northern State Forests, published in 1999. Among these was an assessment of regional ecology, which used information from the National Hierarchy Framework of Ecological Units to describe in detail the overall regional ecological picture in which several of the Northern State Forests lie and to analyze ecological management opportunities for specific State Forest properties. Natural Heritage information, Forest Inventory data, and general Forest Habitat Type Classification System information was also used to describe the natural resources of northern Wisconsin. This regional ecological assessment provides a more detailed level of ecological understanding of the forest's past, present, and future potential than we have ever had before. This assessment information feeds into the master planning process, which combines a public participation process with the best available information to derive revised master plans for Wisconsin's Northern State Forests that balance the ecological, social, and economic benefits of the forests.

Tablemaker: Tablemaker is a software program developed by the USDA Forest Service Forest Inventory and Analysis Program. It provides the ability to extract data from the Annual Forest Inventory and organize the information into any defined area, including ecological units (using the National Hierarchy Framework of Ecological Units). With this software, forest statistics for a given property (derived from a separate set of calculations) can be compared with statistics for a larger surrounding area (such as an ecological unit) and therefore assessed in relation to the larger landscape. Questions such as the following can be answered:

- Is this property unique, rare or common relative to specific variable(s) or composition on the larger landscape?
- Where does the property "fit in" in productive capability compared to the surrounding landscape?
- Can attributes of the property be changed or maintained to benefit the larger landscape while considering property capabilities and conditions as well as the landowner's objectives.

▲ ▲ ▲

These are just a few examples—ranging from broad multi-party agreements to site-specific analyses—of the ways that current information tools and technology can help us understand and thoughtfully manage Wisconsin's forest resources. With continued development and refinement of such tools, we are able to provide useful information to those interested in participating in planning processes, and we are able to gauge the effectiveness of our management decisions over time.

Figure 31

Vegetation cover of Wisconsin in the mid-1800s, compiled from U.S. General Land Office Notes by Robert W. Finley, 1976.

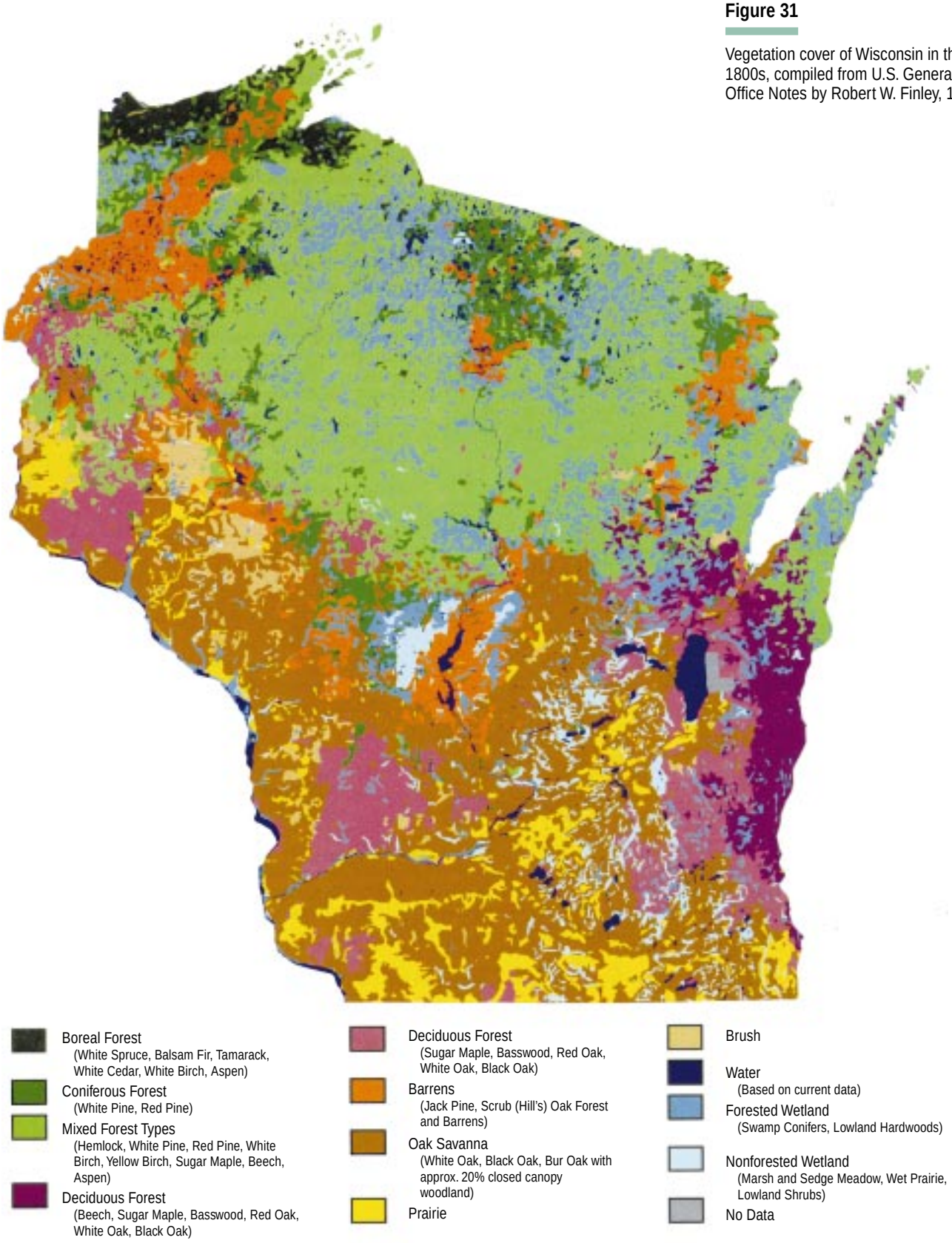
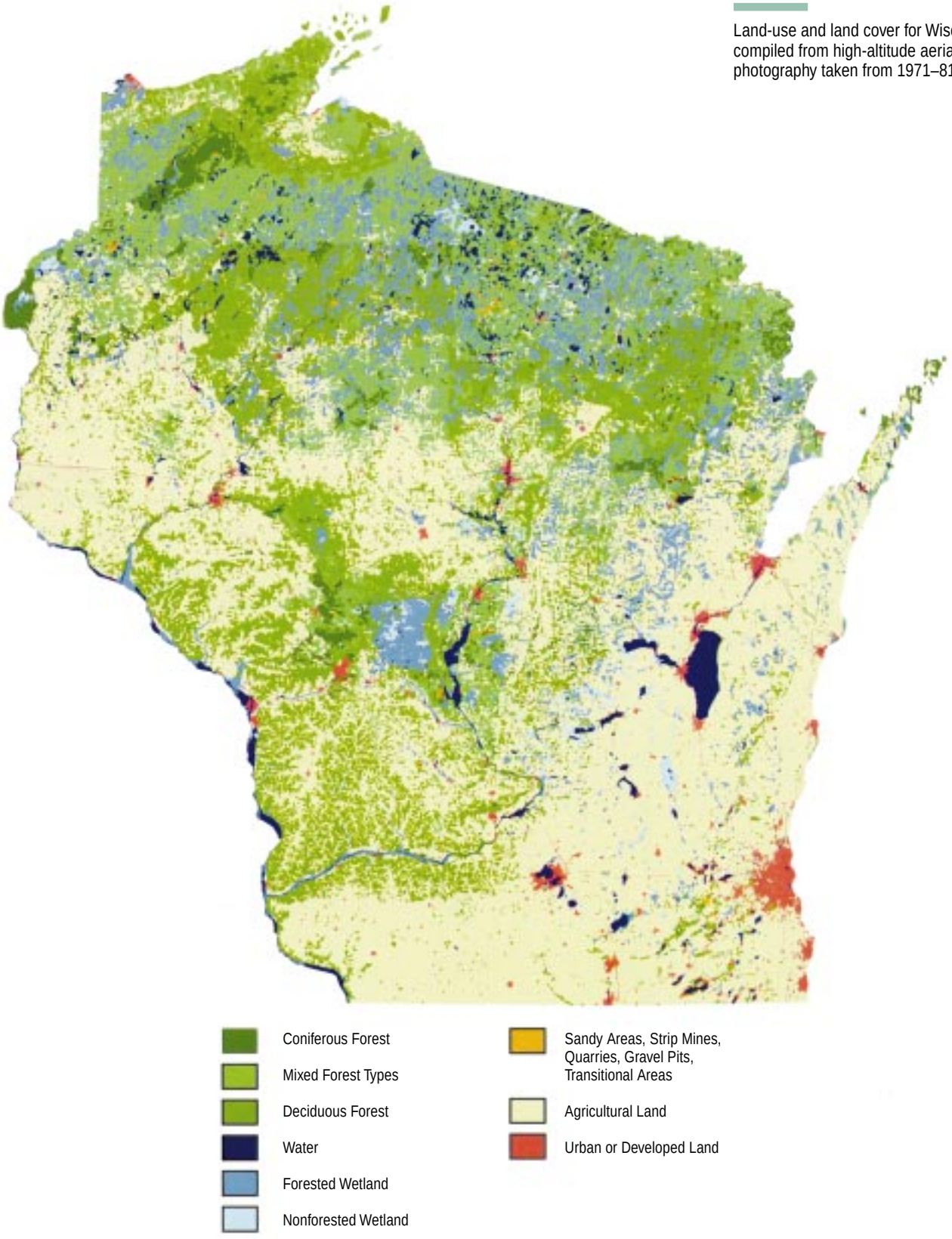


Figure 32

Land-use and land cover for Wisconsin, compiled from high-altitude aerial photography taken from 1971–81.



Stephen J. Lang

APPENDIX 2

Wisconsin's Endangered and Threatened Forest Species and Species of Concern

Endangered and Threatened Species and Species of Concern of Wisconsin's Northern Mixed Forest

Animals

Endangered

timber wolf	*Canis lupus*
pine marten	*Martes americana*

Threatened

wood turtle	*Clemmys insculpta*

Species of Concern

woodland vole	*Microtus pinetorum*
woodland jumping mouse	*napaezapus insignis*
arctic shrew	*Sorus arcticus*
pigmy shrew	*Sorus hoyi*
water shrew	*Sorex palustris*
northern goshawk	*Accipiter gentilis*
long-eared owl	*Asio otus*
pine siskin	*Carduelis pinus*
Swainson's thrush	*Catharus ustulatus*
evening grosbeak	*Coccothraustes vespertinus*
black-throated blue warbler	*Dendroica caerulescens*
Cape May warbler	*Dendroica tigrina*
yellow-bellied flycatcher	*Empidonax flaviventris*
merlin	*Falco columbarius*
Connecticut warbler	*Oporornis agilis*
black-backed woodpecker	*Picoides arcticus*

great gray owl	*Strix nebulosa*
Tennessee warbler	*Vermivora perigrina*
northern ringneck snake	*Diadophus punctatus edwardsii*
four-toed salamander	*Hemidactylium scutatum*
bullsnake	*Pituophis melanoleacus sayi*
West Virginia white	*Pieris virginiensis*
dull gloss	*Zonitoides limatulus*

Plants

Endangered

purple milkweed	*Asclepias purpurescens*
green spleen	*Asplenium viride*
Cooper's milkvetch	*Astragulus neglectus*
moonwort grape fern	*Botrychia lunarium*
little goblin moonwort	*Botyichium mormo*
northern comandra	*Geocauldon lividum*
Smith's melic grass	*Melica smithii*
large-leaved sandwort	*Moeringia macrophylla*
giant pinedrops	*Pterospora andromedea*
lesser wintergreen	*Pyrola minor*
small yellow water crowfoot	*Ranunculus gmellini var.*
low spikemoss	*Selaginella selaginoides*
foamflower	*Tiarella cordifolia*
dwarf huckleberry	*Vaccinium cespitosum*
mountain cranberry	*Vaccinium vitis-idaea ssp. minus*
squashberry	*Viburnum edule*
sand violet	*Viola fimbriatula*

Threatened

round-leaved orchis	*Amerorchis rotundifolia*
fairy slipper	*Calypso bulbosa*
beautiful sedge	*Carex concinna*
handsome sedge	*Carex formosa*
Michaux's sedge	*Carex michauxiana*
drooping sedge	*Carex prasina*
ram's head lady's slipper	*Ciprepedium arietinum*
slenderleaf sundew	*Drosera linearis*
western fescue	*Festuca occidentalis*
dwarf lake iris	*Iris lacustris*
broad-leaved twayblade	*Listera convollarioides*
marsh grass-of-parnassus	*Parnassia pulustris*
arrow-leaved sweet colt's foot	*Petasites saggitatus*
Braun's holly fern	*Polystichum braunii*
Canada gooseberry	*Ribes oxyacanthoides*
marsh valerian	*Valeriana sitchensis ssp.*

Species of Concern

climbing fumitory	*Admumia fungosa*
Deam's rock-cress	*Arabis missouriensis var deamii*
swamp-pink	*Arethusa bulbosa*
maidenhari spleenwort	*Asplenium viride*
blunt-lobe grape-fern	*Botrychium oneidense*
spoon-leaf moonwort	*Botrychium spathulatum*
large toothwort	*Cardamine maxima*
cuckooflower	*Cardamine pratensis*
Assiniboine sedge	*Carex assiniboinensis*
Rocky Mountain sedge	*carex backii*
hair-like sedge	*Carex capillaris*
varigated horsetail	*Equisetum variegatum*
woodland cudweed	*Gnaphalium sylvaticum*
giant rattlesnake plantain	*Goodyera oblongifolia*
limestone oak fern	*Gymnocarpium robertianum*
twinleaf	*Jeffersonia dyphylla*
large-flowered ground-cherry	*Leucophysalis grandiflora*
fir clubmoss	*Lycopodium selago*
white adder's-mouth	*Malaxis brachypoda*
Indian cucumber-root	*Medeola virginiana*
marbleseed	*Onosmodium molle*
Chilean sweet cicely	*Osmorhiza chilensis*
green arrow-arum	*Peltandra virginica*
broad beech fern	*Phegopteris hexagonoptera*
leafy white-orchis	*Platanthera dilatata*
Hooker's orchis	*Platanthera hookeri*
large round-leaf orchid	*Platanthera orbiculata*
Christmas fern	*Polystichum acrostichoides*
brown beakrush	*Rhynchospora fusca*
northern black currant	*Ribes hudsonianum*
veined meadowrue	*Thalictrum venulosa*
comon bog arrow-grass	*Triglochin maritimum*
northern wild raisin	*Viburnum cassinoides*

Endangered and Threatened Species and Species of Concern in Wisconsin's Southern Broadleaf Forest

Animals

Endangered

yellow-throated warbler	*Dendroice dominica*
worm-eating warbler	*Helmintheros vermivorus*
eastern massasauga rattlesnake	*Sistrurus catenatus*

Threatened

red shouldered hawk	*Buteo lineatus*
cerulean warbler	*Dendroica cerulea*
acadian flycatcher	*Empidonax virescens*
Kentucky warbler	*Oporornis formosus*
hooded warbler	*Wilsonia citrina*
wood turtle	*Clemmπys insculpta*

Species of Concern

woodland vole	*Misrotuc pinetorum*
northern myotis	*Myotis septenttrionalis*
Indiana bat	*Myotis sodalis*
eastern pipistrelle	*Pipistrellus subflavus*
arctic shrew	*Sorex arcticus*
pigmy shrew	*Sorex hoyi*
yellow-billed cuckoo	*Coccyzus americanus*
spruce grouse	*Falcipennis canadensis*
worm-eating warbler	*Helmitheros vermivorous*
connecticut warbler	*Oporornis agilis*
prothonotary warbler	*Ptotonaria citrea*
Louisiana waterthrush	*Seiurus motacilla*
northern ringneck snake	*Diadophis punctatus edwardsii*
black rat snake	*Elphae obsoleta*
bullsnake	*Pituophis melanoleucus sayi*
swamp darner	*Epiaeschna heros*
cherrystone drop	*Hendersonia occulta*

Plants

Endangered

purple milkweed	*Asclepias purpurascens*
Cooper's milkvetch	*Astragulus neglectus*
ravenfoot sedge	*Carex crus-corvi*
false hop sedge	*Carex lupuliformis*
intermediate sedge	*Carez media*
Canada horse-balm	*Collinsonia canadensis*
hemlock parsley	*Conioselinum chinense*
American beak-grass	*Diarrehena americana*
harbinger-of-spring	*Eriginia bulbosa*
heart-leaved plantain	*Plantago cordara*
nodding rattlesnake root	*Prenanthes crepidinea*
Lapland azalea	*Rhodedendron lapponicum*
bluestem goldenrod	*Solidago caesia*

Thomas A. Meyer

	hairy-jointed meadow parsnip	*Tthaspium barbinode*
	sand violet	*Viola fimbriatula*
Threatened		
	northern wild monkshood	*Aconitum noveboracense*
	musk-root	*Adoxa mostchatellina*
	yellow giant hyssop	*Agastache nepetoides*
	forked aster	*Aster furcatus*
	kitten tails	*Besseya bullii*
	Carey's sedge	*Carex careyana*
	handsome sedge	*Carex formosa*
	drooping sedge	*Carex prasina*
	ram's head lady's slipper	*Cypripedium arietinum*
	blue ash	*Fraxinus quadrangulata*
	yellow gentian	*Gentiana alba*
	slender bush-clover	*Lespedeza virginica*
	bog bluegrass	*Poa paludigena*
	snow trillium	*Trillium nivale*
	marsh valerian	*Valeriana sitchensis ssp.*
Species of Concern		
	climbing fumitory	*Adlumia fungosa*
	swamp agrimony	*Agrimonia parviflora*
	swamp-pink	*Arethusa bulbosa*
	maidenhair spleenwort	*Asplenium trichomanes*
	great Indian plantain	*Cacalia muehlenbergii*
	ciuckooflower	*Cardemine pratensis*
	dry woods sedge	*Carex artitecta*
	Rocky Mountain sedge	*Carex backii*
	clustered sedge	*Carex cumulata*
	long sedge	*Carex folliculata*
	variegated horsetail	*Equisetum variegatum*
	harbinger of spring	*Erigenia bulbosa*
	upland boneset	*Eupatorium sessilifolium var.*
	wood spurge	*Euphoria commutata*
	bluntleaf spurge	*Euphoria obstutata*
	limestone oakfern	*Gymnocarpium robertianum*
	Kentucky coffee-tree	*Gymnocladus dioicus*
	green violet	*Hybanthus concolor*
	twinleaf	*Jeffersonia diphylla*
	violet bush-clover	*Lespedeza violacea*
	American gromwell	*Lithospermum larifolium*
	rock clubmoss	*Lycopodium porophylum*
	white adder's mouth	*Malaxis brachypoda*
	Indian cucumber-root	*Medeola virginiana*
	three-flower melic grass	*Melica nitens*

small forget-me-not	*Myosotis laxa*
glade mallow	*Napaea dioica*
marbleseed	*Onosmodium molle*
broad beech fern	*Phegopteris hexagonoptera*
leafy white orchis	*Platanthera dilatata*
Hooker's orchis	*Platanthera hookeri*
large roundleaf orchid	*Platanthera orbuculata*
sycamore	*Plantanus occidentalis*
Christmas fern	*Polystichum acrostichoides*
wafer-ash	*Ptela trifoliata*
pin oak	*Quercus palustris*
lance-leaved buckthorn	*Rhamnus lanceolata var.*
fragrant sumac	*Rhus aromatica*
heart-leaved skullcap	*Scutellaria ovata*
prairie fameflower	*Talinum rugospermum*
bog fern	*Thalipteris simulata*
common bog arrow-grass	*Triglochin maritimum*
relaxed trillium	*Trullium recurvatum*
nodding pogonia	*Triphora trianthophora*
northern wild raisin	*Viburnum cassinoides*
smooth black-haw	*Viburnum prunifolium*
long-spur violet	*Viola rostrata*
striped violet	*Viola striata*

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Appendix 3

Sustainable Forestry Criteria

Criteria and Indicators for Michigan, Minnesota, Ontario & Wisconsin (taken from the *Sustainable Forest Management: Policy, Planning & Practice Forum Report,* hosted by The Johnson Foundation, The Great Lakes Forest Alliance, and the USDA Forest Service May 15–17, 2000).

I. Ecological Pillar

Criterion 1: Maintenance of Biological Resources

Indicator 1	Proportion of forest in each successional stage
Indicator 2	Proportion of forest area in each cover and age-class type
Indicator 3	Abundance of, and trends in, rare, threatened and endangered forest-based species
Indicator 4	Abundance of selected forest-based species
Indicator 5	Amount of habitat for selected forest species
Indicator 6	Area of forest not satisfactorily regenerated
Indicator 7	Trends in the area of forest land as a result of deforestation (by type of loss) and afforestation.
Indicator 8	Frequency of disturbance and distribution of disturbed area, by disturbance type and severity.
Indicator 9	Fragmentation and connectivity

Criterion II: Maintenance of Soil, Water and Air Quality

Indicator 10	Compliance with, and effectiveness of water quality BMPs (Best management practices)
Indicator 11	Impact of forest activities on soil

II. Economic Pillar

Criterion III: Provision of Multiple Economic Benefits

Indicator 12 Area of forest land

Indicator 13 Percent of primary industry expenditures accounted for by renewable raw materials (forest and agriculturally derived fiber)

Indicator 14 Great Lakes share of North American and global forest products markets accounted for by forest-based businesses

Indicator 15 Wood flow in the Great Lakes region

Indicator 16 Harvest vs. growth on Great Lakes timberland

Indicator 17 Number and value of forest recreation days

Indicator 18 Diversity of forest-based industry (sales volume by sector)

Indicator 19 Forest-based employment picture by sector

Indicator 20 Value added by forest resource-based industries

Indicator 21 Capital expenditures by forest resource-based industries (including forest products, tourism, other)

Indicator 22 Net carbon flux of Great Lakes forests

III. Social Pillar

Criterion IV: Maintenance of community and cultural values

Indicator 23 Importance of forests in people's daily lives

Indicator 24 Important features and places

Indicator 25 Range of uses of the forest and meanings for those uses

Indicator 26 Access to both public and private forest lands

Indicator 27 Community capacity and civic responsiveness

Indicator 28 Social trends

Criterion V: Society's Framework for Sustainable Forest Management

Indicator 29 Availability of incentives

Indicator 30 Existence of laws, policies and regulations

Indicator 31 Awareness and support for sustainable forest management

Indicator 32 Representativeness of all publics in public participation processes

Indicator 33 Perceptions of fairness and justice

Glossary

Darrell Zastrow

abiotic: refers to non-living objects, structures, and processes.

age class: describes the age of a stand of trees, usually broken down into 20 year classes, i.e. 0–20 years, 21–40 years, etc.

artificial regeneration: the process of renewing the forest through sowing of seed, planting of seedlings or other human means.

associate: in an ecological context, associates are those organisms that characteristically share habitats and are often found near one another.

average annual temperature: the average temperature of each day, averaged by year, for the last 30 years.

barrens: an ecosystem dominated by scrubby tree growth, dry soils, and woody shrubs.

bedrock: any solid rock exposed at the earth's surface, or overlain by unconsolidated material.

biodiversity: the diversity of life at a all scales - genetic, species, ecosystem and landscape.

board feet: Unit of volume measure for lumber or trees equal to 1" x 12" x 12".

boreal: means "north," refers to a particular type of forest vegetation that is characteristic to high latitudes.

broadleaf: refers to those trees that have wide, flat leaves. In Wisconsin, these trees are deciduous, loosing their leaves in winter. Most are also angiosperms.

central sands: a region in Wisconsin in Portage, Wood, Juneau, Adams, Marquette, Waushara, and Waupace Counties that has characteristically sandy soil. Much of this area historically supported pine barrens.

clay: the smallest category of soil particles, less than $^{1}/_{256}$ millimeter in diameter.

clear cut: the timber harvest process that removes all trees from an area at the same time.

climate: the long-term weather pattern of an area.

community: in the assessment, forest composition refers to all of the tree species that are found in the forest.

composition: the makeup of forest or ecological unit in terms of the living organisms or group of organisms and non-living components present in the forest or ecological unit.

conifer: trees that carry their seeds in cones; trees that are primarily not broad-leaved (gingko, exception). Most are gymnosperms.

coulee: a streambed or valley with steep sides or surrounded by hills.

cubic foot: unit of volume measure equal to 12" x 12" x 12".

Cutover: the period of time during or area in which most of the timber from the upper Lake States was removed, about 1850–1920; can also describe forested land that has been completely harvested.

dbh: diameter at breast height; refers to the diameter of a tree as it stands in the forest at 4.5 feet from the ground.

defoliation: removal or loss of a plant's leaves, i.e., by insects.

disturbance: a discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

dominant: the largest trees in a stand.

Driftless Area: the area of Wisconsin that was never covered by glaciers. Located in the southwest area of the state, also includes parts of Minnesota, Iowa, and Illinois.

early succession: the first stages of succession (pioneer vegetation) immediately following disturbance, usually characterized by open, sunny conditions.

ecological capability: the inherent characteristics of land that determine what type of ecological communities may eventually develop there.

ecosystem: the plants, animals, fungi and microorganism together with their abiotic, physical surroundings and the interactions between these components that function as an ecological unit, such as a forest, pond, or swamp.

ecosystem: The biotic organisms of a particular habitat or area, such as a savanna or forest, together with the abiotic physical environment in which they live.

endangered: a species in danger of becoming extinct in all or part of its range.

European-American settlement: the time or process during which there was a dramatic increase of people of European descent moving into Wisconsin. Although the first Europeans arrived in Wisconsin in the 1630s, intense settlement did not occur until about 1825–1880.

extinction: the death of an entire species.

extirpation: the removal or loss of an entire species from an area.

flora: all of the plants in an area.

forest division: an ecological unit at a continental or regional scale; usually includes tens of thousands to millions of square miles.

forest health: the condition of the forest—considering biodiversity; ability to support trees, wildlife, other plants, and humans; functionality of natural processes; etc.

forest inventory: a random, systematic, statistically reliable survey of forest land to ascertain an estimate of various measurements of quantity, quality, health and trends of the forest.

forest survey units: units that the United States Forest Service uses to delineate forest regions. These are primarily based upon social and political boundaries. There are 5 Forest Survey Units in Wisconsin: Northeast, Northwest, Central, Southeast, and Southwest.

forest type: classification of forestland based on the most common species, determined by plurality of stems (whatever species has the most living stems). Associated species are determined by their volume.

forestland: land at least 16.7% stocked with trees of any size, or formerly having such tree cover and not currently developed for non-forest use. The area must be at least one acre in size, and 120 feet wide to be classed as forestland.

fragmentation: the process of dividing forest into smaller patches surrounded by disturbed or developed areas.

function: the roles played by the living and non-living components of ecosystems in driving the processes (e.g., carbon cycle, water cycle, nutrient cycle) that sustain an ecosystem.

game: wild animals that are hunted or fished for sport or food.

growth to removal ratio: numerical comparison of annual volume removed from a forested area to net annual growth volume in the same area. A measure of forest sustainability.

habitat: the specific environment that supports a particular plant, animal, fungi or microorganism population.

hard maple: trees in the maple genus (Acer) whose wood has a specific density greater than one. In Wisconsin this includes Sugar maple and black maple.

hardwood: usually refers to broadleaf timber species, more specifically—dicots.

herbivory: consumption of herbaceous vegetation (plants).

high-grade: a type of timber harvest method that harvests only the best trees in a stand.

hydrology: the moisture characteristics of the land; the distribution, characteristics, and cycling of water in a particular area.

Ice Age: in the assessment, Ice Age refers to the most recent time period when large sheets of ice covered major portions of Earth's land, which reached its peak at about 20,000 thousand years ago. During this time glaciers advanced into Wisconsin, covering most of the state. Glaciers retreated about 10,000 years ago.

invertebrate: an animal that does not have a backbone. Usually, invertebrates tend to be very small animals, like insects, spiders, and single-celled animals.

kettle: a depression caused by a large block of glacial ice that was covered by till or outwash and subsequently melted. Many kettles in Wisconsin are now filled with water and are lakes.

loam: a soil that is a mixture of sand and silt and clay.

lowland: an area of land that is moist much of the time due to geographic position or high water table influence.

mesic: having a temperate, moist climate, neither very dry nor very wet; pertaining to conditions of medium moisture supply.

moraine: a landform created by material pushed by a glacier.

national forests: A federal reservation, generally forest, range, or wildland, which is administered by the Forest Service, U.S. Department of Agriculture, under a program of multiple use and sustained yield for timber production, range, wildlife, watershed, and outdoor recreation purposes.

Natural Heritage Inventory: a Wisconsin DNR Bureau of Endangered Resources program that monitors the status and location of rare species, natural communities, and natural features in Wisconsin. It is connected to an international effort to do the same throughout the world which is administered by The Nature Conservancy.

natural regeneration: renewal of the forest either through re-seeding or the vegetative reproduction of existing plants.

non-industrial private forest land: land owned by individuals or corporations that are not directly involved in the forest industry.

non-productive forestland: land that cannot produce a commercially desirable tree due to poor stand or site conditions.

Northern Mixed Forest: a forest division that occurs in Wisconsin north of the tension zone. It is characterized by both broadleaf and conifer trees.

old growth: a forest that is old (significantly past the age of maturity of it's dominant species), has a well-developed structure, usually characterized by many snags and dead wood on the ground; usually refers only to forest types that are a late successional type for the area; sometimes refers only to undisturbed, never-harvested forests.

other red oak: a term used traditionally to indicate species in the red oak category that are of lesser economic value for timber. In Wisconsin, these include Northern pin oak, Pin oak, and Black oak.

outwash: material, usually sand or gravel, that is deposited by water melting off glaciers.

parent material: the unconsolidated material, more or less weathered, from which soil is developed.

pioneer: in the assessment, a pioneer refers to a species that is among the first to colonize an area after disturbance.

plantation: an artificially reforested area sufficiently productive to qualify as timberland. The planted species is not necessarily predominant. Christmas tree plantations, which are considered cropland, are not included.

poles: an abbreviation for poletimber.

poletimber: a timber size class, indicating a tree that is of the poletimber size, at least 5 inches diameter at breast height but smaller than sawtimber size, (9 inches dbh for softwood and 11 inches dbh for hardwood).

prairie: an ecosystem dominated by grasses with few if any trees, usually with rich fertile soils.

precipitation: any form of water (snow, rain, sleet, etc.) that falls from the sky and reaches the ground.

primary forest: forest that has never been harvested or otherwise disturbed at a large scale by humans.

private land: land that is owned by an someone other than governments (National, State, County, or Municipal).

public land: land that is owned by government (National, State, County, or Municipal), may or may not be open for public use.

pulpwood: wood that is used for the pulp industries (usually to make paper).

reconstituted wood products: products made from wood that has been ground, chipped, chopped, etc. into small pieces of various shapes and sizes for use in product manufacture. Examples include paper, cardboard, oriented strand board (OSB), particleboard, animal bedding, mulch, etc.

reforestation: the reestablishment of a forest, either by planting seedlings or by allowing trees to naturally regenerate.

regeneration: the process by which land renews itself after major disturbance, the process of forest renewal.

removals: wood volume that has been removed from forest land through harvest, land use change or forestry operations such as thinning, site preparation, etc.

riparian: having to do with rivers and river systems.

sand: soil made up of particles that are clearly visible to the naked eye and up to 2mm in diameter. Sandy soils tend to be infertile and droughty.

saplings: a live tree 1.0–5.0 inches diameter at breast height.

savanna: an ecological community that is dominated by scattered trees and large areas of grasses and other forbs.

sawtimber: live tree of commercial species that has at least one 12 foot section (log), or two 8 foot sections (logs) usable for timber production. Softwood sawtimber must be at least 9 inches diameter at breast height, and hardwood must be at least 11 inches diameter at breast height.

second growth: a "second generation" forest—a forest that is a result of natural regeneration of a disturbed site.

select red oak: a term used traditionally to indicate tree species in the red oak category that are of greater economic value as timber. In Wisconsin, this includes only Northern red oak.

select white oak: a term used traditionally to indicate tree species in the white oak category that are of greater economic importance. All of Wisconsin's white oaks fall into this category. They include White oak, Swamp white oak, Bur oak, and Chinkapin oak.

seral stage: a phase in the succession of an ecosystem, from very early successional communities to climax communities.

silt: the mid-size soil particle, between clay and sand.

site capability: the specific ability of a site to support vegetation or an entire ecosystem.

size class: describes the diameter of a tree, usually divided into 2 inch classes (e.g., 5.0–6.9 inches dbh).

slash: wood residue from logging.

soft maple: a term traditionally used to describe some species in the Acer (maple) genus. The wood of soft maples has a specific density of less 1.0 (it floats). Wisconsin soft maples include Red maple and Silver maple.

softwood: refers to the conifer trees.

Southern Broadleaf Forest: the forest division that occurs south of the Tension Zone in Wisconsin.

species: a taxonomic classification of life describing a group of organisms that are able to produce offspring through sexual reproduction.

species group: a designation used by the US Forest Service to lump some species with similar properties together. For example "aspen" is a species group composed of both Trembling aspen and Bigtooth aspen.

species of concern: a designation used by the Wisconsin DNR (and many other agencies and organizations) to describe those species about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

structure: the pattern or physical organization of a forest or ecological unit. It has both vertical and horizontal components.

stumpage: value of standing trees for forest products to the forest landowner.

succession: the relatively predictable changes in an ecological community that occur after either natural or human-caused disturbance.

Tension Zone: an area between the Northern Mixed Forest and the Southern Broadleaf Forest that contains characteristic species from both forest divisions.

threatened: a legally defined status of a species (or population) that is likely to become endangered. These species are very rare and imperiled.

till: soil and other material that was deposited by the glaciers during the last Ice Age.

timber: trees or the wood of trees used for construction.

timberland: a technical definition of the US Forest Service. Refers to forestland that is producing or is capable of producing more than 20 cubic feet per acre per year of wood growth, under natural conditions. Timberland must also not be withdrawn from timber utilization (such as a State Park would be).

understory: the layer of a forest that is closest to the ground. Usually includes seedling trees, woody shrubs and a variety of non-woody plants.

ungulate: a hoofed mammal, usually herbivorous. Ungulates that have called Wisconsin home include whitetail deer, American buffalo, elk, and many others.

vernal pond: a pond that is only filled with water in the spring time.

vertebrate: an animal that has a backbone, usually a larger animal. Bats, horses, and fish are some vertebrates.

wetlands: an area that has saturated soil for at least some part of the year.

wildlife: A broad term that includes non-domesticated vertebrates, especially mammals and birds, and sometimes refers to fish or herptiles.

DNR Photo Archives

Appendix 5

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Paul DeLong

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